Current Practice in Flood Risk Management in the European Union

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EXECUTIVE SUMMARY

Introduction

This European Commission report presents a compilation of current practices in Flood Risk Management (FRM) in the European Union (EU). It is not intended to be an exhaustive overview of current practice of FRM in the EU. Rather, it focuses on particular aspects identified by Member States (MS) as being challenging to tackle, and the report is based on cases that have been made available by MS. The objective is to strengthen FRM in the EU via the compilation and dissemination of approaches that could potentially be adapted and replicated across MS, regions or localities.

The short-list of aspects prioritised by MS covers the whole cycle of FRM, i.e. from identifying, assessing, mapping and communication of present and future flood risk, through to the planning, implementation, monitoring and evaluation of flood risk reduction and associated management measures. The information is based on the review of 34 cases through meetings with practitioners from 15 MS.

In terms of success stories a number of cases were identified and presented, including nature-based solutions. The latter include cases reconnecting rivers with their floodplain in Spain and the UK[1], river restoration projects in Hungary and planting native species to slow the flow and stabilise river banks in Portugal.

The EU Strategy on Adaptation to Climate Change, adopted by the European Commission in February 2021, highlights a number of actions in relation to flood risk management. While most MS have ongoing climate studies, the Strategy provides another opportunity to implement measures for reducing flood risk. In this report examples relevant to climate change have been shown on scenario modelling (Republic of Ireland) which includes projections for the potential impacts on flood risk and hazard, hydrological methods (flash floods in Italy) where a flash flooding mapping service allows prioritising areas or catchments prone to flash floods and "Epoch" modelling (Spain's climate change study).

Investments in flood risk management can be costly but the benefits often outweigh the costs. A cost benefit analysis is generally needed to identify this. One example shown is the Multi-Criteria Analysis (MCA) to assess Flood Risk Management measures across a range of objectives from Republic of Ireland. Generally, in relation to CBAs for flood related measures, the World Bank has recently produced a report with case study

[1] At the time of launching the study the UK was an EU MS.

examples and confirmed that flood related measures are sound investments[2].

Report Findings

The findings are summarised in the table below within a broad group of the aspects shortlisted.

Broad aspects	Findings
Assessing, mapping and communicating flood risk	Understanding and mapping of historic flooding and present flood hazard and risk is mature across MS. Many are at strategic/river basin scales. Mapping of sources of flooding such as groundwater and flash floods were limited, and where they exist are often high level. In some practice cases, present (and in some cases future) flood risks were accessible in portals and national databases, accessible by web mapping interfaces.
Climate change	While most MS contributing had completed or have ongoing climate impact studies, there were often no clear policies, methods or guidance on how to apply them in practice. Variabilities and uncertainties due to different emission scenarios and climate models are inter alia leading to challenges in communicating climate change impacts. Some cases are presented which aim to present simple communication of the impacts.
Land use planning	MS are using historical flooding or probabilistic flood risk information to varying extents to ensure new development is only permitted in areas of low flood risk. Where development is required in higher flood risk areas, cases were identified where various processes and approaches were used to permit new developments (often with further mitigation or resilience measures) based on the mapped or assessed flood hazard. The level to which climate change is incorporated in land-use planning varies across MS.
Linking objectives to measures and monitoring progress	The understanding of the baseline hazard and risk, development of objectives and identification of measures to deliver these is general practice across MS. The extent to which the objectives are tracked through the process to ensure they are driving the measures and associated indicators identified and monitored to ensure delivery and learning, is however limited. In some

[2] wb_ec_2021_disaster_economics_investments_background_c1.pdf (europa.eu)

Broad aspects	Findings
	cases, methods and tools have been developed to systematically link and monitor the link between objectives, measures and outcomes. Opportunity exist for these to be taken further to become whole life performance management tracking tools.
Implementation of measures	MS are developing, appraising and delivering measures to reduce their flood risk. Some examples of systematic approaches for option development and cost-benefit analyses were identified. To deliver the broader requirements of the Floods and other Water Directives, objectives are becoming wider to include environmental, sustainability and local outcomes. This requires accounting for intangible benefits and engagement of wider groups of institutions, stakeholders and the public in the development of measures and associated decision making and delivery processes. Cases were identified which use multi-criteria analyses, methods and tools that enable systematic appraisal process, funding and stakeholder engagement.
Working in partnership	Delivery of flood risk management measures requires partnership working across countries which share river basins, tiers of government, other managers and users of water and land, and relevant stakeholders. Many cases were presented showing methods and processes, a lot of which are supported by mapping and communication tools. These include partnership working across arms of government, public and private organisations and multiple stakeholders, developed to suit the circumstances. The cases across multiple countries cover approaches such as river contracts and large complex projects.
Working with the public	As flood risk measures often interact with communities and associated way of life, effective engagement with the public is important. This enables understanding and incorporation of local issues, constraints and opportunities to achieve local acceptance and local participation especially where public action is required such as response to flood warnings or development of community or property level flood plans. In some cases, engagement has enabled co-funding. Public engagement has proved more challenging compared to that with professional partners. Some cases were presented showing approaches and tools for public engagement, however, this remains an area of challenge and significant potential for improvement.

Broad aspects	Findings
Nature-based solutions	Nature-based solutions offer opportunities to work with natural processes to deliver wider benefits for flood alleviation as well as ecology, habitat diversity, water resource and quality and enhance circular water management. Several cases were presented by MS on nature-based solutions for inland and coastal contexts at strategic and local scales. Many included a combination of measures to store, delay, reconnect or optimise flood plain use and allow natural processes to create sustainable flood alleviation. While they all provide multiple benefits, some had flood alleviation as their primary objective, while others did not. The multi-objective measures enabled funding from multiple sources. The multi-functional nature often required wider engagement, but this was judged worthwhile for these cases.
Urban flood risk management	Flood risk management in urban areas is typically complex because any measure will affect many functions. Extensive engagement at all levels and the integration of multiple objectives into multi-functional outcomes is even more pertinent for urban areas. Cases of urban flood risk management are presented, showing different structural plans systems and approaches allowing urban/city scale management to occur within the context of catchment understanding.

Recommendations

Since the introduction of the Floods directive in 2007 a lot of ground has been covered. This study has identified and presented many practice cases across aspects of FRM that could be shared and adopted more widely across MS. The report presents the practice cases and fact sheets for access to further information. It is recommended the report is disseminated widely among MS practitioners at all levels of governance. It is for the officials, practitioners and experts at the national, regional and local scales to appreciate which approaches might work for the particular flood related challenges they face and what adaptations to these approaches are necessary in the national, regional or local context.

The report presents a snapshot in time of the current approaches for delivering FRM within the EU. While some issues are quite mature in practice, others are at various stages of evolution. Aspects which are not yet well developed or embedded in practice and require continued focus include:

- Taking better account of climate change through improved communication of its impacts and guidance on application for future FRM and land use management planning and delivery. The application of nature based solutions (and their funding) has room for improvement.
- Improved use of anticipatory FRM through adaptive approaches and pathways, in light of uncertainties in future flood risk due to changes in socio-economic development as well as the climate. Socio-economic developments will need to be monitored, captured, shared and embedded into practice. They are also relevant to urban flooding of pluvial nature.
- Development, sharing and embedding of more appropriate processes, methods and tools for engaging and communicating with the general public and public groups about flood hazard and risk and improving their inclusion in the development and delivery of FRM measures.

LIST OF ABBREVIATIONS

Abbreviation	Description
AFA	Ireland's Areas of Further Assessment
APSFR	Areas of Potential Significant Flood Risk
BJC	Business Justification Case
BMLR	Austrian Federal Ministry of Agriculture, Regions and Tourism
CaRR	Welsh Communities at Risk Register
CBA	Cost Benefit Analysis
CCG	Civils Contingencies Group
CFRAM	Catchment-based Flood Risk Assessment and Management framework
CPC	Jelgava's Civil Protection Committee
CRC	Climate Ready Clyde
DEFRA	UK Department for Environment, Food and Rural Affairs
DTM	Digitial Terrain Model
EC	European Commission
ECA	European Court of Auditors
ELY	Finnish Economic development, Transport and Environment
EU	European Union
FBC	Full Business Case
FCERM	UK's Flood and Coastal Erosion Risk Management
FD	Floods Directive 2007/60/EC1
FDM	Flood Danger Map
FHRM	Flood Hazard and Risk Maps
FHZP	Austrian Flood Hazard Zone Plan
FMG	Flood Management Group

Abbreviation	Description
FRAW	Flood Risk Assessment Wales
FRM	Flood Risk Management
FRMP	Flood Risk Management Plan
GE-RM	Austrian River Development and Risk Management concept
GEV	General Extreme Value frequency law
HORA	The Austrian Platform for Natural Hazards
IAWG	Institute for Applied Water Resources Management and Geoinformatics
IPCC	Intergovernmental Panel on Climate Change
ISPRA	The Italian Institute for Environmental Protection and Research
LAWA	German Working Group on Water Issues of the Federal States and the Federal Government
LiDAR	Light Detection and Ranging
LIR	Local Individual Risk
LIWO	*Landelijk Informatiesysteem Water en Overstromingen* (Dutch National Information System Water and Floods)
MCA	Multi-Criteria Analysis
MCM	Multi-Coloured Manual
MGSDP	Metropolitan Glasgow Strategic Drainage Partnership
MITECO	Spanish Ministry for the Ecological Transition and the Demographic Challenge
MS	Member States
NBS	Nature-Based Solutions
NFM	Natural Flood Management
NGO	Non-Governmental Organisation

Abbreviation	Description
NIEPG	Northern Ireland Emergency Preparedness Group
NPV	Net Present Value
NRD	UK's National Receptor Database
NRW	Natural Resources Wales
OBC	Outline Business Case
OECD	Organisation for Economic Cooperation and Development
OPW	Irish Office for Public Works
PFRA	Preliminary Flood Risk Assessment
PHCs	Spanish Hydrological Plans
POIC	Jelgava's Operative Information Centre
PPP	Public Private Partnership
RBMP	River Basin Management Plan
RCRG	Regional Community Resilience Group
RP	Return Period
SA	Belgium's Signal Area
SCCAP	Ireland's Scheme Climate Change Adaptation Plan
SEPA	UK's Scottish Environment Protection Agency
SVP	Slovak Water Management Enterprise
SYKE	Finnish Environment Institute
UKCP18	UK Climate Projections 2018
VVO	Association of Austrian Insurance Companies
WA	Belgium's Water Assessment
WFD	Water Framework Directive
WGF	Working Group Floods
WMCN	*Watermanagementcentrum* (Dutch Water Management Centre)

Abbreviation	Description
WWNP	Working with Natural Processes

CONTENTS

1. INTRODUCTION

Background and aim

1.1. The European Commission (EC) supports the EU's Member States (MS) in reducing the adverse consequences of floods for human health, the environment, cultural heritage and economic activity. This is the purpose of the Floods Directive (FD) 2007/60/EC[3], through the framework it provides for the assessment, mapping and management of flood risks. The EC also facilitates a working group of MS representatives and stakeholders, with the aim of coordinating the implementation of the FD (including the Preliminary Flood Risk Assessments, Flood Risk and Hazard Maps and Flood Risk Management Plans).

The Working Group on Floods (WGF)[4] also shares broader knowledge and experience on Flood Risk Management (FRM) between the MS, and in that context it identified the need for this report: a compilation of current practice in FRM in the EU. The objective is to strengthen FRM in the EU via the identification, description and dissemination of approaches that could potentially be adapted and replicated in other MS, regions or localities.

1.2. This report is not intended to be an exhaustive overview of current practice of FRM in the EU. After all, it includes practice from 15[5] MS (practice from additional MS may be added in a future update). Rather, it is structured around those aspects that are experienced by the MS to be challenging to tackle. These challenges are addressed via a number of cases that have been made available by the MS themselves. The overview provided within this report is therefore limited by the amount and nature of cases provided by MS.

Approach for developing the report

The development of this report followed a three-step approach.

In the first step, the authors worked with the EC to develop a longlist of 27 aspects of FRM that had been identified as challenging in discussions and workshops from WGF meetings, the European Court of

[3] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007L0060&from=EN

[4] The Common Implementation Strategy's Working Group on Floods, https://ec.europa.eu/environment/water/water-framework/objectives/implementation_en.htm

[5] Austria, Belgium, Czechia, Finland, Germany, Hungary, Italy, Ireland, Latvia, the Netherlands, Portugal, Slovakia, Spain, Sweden and the United Kingdom (which at the time of launching the study was an EU MS).

Auditors' (ECA) audit and the EC review of the first cycle of Flood Risk Management Plans (FRMP)[6]. The MS enhanced and refined this longlist of aspects, which were subsequently prioritised by the MS into a shortlist of 17 aspects that were considered the most challenging.

WGF members were then invited to work with their colleagues in the MS to propose cases of example practices dealing with these prioritised aspects of FRM. The aim was to identify embedded practice: more focussed on established day-to-day approaches rather than one-off innovative projects.

The authors then collated information and held online interviews with the practitioners connected to the 34 most promising of the proposed cases. These interviews were designed not only to collect more detailed information on the cases, but predominantly to highlight the elements of the cases related to the shortlisted aspects of FRM, the embeddedness of the cases, and their transferability to other MS.

For the purpose of the report, the 17 aspects were grouped into nine clusters. Each of these clusters are supported by elements of several of the cases, which together illustrate the current practice on that topic in the European flood management community. The combination of these cases shows per aspect the differences in implementation of FRM in the different MS, but also the similarities between approaches, and the common lessons learnt.

1.3.

Usage and users

From the onset of the process of developing this document, the FRM practitioners who carry out the whole spectrum of FRM activities have been envisioned as the ultimate users. The document aims to inspire FRM practitioners by showing a range of possibilities to address aspects of FRM that might be considered as difficult, and for them to learn from these practices, potentially adapting and implementing them in their own MS, which will stimulate engagement between MS within the
1.4. European community. This is envisioned to strengthen FRM in Europe as a whole and help achieve the EC's and MS objective of reducing the adverse consequences of floods in the EU.

Document Structure

The document is structured around the nine clustered aspects (Chapters 4 to 12) listed below. Chapter 2 introduces the aspects and the cases. This is followed by a concise synthesis (Chapter 3), which provides a structured overview of the challenges, and the typical approaches used

[6] https://ec.europa.eu/environment/water/water-framework/impl_reports.htm

by MS to overcome these. The Sections per aspect are covered in the following chapters:

- Chapter 4: Assessing, Mapping and Communicating Flood Risk
- Chapter 5: Climate Change
- Chapter 6: Land Use Planning
- Chapter 7: Planning and implementation of measures
- Chapter 8: Working in Partnership
- Chapter 9: Working with the Public to Manage Flood Risk
- Chapter 10: Measuring Progress
- Chapter 11: Nature-Based Solutions
- Chapter 12: Urban Flood Risk Management

Each aspect section presents the context of the particular challenges associated with that aspect of FRM, the cases supporting that particular aspect and how the cases address the particular challenges, and a concluding summary drawing out common lessons and key findings.

For each case, an individual fact sheet is included at the end of this document, in Appendix A.

2. ASPECTS AND CASES

2.1. Aspects of Flood Risk Management

The assessment of current practice in FRM within this report is structured around nine clustered "Aspects of Flood Risk Management", formed by the clustering of the 17 aspects which were prioritised by the MS representatives of the WGF as being particularly challenging. The selected aspects span the full field of FRM in various different dimensions. **Error! Reference source not found.** presents the 17 a spects and their relative ranking by MS. Table 2-2 presents the amalgamation of the 17 aspects into the nine clustered aspects for analysis and reporting.

The clustered aspects include the stages of the FRM process in line with the FD deliverables (preliminary assessment – mapping – planning – implementation). Within these topics, all different sources of flooding have been covered. Floods affect a multitude of people, businesses and services, and the complexity of these interactions is treated in this report, and in particular working with stakeholders, partners and the public to effectively achieve the implementation of FRM measures. Climate change and adaptive measures (such as nature-based solutions) form a thread through all these topics, and it was clear from the MS responses that this is an area under development.

For some of the more technical topics, such as the determination of extreme events and the significance of floods, as well as 'traditional' flood risk measures, it became clear that most MS are already well equipped to deal with those topics, and there was no need to cover them in this report. One of the aims of this report is to enhance this cross-border interaction by inspiring practitioners to reach out to their counter parts to learn from each other's practices.

Table 2-1 Shortlist of original 17 FRM Aspects

Ranking	Longlist Nr	Aspect
1	3.1	Indicators for monitoring progress in flood risk reduction - linking objectives and measures
2	3.6	Nature-based solutions
3	7.1	Assessing the impact of climate change on probability, damage and risk
4	7.3	Anticipatory flood risk management: planning for future change and uncertainty (climate change socio-economic)
5	6.1	Urban Flood Risk
6	4.2	Land use planning provisions in relation to flood prone areas
6	1.4	Calculation of flood damages (to inform economic risk calculation methods and justification for investment)
6	2.1	Comprehensive but still user-friendly online Flood Hazard and Flood Risk Maps (FHRM); Communicating complex concepts (probability, risk, uncertainty)
9	3.4	Funding of the implementation of strategies and measures
9	5.1	Public participation (in assessment, mapping and planning stages)
11	1.5	Wider impacts of flooding (and how to measure risk, and the associated benefits of measures): environmental, geomorphological, health, social, cultural heritage, critical infrastructure, cascade impacts
11	5.2	Engagement with public and stakeholders
11	6.2	Flash floods and debris floods
14	5.4	Engagement of the civil protection sector in FRM
14	7.2	Mapping and communicating climate change
14	4.3	Definition of prevention versus protection measures; balancing a full portfolio of measures
17	3.2	Prioritisation of measures

Table 2-2 Amalgamation of original 17 aspects into the clustered aspects and their report chapter

Clustered aspects (Chapter)	Original aspects
Assessing, mapping and communicating flood risk (4)	2.1 Flood Hazard and Risk (FHR) Maps; Communicating complex concepts
Climate change (5)	7.1 Assessing the impact of CC on probability, damage and risk 7.2 Mapping and communicating climate change 7.3 Anticipatory flood risk management: planning for future change and uncertainty (CC, socio-economic)
Land use planning (6)	4.2 Land use planning for flood prone areas
Planning and implementation of measures (7)	1.4 Calculation of flood damages 1.5 Wider impacts of flooding – risks and benefits 3.2 Prioritisation of measures 3.4 Funding of implementation 4.3 prevention versus protection
Working in partnership (8)	5.2 Engagement with public and stakeholders 5.4 Engagement of the civil protection sector
Working with the public to manage flood risk (9)	5.1 Public participation
Measuring progress (10)	3.1 Indicators for monitoring progress
Nature-based solutions (11)	3.6 Nature-based solutions
Urban flood risk management (12)	6.1 Urban Flood Risk

Current Practice Cases

The current practice cases in this report were brought forward by the MS themselves, in response to the prioritised aspects of FRM. Figure 2-1 provides a full list of the cases, showing how they link to the cluster of aspects and the country from which they were sourced. Fact sheets for each of the cases, including links to more information, can be found in Appendix A.

2.2.

Each case supports one or more of the aspects of FRM; the particular parts of the case that are associated with a particular aspect, have been brought out in more detail in the relevant aspect's chapter, including how this practice is applicable to other MS. This shows that certain topics are more overarching and are covered in some shape or form in many cases; climate change and working in partnership are good examples of this. It also shows the importance of these topics for FRM practice as a whole.

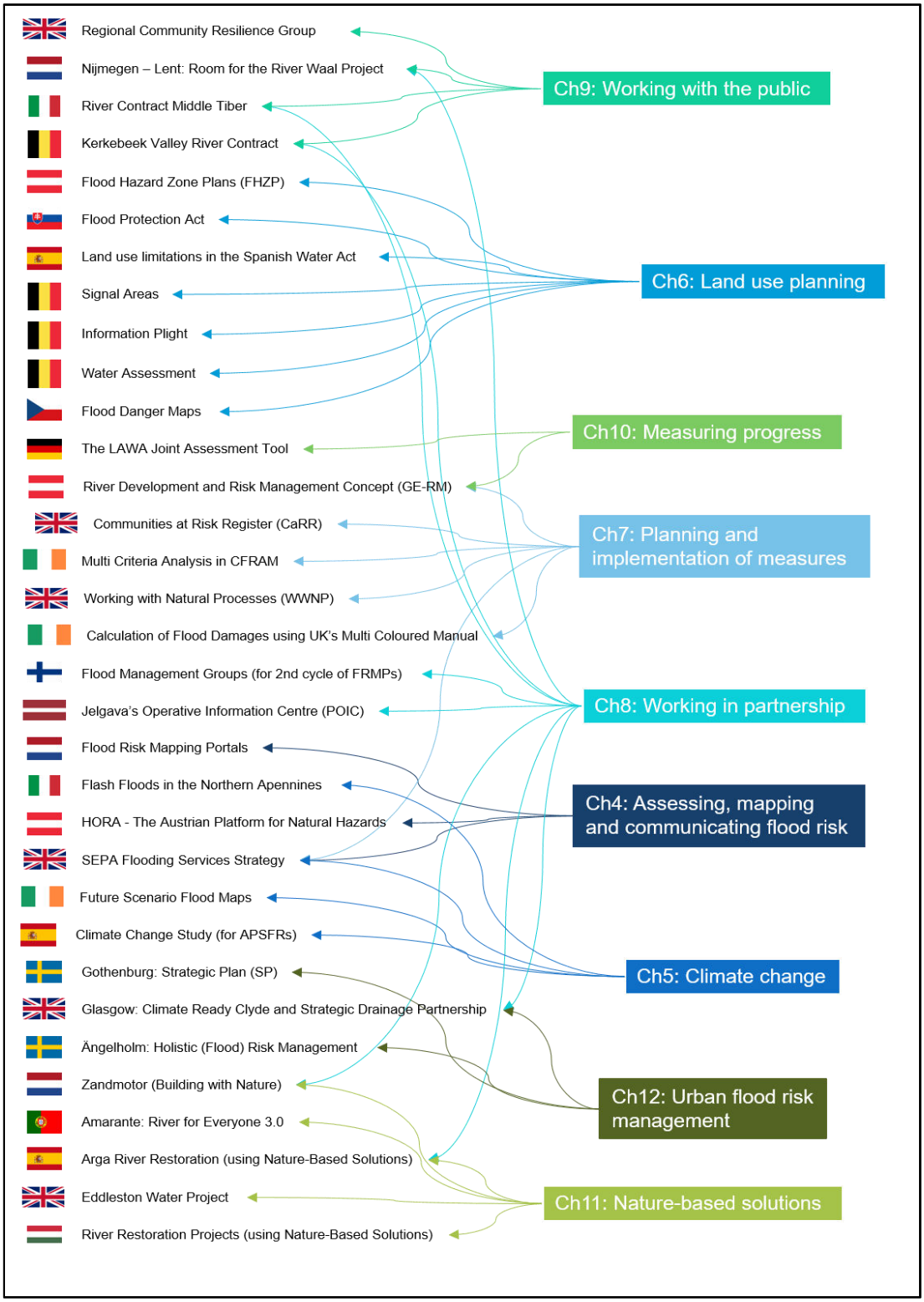

Figure 2-1 Overview of links between Aspects of FRM and current practice cases

3. OVERVIEW OF CURRENT PRACTICE

This section aims to provide a synthesis of the findings of this Current Practice Report. Chapters 4 to 12 provide a short summary of the findings per aspect. Drawing these together does not necessarily give a complete overview of the state of FRM practice in the EU, because of how the aspects were prioritised (those that MS currently are finding challenging to deal with) and how the cases were collected (those that MS themselves see as good practice). Still, it is possible to draw some broad conclusions.

The cases suggest that:

- Mapping and land use planning based on present-day flood risk information are relatively mature. The extent to which future flood risk information is used in mapping or land use planning is variable. It often depends on the extent to which climate change assessments have been carried out, the confidence in the outputs and the level of buy-in envisaged for its application. The cases show a wide range of approaches for communicating flood risk and managing land use in flood risk areas. Embedded approaches for communicating flood risk are typically geared towards professionals. Some good examples are emerging of clearer and more innovative ways of communicating flood risk to the wider public and stakeholders, with more in development, as understanding of what the public needs gets better and technology improves.

- Addressing and communicating climate change is challenging. While some countries are developing good understanding of the possible range of impact of climate change on their future flood risk, the incorporation of study outputs into policies and flood management is rather limited. Some MS provide available climate change outputs and request that they be considered in management and risk reduction projects, however, application to land use planning occurs to a lesser extent. Many MS indicate that more elaborate accounting for climate change is an envisaged next step of development.

- The planning of measures is still often partly driven by historic flood events, but predicted and modelled risk is increasingly becoming embedded. While the concept of developing objectives and using these to drive the measures and monitor the outcomes are well understood, only a few MS appear to have systematic processes to ensure this occurs. The associated option development and appraisal processes are increasingly being used to support prioritisation and funding. Most of the funding comes from the various tiers of government, and/or from the EU. There is an increasing number of examples where collaboration to achieve other objectives, such as for the Habitats Directive, the Water Framework Directive for local

development, has provided external funding to co-deliver multi-objective programmes.

- Multi-sectoral approaches are adopted in many of the cases; the cases in this report are typically successful, and show the benefits of working in partnership, but they also demonstrate the challenges of higher complexity. The outcomes suggest that while forming and developing partnerships can be challenging, once set-up, these could bear fruit in terms of significant benefits such as achieving both local and strategic objectives.

- Engagement with the public takes more effort if there have not been recent floods, but the effort can be worthwhile, raising awareness and improving quality of and buy-in for measures. This is even more important with climate change impact leading to increased future risk and situations where flood risk reduction measures and planning restrictions are needed in places with no recent records of flooding. Improved engagement with the public is leading to better and clearer communication with them and as a result, better acceptance and co-ownership of local flood risk and its management.

Assessing, Mapping and Communicating Flood Risk

3.1. The approach taken depends on the nature of a project and the potential stage of understanding. Flood risk is investigated through a process of prioritisation; areas of greatest risk defined initially, leading to more detailed studies improving accuracy. In addition, the sources of flood risk influence the chosen methods, which are subsequently affected by the availability of input data, and the target end-users.

3.1.1. Mapping of Flood Risk

This follows a generally similar method of increased detail through prioritisation. Reviewed cases exemplify the different stages of understanding; from regional studies, through strategic level assessments, to detailed and comprehensive, local data.

3.1.2. Communicating Flood Risk

3.2. Communicating flood risk can present a challenge where multiple end-users, with varying degrees of understanding, need to interpret or apply the information. These, often conflicting, applications of the information, lead to varying communication styles between MS.

Climate change

Various climatic scenarios predict changes to precipitation. There is, however, uncertainty in how these changes, in the form of extreme precipitation events, will manifest across regions and nations. The

inclusion of climate change projections in the management of future flood risk should therefore consider the inherent uncertainties in the projections of the impacts of climate change on river catchments and sea levels. This is currently not standard practice, and MS are using a wide range of methodologies to predict future floods.

Communicating uncertainty in climate change predictions requires careful consideration to ensure that information is interpreted correctly, especially by non-practitioners. While many scenarios are sometimes run to understand the wide range of potential climate change impacts, the communication of the outcomes are usually kept simple to enable take-up by practitioners and understanding by a wider range of stakeholders and the public.

The EU Strategy on Adaptation to Climate Change, adopted by the European Commission on 24 February 2021, highlights a number of actions in relation to flood risk management, with a particular focus on closing knowledge gaps on climate impacts and resilience, ecosystem restoration and management, as well as on nature-based solutions as tools to reduce risk of flooding.

Decision-making and acting in the face of climate uncertainty can be facilitated by anchoring decisions in the latest science. We already have a robust knowledge base for action, however, further work is needed, for example on modelling to more accurately estimate future damage and customise adaptation measures, on understanding the cascading effects from simultaneous or sequential climate impacts, or tipping points in Earth systems. The strategy aims to enlarge and make more accessible a toolbox that adaptation actors can use in their work and adapt to their individual needs. To help informed decisions, the strategy promotes knowledge sharing and data availability.

3.3.

Land use planning

In general, the transformation of flood risk into planning policy can be broken down into four distinct methods, increasing in comprehension and complexity:

- Awareness of flood risk is raised in a broad sense, often at the stage of purchasing a property;
- Flood Risk is translated into a ‘flood zone’ defining an area where development activities are not permitted;
- Flood Risk is translated into ‘flood zones’ with differing likelihoods and impacts with regional defined land-use limits; and

- Flood Risk is translated into 'flood zones' with differing likelihoods and impacts with nationally defined vulnerability classes and regulated limitations on land-uses.

A secondary consideration is the method used to interpret flood risk data. Two methods have been identified in the analysed cases:

- Using the flood extent(s) of a particular likelihood event(s); or
- Using the calculated flood hazard as a combination of flood depth and velocity.
- There is a general acceptance that flood risk information used for land use planning purposes should be kept simple to enable uptake. This has led primarily to the use of simple methods and maps. There are current examples and future plans to include more climate change data and improve the content of the maps and methods, while still keeping the messages simple.

Planning and implementation of measures

3.4. In planning FRM measures, the approaches taken by MS are becoming more risk and evidence-based, rather than reacting to historic floods. Actual risk to communities plays a much larger role in the decision of where and when to intervene.

At a local scale, it is increasingly important to define a package of measures that meets a broad range of objectives and requirements, which are not solely confined to FRM. This requires consideration of wider benefits, rather than just flood risk reduction, to a larger group of recipients. The consideration of these wider benefits and impacts is therefore also becoming increasingly important for the actual selection of measures at a project or scheme level. Straightforward Cost-benefit Analysis (CBA) is not well equipped to deal with this, and different methods are currently being developed to better appreciate (non-monetarised) those additional benefits. Prioritisation of schemes by governmental agencies increasingly includes the consideration of additional benefits as well, but methods vary significantly. Some MS are using the stick approach whereby national funding is only available when some methods are followed, including the delivery of wider benefits such as for ecology, spatial quality and habitat diversity. Generally however, for flood related measures, the World Bank has

recently produced a report with case study examples and confirmed that flood related measures are sound investments[7].

It is especially difficult for projects that include Nature-Based Solutions (NBS) to define the additional wider benefits that those NBS bring. Binding legislative frameworks to take these benefits into account (for example when applying for funding) are seldom in place either.

The adaptability of communities is developing into an important element of national strategies; there is a trend towards empowering communities to take charge of FRM of their own region; especially in cases where government funding schemes based on risk lead to centre-bias of the funding allocation.

Working in partnership

3.5. Collaboration with partners *from the start of a project* is key for successful implementation. Allowing all stakeholders and affected parties to be involved in communications and decision-making *throughout the project* reduces chances of opposition, which can otherwise slow down progress. Resistance from partners has occurred on some projects, but due to collaborative approaches taken in those projects, issues and concerns were listened to, respected and often resolved.

Governments are beginning to invest more money into FRM due to the increase in coastal water levels and the more regular occurrence of flooding and erosion. On the other hand, increased partnership can lead to additional funding from different sources that enables the inclusion of wider benefits.

3.6. In many of the cases, the successful implementation of projects has led to further initiatives within the respective countries. This highlights the potential for these cases to be implemented in other MS as well, in which case they could benefit many communities across Europe.

Working with the public

Public engagement can lead to improvement of design of flood risk reduction measures and help deliver additional benefits, such as improvement of the cityscape.

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7 https://ec.europa.eu/echo/sites/default/files/wb_ec_2021_disaster_economics_investments_background_c1.pdf

In a similar manner as when working with partners, engagement of public should start as early as possible; this can lead to better quality engagement and more meaningful input.

It has proven difficult to engage with communities in areas where there has not been any flooding recently (even if they are known to be at high risk), and with younger people who may not have any memory of significant flood events.

Measuring progress

Measurement of progress has been shown to be executed at different scales of FRM, essentially fulfilling different purposes. The two example
3.7. cases showed:

- Measuring progress against national objectives to create a national overview inventory. This requires nationally defined objectives and indicators, and is supported by a national catalogue of measures.

- Measuring progress against an integrated set of catchment-wide objectives, defined by a wide stakeholder group and relying on an interpretation of different national legislations and framework. This method is also supported by a national catalogue of measures.

Underlying both methods is a clear definition of the objectives and indicators that progress needs to be measured against, and by linking these to a national catalogue in both cases, targets are clearly defined, allowing progress to be monitored effectively.
3.8.

Nature-based solutions

Nature Based Solutions might not only reduce flood risk, but can also provide a large range of wider benefits, such as improving the landscape, increasing habitat diversity, sequestering carbon and increasing tourism. However, the multisectoral nature of these solutions can sometimes act as a barrier to financing projects and funding is often only provided for specific outcomes, such as a reduction in flood risk. The secondary benefits are not always taken into account in cost-benefit analyses.

Implementing NBS is especially difficult in areas that have been affected by significant flood events in the recent past and therefore communities are keen for maximum and robust protection, and do not often see NBS as providing this.

Most of the cases reviewed as part of this study had the delivery of multiple objectives at their core. While they all delivered flood risk benefits, this was not always the driver. This demonstrated a significant potential for delivering more nature-based solutions through developing

more multi-objective and multi-functional schemes, of which flood risk reduction is one of the principal outcomes.

Urban flood risk management

Although urban flooding is generally thought to be dominated by pluvial flooding, cases show that a holistic consideration of all sources and their combined risk is important to drive FRM planning.

3.9. Working in partnership is important to develop a diverse portfolio of measures, which in turn leads to additional wider benefits. Partnership should be considered between city districts and between different departments within the participating municipalities. Looking over the borders of the city region is logical next step: catchment-wide approaches are preferable, even for solving problems within city boundaries. However, this will add another level of complexity to urban FRM.

Dependency on politics and public funding from several different sources limit climate adaptation with a horizon sufficiently far in the future. Strong city leadership, or at least strong steering of a partnered group, is needed to achieve results and have all parties commit to a common goal. An overarching vision of an adaptable city in a changed future can provide a strong incentive as well as a handle for other organisations to look beyond their normal remit and to suit their action plans to realise this vision over time.

4. ASSESSING, MAPPING AND COMMUNICATING FLOOD RISK

Definition and Context

4.1. Mapping of flood risk is important because it visualises the spatial nature and helps communities and other stakeholders understand the nature of the risk to them and their properties. This aspect covers the whole spectrum of flood mapping that is prepared and published to communicate flood risk to communities and stakeholders: flood extent, flood hazard and flood risk, from all sources and for any receptors, with or without consideration of flood defences, and for any purpose. Flood maps can have various purposes, in particular raising public awareness (to enhance the public's ability to manage their own risk), supporting land use planning (to limit development in areas at risk) and informing the insurance industry.

Three cases have been reviewed to highlight the ways in which flood risk is assessed, mapped and communicated across the MS. The three cases cover regions with differing flood risk and approaches to communications.

Cases

4.2.

4.2.1. Overview

This chapter presents three cases which combine assessing, mapping and communicating of flood risk, as follows:

- Austria – HORA: The Austrian Platform for Natural Hazards (Section 4.2.2)
- Netherlands – Flood Risk Mapping Portals (Section 4.2.3)
- United Kingdom – SEPA Flooding Services Strategy (Section 4.2.4)

The SEPA Flooding Services Strategy is also described in Chapter 5 Definition and ContextClimate Change and Chapter 7 Planning and implementation of measures Three further cases are relevant for assessment, mapping and communicating of flood risk, but are discussed in different Chapters, with a focus on the aspects of FRM that inform the mapping and communication. This concerns: Future Flood Scenarios Mapping (Ireland) in Chapter 5 Climate Change, and Flood Zone Hazard Plans (Austria) and Flood Danger Maps (Czech Republic) in Chapter 6 Land Use Planning.

4.2.2. Austria – HORA: The Austrian Platform for Natural Hazards

Context

In Austria, the economic cost of flooding from direct damages, insurance claims and loss of economic output has been estimated to exceed 500 million euros nationally in a typical year. Planning for flooding and ensuring the provision of appropriate insurance instruments requires a common framework of understanding across various sectors and stakeholders.

Challenge

Communicating the likelihood and risk of flooding for different users can be challenging on a national scale. The challenge was to develop a nationwide zoning system for natural disasters with a special focus on the potential likelihood of flooding, which will improve awareness of pertinent risks among the people. It would also help curtail potential losses in the future and inform insurance provision in the light of devastating events; enabling the private insurance providers, policyholders and the state to share the burden.

What is it?

The Austrian Platform for Natural Hazards (HORA) is an interactive web-mapping service that communicates environmental hazards, including flooding from various sources, across Austria.

Approach

A Public-Private Partnership (PPP) between The Federal Ministry of Agriculture, Regions and Tourism (BMLRT) and the Association of Austrian Insurance Companies (VVO) was initiated to fund and develop a system for mapping and communicating flood risk across Austria.

HORA's web-mapping service presents the outcomes of this partnership, allowing the user to view a nation-wide zoning system of hazards, including flood risk.

Figure 4-1Figure 4-1 shows the interface of the HORA service with icons showing the types of hazards from which to choose.

HORA presents flood mapping on a national scale for different likelihood events for fluvial and surface water flooding. Three undefended fluvial risk zones (*Hochwasserrisikozonierung*, 1 in 30, 100 and 200-year return period events), as well as the Flood Hazard and Risk Maps (FHRM) according to the EU FD are on display.

To create the flood zones, regional and national scale hydrological and hydraulic models were developed. Several institutions were brought together to research, develop and deliver the flood risk maps.

The map user is able to interactively navigate around the map, viewing and inspecting flood risk at specific locations (Figure 4-3).

Figure 4-1 HORA user interface

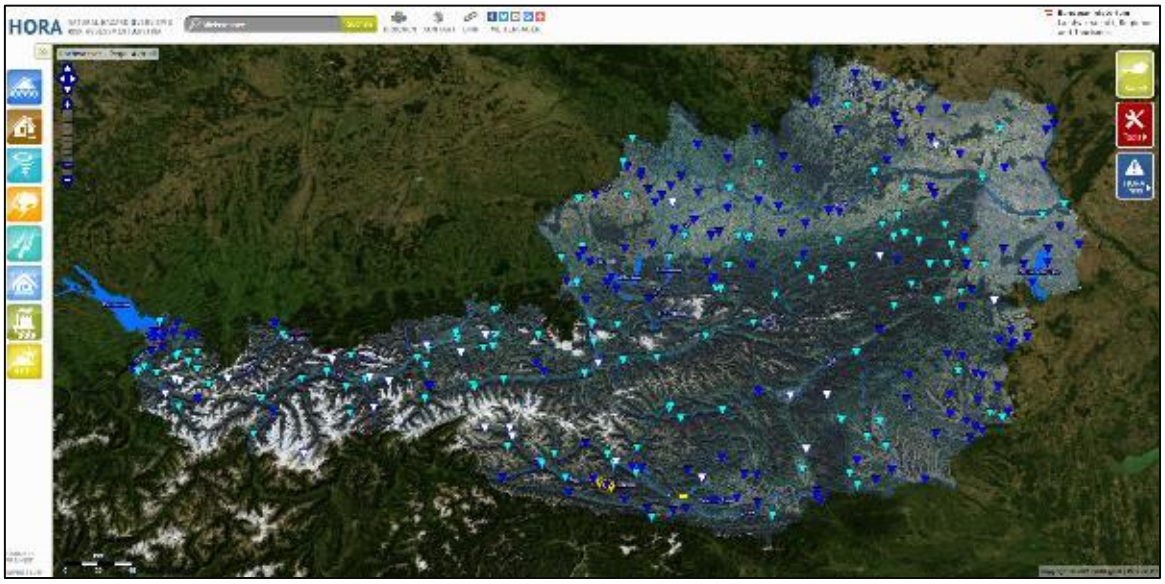

Figure 4-2 Network of river gauging stations in Austria via HORA

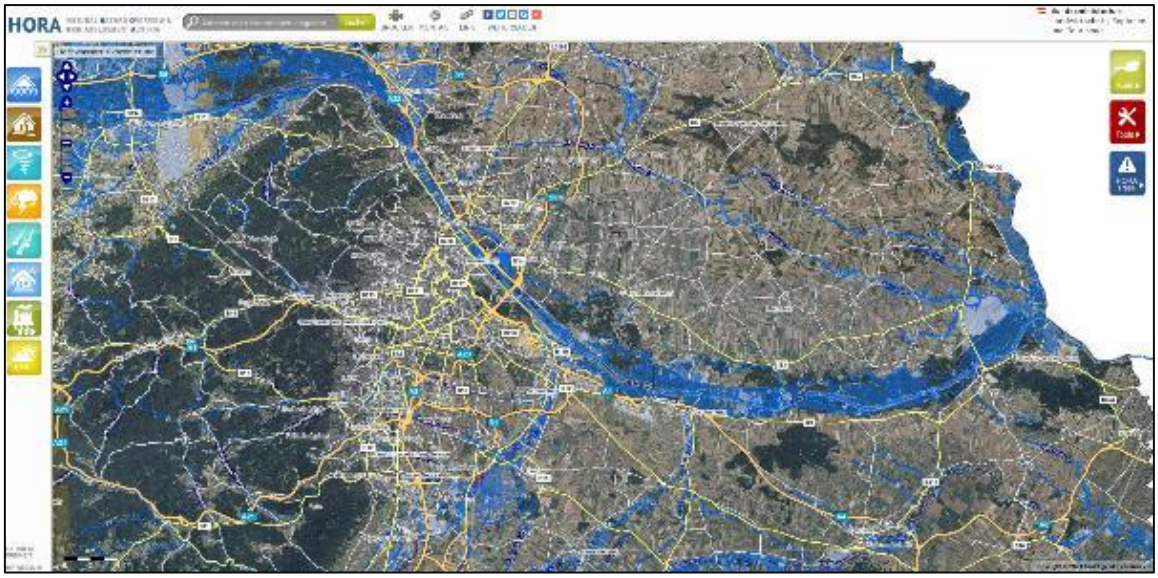

Figure 4-3 Flood Zones in an urban area using HORA

A screening tools is available to inspect specific locations, with the option of buffering to a user-defined distance. This screening tool outputs a Summary Report of the various environmental hazards and likely risk categories for the inspected location.

Applicability of Approach

The approach is applicable to regions where existing mapping of flood risk is poorly defined. The national and regional approach is an appropriate first step to defining flood zones in areas where there is a strong understanding of hydrological processes and a network of catchment data. The PPP approach is applicable for regions where funding opportunities are not readily available.

Benefits of Approach

The PPP approach provides necessary investment, potentially delivering information more quickly than traditional government funding routes. It also ensures that the end use is considered throughout the development to create a tool that can be used by a range of practitioners.

The high-level, regional and national modelling approach provides a suitable and rapid means for performing strategic flood risk mapping.

Limitations of Approach

The partnership with exclusively the insurance industry may omit other considerations or points of view that need to be considered when developing tools for various end users, e.g. emergency services or land-use planners.

The regional and national hydraulic models are potentially too coarse in resolution for local detail and decision making.

Unlike the Dutch case (Section 4.2.3), the HORA maps focus on high-level assessments and don't assist in emergency planning, lacking the more nuanced information, like arrival times and damages, that detailed local models provide.

Climate change is not considered in the current version of HORA.

4.2.3. Netherlands – Flood Risk Mapping Portals

Context

Flood Risk mapping in the Netherlands is conducted by regional and national authorities requiring a common data environment to improve communication.

The majority of areas at risk of flooding in the Netherlands are robustly protected against extreme events from the rivers and coast. As a result, the chance of flooding from those sources is very low, but the consequences would be very high in the event of defence breaches.

Challenge

Mapping and communicating flood risk from various sources for different scenarios and risk profiles can be a challenging undertaking. It is difficult for people to appreciate flood risk if the chance is very low despite the consequences being very high. In the Dutch context, people are aware that they live behind flood defences, but they expect and trust the defences to perform, and it is difficult to appreciate that there is still a risk.

Emergency planners and land-use planners should be making assessments using the same information and have access to all the necessary data needed to complete their jobs.

Understanding the risk and developing the appropriate responses to flood risk and flood events is particularly complex when there are various different sources of flood risk, with different combinations of likelihood and consequence.

The nature of flood risk from other sources such as local rainfall is very different: higher probability but lower consequences.

What is it?

LIWO- *Landelijk Informatiesysteem Water en Overstromingen* (National Information System Water and Floods) is an interactive Web-mapping service that provides flooding, flood risk, and flood consequence

information for the whole of the Netherlands, for use by professionals involved in planning for and response to flooding.

LIWO uses the same data as provided at the national public risk website (risicokaart.nl), which is the official national website for flood risk information, following the EU FD guidelines. LIWO combines this data with other natural risk information and is developed for use by the general public and professionals. The LIWO website provides in addition, more granular flood hazard and risk data and tools, to be used for more detailed assessments by professionals.

Approach

The LIWO web-mapping service brings together flood risk mapping from thousands of scenarios, risk profiles and sources of flooding into one platform. The data is compiled by the *Watermanagementcentrum* (Water Management Centre) Netherlands (WMCN) and combined by *Rijkswaterstaat* (Nation Water Management Authority) to allow the user to view information about flooding across the entire country. The service presents data generated by various authorities, combining information created on local and national levels, and hosting it in a common environment using consistent terminology.

The mapping includes most of the necessary information with which to conduct flood risk assessments, response and emergency planning, including water extents and depths, inundation and arrival times, evacuation warnings, available refuge sites, and affected infrastructure.

The data focuses on composite flood risk, considering the combined flood risk from multiple sources for both defended and undefended scenarios. There is a comprehensive dataset for modelled defence breaches and their consequences, both of primary defences and regional defences (reflecting the specific context of the Netherlands, with its important role for flood defences, and associated strong focus on data and technical assessment).

A range of probability events are presented; from the more likely 1 in 10 per year event to extremes, such as the 1 in 100,000 per year tidal surge. Information is also provided within the service explaining the meaning of each dataset.

Figure 4-4 shows an example of the LIWO interface. The service provides numerous map options (*Kaarten*) that tailor to specific scenarios and types of flooding (the highlighted ones are illustrated in the figures below).

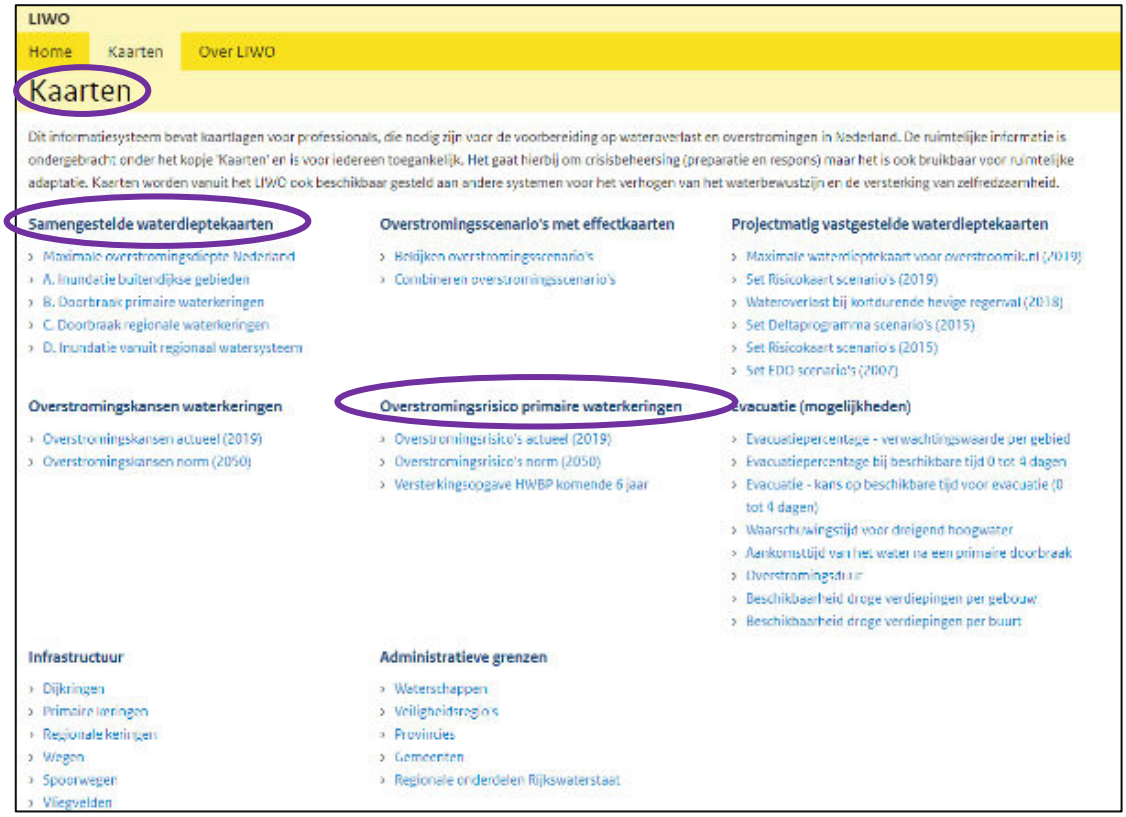

Figure 4-4 LIWO mapping contents page

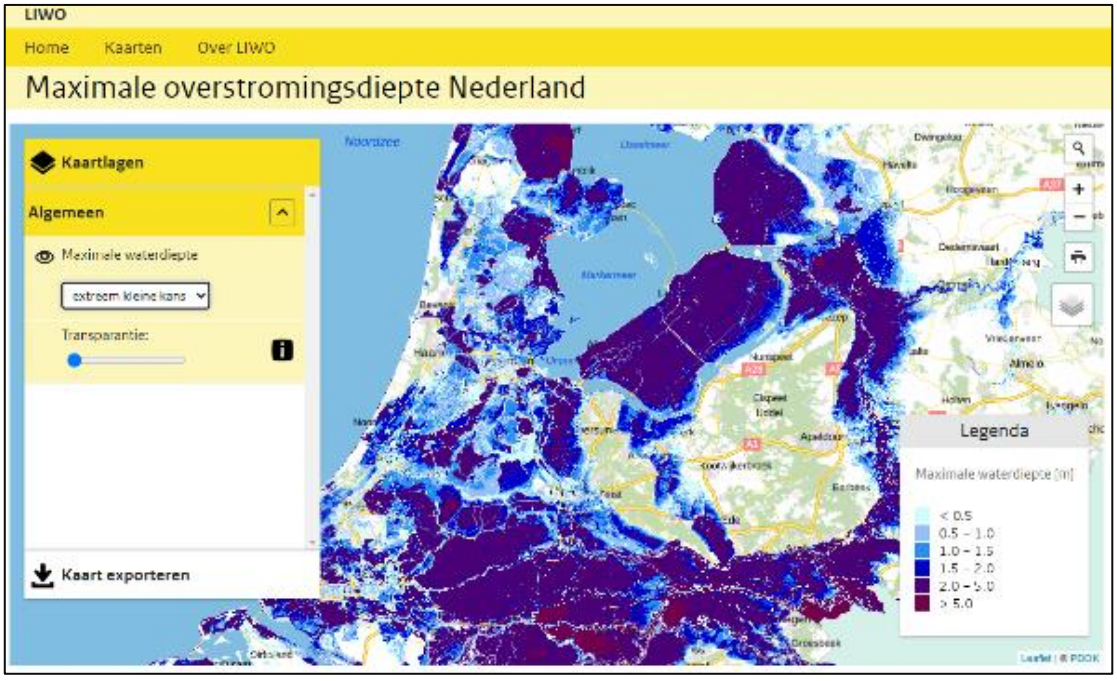

Figure 4-5 Example of LIWO mapping of amalgamated extreme flood depth

The *Samengestelde waterdieptekaarten* map aggregates the flood scenarios for different types of floods (Figure 4-5).

The *Overstromingsrisico primaire waterkeringen* map provides an estimation of flood risk (damage and casualties) resulting from a breach of the primary flood defences. Figure 4-6 shows the Local Individual Risk (LIR): the likelihood of death of an individual in a particular location.

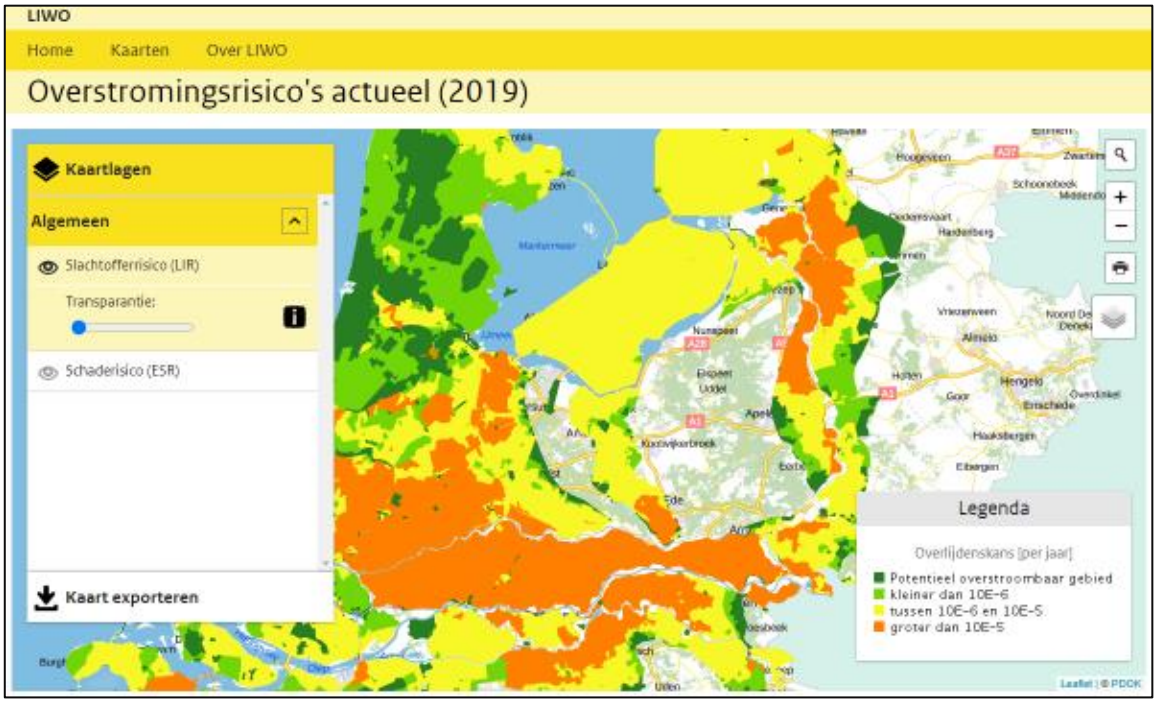

Figure 4-6: Example of LIWO mapping of the present day danger to life

The user is able to adjust the presentation of the information with full functionality to select and adjust multiple datasets to build a particular story. For example, the combined flood extent from various breach locations can be visualised simultaneously to understand flood risk and the potential impacts.

The user is also able to extract predicted depths at a chosen location for the various scenarios and events.

Applicability of Approach

The combination of datasets for numerous scenarios and flood events is suitable and worthwhile where a significant amount of detailed modelling is, or has already been, conducted.

The level of detail that LIWO provides, and the national coverage is applicable to regions where there is both a widespread risk of flooding and potentially high consequence of flooding.

The composition of numerous scenarios, for example defence breaches, is an appropriate way of communicating information when the residual risks (i.e. risk due to failure of flood defences) of flooding are significant.

Benefits of Approach

The dataset and results are very comprehensive and provide a large amount of the information required to conduct emergency and land-use planning.

The accessibility of the data and the combination of regional and national data creates a tool that can be used by a range of authorities and stakeholders. In addition, ensuring that various users are referencing the same information from the same source is likely to have overall efficiency benefits for national flood risk managers.

The archiving of the data in one location removes ambiguity over the provenance, validity and novelty of the information.

The interactive functionality of the mapping and customisable outputs is a powerful tool for engaging a range of end users.

Limitations of Approach

The maps are designed for competent users and those with an introductory understanding of flood risk, and risk mapping. While the maps are not designed for the general public, they could potentially misinterpret information in them without sufficient background understanding. LIWO is not intended for the general public, who are referred to a public-focused mapping platform.

The extensive and comprehensive datasets could become out of date without regular due care and oversight of the service.

4.2.4. United Kingdom – SEPA Flooding Services Strategy

Context

Like the rest of the world, Scotland is beginning to feel the effects of climate change. There is a high level of uncertainty regarding how climate change will impact flood risk in Scotland, and it is difficult to communicate this uncertainty to protect communities in an effective way.

Challenge

The Scottish Environment Protection Agency (SEPA) is in the process of drafting a Flooding Services Strategy with the aim of providing clearer guidance and direction for the management of flooding and adaptation to climate change across Scotland.

This strategy will include updated flood maps to make use of latest UK Climate Projections (UKCP18) for the impacts of climate change for both coastal and fluvial environments.

A review of the existing public communications strategy, with focus on the flood risk web-mapping service, was conducted with feedback from the public. The outcomes of this public consultations showed, in general, that the use of mapping tools is not an effective way of communicating risk to non-practitioners.

What is it?

The new Flood Services Strategy from SEPA has been developed as a catalyst to transform SEPA to be able to meet future challenges. Within the new strategy will be a principle of clearer communication of flood risk.

Approach

User friendly Flood Maps underpin the aims and goals in the Strategy. In the past, a 'one-size-fits-all' approach was applied to mapping; the same maps were produced for Scottish Government, Local Authorities, developers, flood risk professionals and the public. SEPA is stepping away from that now and creating separate maps for the public, using an iterative process in which the public is actively engaged. Important considerations are:

- how does the public interpret information that might be clear to flood risk professionals?
- how many clicks do you need to get through to the information you are looking for?
- how accessible are these maps to the elderly?
- how good does a user's broadband need to be?

An early outcome of this development is that the public generally does not like maps. The public much prefers a simple yes / no to the question they are asked. Maps are deemed useful but miss the wider perspective. In the new maps, the user is therefore first taken on a text-based journey, which accompanies the maps. Flooding comes with uncertainty, and it is a challenge to take the user along and not lose them along the way. These new public maps are based on the same data as the maps produced for the FD.

Insurers are part of the stakeholder group of these newly developed maps. In the past, information was not shared with this group due to concerns about house pricing and insurance premiums. SEPA is now

working to understand how they can share flooding information with insurers. Ideally this would be part of an exchange system, so that SEPA can validate their assumptions on risk and impacts of flooding. SEPA is furthermore working with insurers on how to implement requirements for resilient repairs of flooding damage.

Applicability of Approach

The applicability of the tool to better communicate flood risk and hazard to other users and MS will depend on the target groups as well as social and cultural characteristics.

Benefits of Approach

The benefit of the approach will be clearer communication of present and future flood risk and hazard information.

Limitations of Approach

Like all systems requiring user interface, its utility could be limited by internet capacity and capability of the users.

4.3. Issues / Key Findings

The approach taken to assess flood risk is dependent on several factors. Firstly, the detail to which risk is understood depends on the nature of the project and the potential stage of understanding. Generally, flood risk is investigated in a process of prioritisation, where areas at greatest risk are initially identified, leading to more detailed studies to improve accuracy in the priority areas. Secondly, the nature of the flood risk (i.e. sources of risk) affects the choice of assessment. The type of risk being assessed, in turn, influences the modelling approach or calculation methods. These methods are subsequently affected by the availability of input data, and the target end-users.

Mapping flood risk generally follows a similar method of increased detail through prioritisation. The cases reviewed above exemplify the different stages of understanding: from strategic level assessments in the case of HORA in Austria to detailed and comprehensive, local data in the case of LIWO in the Netherlands.

The methods of communicating flood risk can present a challenge where multiple end-users, with varying degrees of understanding, need to interpret or apply the information. These, often conflicting applications of the information, lead to varying communication styles between MS. In Austria, the strategic flood risk assessment data in HORA is presented in a format that could be used by practitioners or the public, with the added functionality of being able to inspect specific locations for further detail if required. Finally, the Netherlands presents a range of scenarios

and datasets in LIWO in a format that is more suited to practitioners and land-use planners.

5. CLIMATE CHANGE

Definition and Context

5.1. Climate change is expected to increase flood risk by speeding up sea level rise and causing more extreme rainfall. Flood risk management needs to recognise and address climate change at all levels: assessing how it may affect risk into the future; communicating this through maps and other means; and considering it when planning and implementing measures. This is complicated by the uncertainty about the precise rate at which the impacts of climate change will materialise. In line with the Intergovernmental Panel on Climate Change (IPCC), it is good practice to use scenarios for assessment, mapping and planning. When it comes to decision making and planning for the long term, climate change and its uncertainty can be addressed through a precautionary approach (assuming an extreme scenario) or through a managed-adaptive approach (keeping options open, combined with monitoring).

Cases

5.2. *5.2.1. Overview*

This chapter presents four cases which can be grouped into three FRM contexts in which MS address climate change, as follows:

- Scenario Modelling
  - Republic of Ireland – Future Scenarios Flood Maps (Section 5.2.2)
- Hydrological methods
  - Italy – Flash Floods in the Northern Apennines (Section 5.2.3)
- Epoch Modelling
  - Spain – Climate Change Study (for APSFR) (Section 5.2.4)
  - United Kingdom – SEPA Flood Service Strategy (Section 5.2.5)

The SEPA Flooding Services Strategy is also described in Chapter 4 Assessing, Mapping and Communicating Flood Risk and Chapter 7 Planning and implementation of measures Four further case studies also describe current practice for climate change, Flood Risk Mapping Portals in Chapter 4 Assessing, Mapping and Communicating Flood Risk, Jelgava's Operative Information Centre (POIC) in Chapter Working in Partnership, and Gothenburg Strategic Plan (SP) and Climate Ready Clyde (CRC) in Chapter 12 Urban Flood Risk Management, but with a

separate focus which incorporates and applies the understanding of climate change.

5.2.2. Republic of Ireland – Future Scenarios Flood Maps

Context

Article 14, Chapter VIII of the Floods Directive requires that "the likely impact of climate change on the occurrence of floods shall be taken into account in the reviews referred to in paragraphs 1 and 3".

Challenge

Communicating the impacts of climate change on flood risk and using this information to develop FRMPs and planning policy is challenging when there is uncertainty in climatic projections.

What is it?

The Future Scenarios Flood Maps are the result of projections for the potential impact on flood risk and hazard for two possible future climate scenarios.

Approach

Flood maps were generated based on extensive and detailed hydraulic models to understand present day and potential future flood risk across Ireland.

The Future Scenario Flood Maps were developed as part of the Catchment-based Flood Risk Assessment and Management (CFRAM) framework whose origins predated the Floods Directive and was meant as a comprehensive suite for Ireland as a whole. The CFRAM Programme includes communities that are home to about two thirds of the Irish Population and has identified measures to provide protection for approximately 80% of properties at risk nationally from rivers and the sea.

This modelling work encompasses all Areas of Further Assessment (AFAs) in Ireland. Detailed bathymetric and topographic datasets (DTM from LiDAR; surveyed channel cross-sections; in-bank / bank-side / coastal structures) were used to inform these hydraulic models). Hydrological models, as well as gauge data for river flow and tidal levels, were also used to inform the hydraulic modelling with design flood flows and coastal levels.

A present-day and two possible future scenarios were modelled and mapped. The future scenarios are not direct simulations of the IPCC's emission scenarios as this would have created a cascade of uncertainty

through the climate and hydrological modelling. Rather, a 'Mid-Range' and a 'High-End' scenario were defined that represent the mid-range and high-end outcomes of all IPCC's scenarios, respectively. These scenarios do not indicate when a certain climate state will be reached, they only specify the consequences of such a state (for example, the effect of 1.0m of sea level rise). The approach is to explore what could happen through scenarios (a mid-range and a more severe scenario) and not when.

The future climate scenarios are summarised as follows:

- High End Future Scenario – 30% increase in rainfall or peak flow, with a 1.00m rise in sea level
- Mid-Range Future Scenario – 20% increase in rainfall or peak flow, with a 0.50m rise in seal level

The Future Scenario Flood Maps are published online in an interactive web-mapping platform making the data widely accessible. Figure 5-1 shows an example of the Irish Flood Maps via the web-mapping platform.

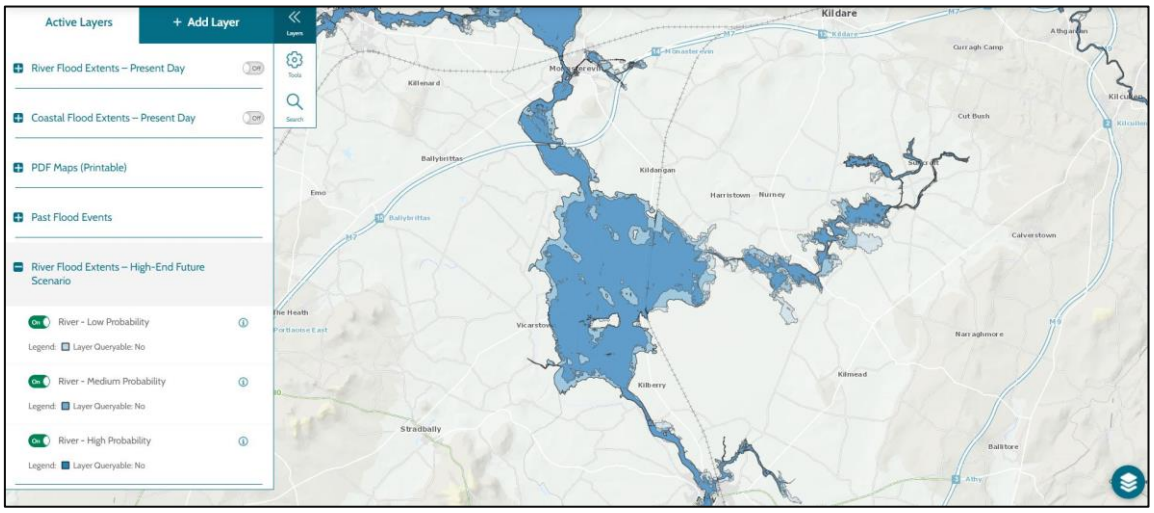

Figure 5-1 Flood Maps and Future Scenarios as published by the Irish Government at www.floodinfo.ie/about_floodmaps/

The current scenarios also inform Ireland's flood zones. Using these flood zones, local authorities stipulate which activities are permitted in certain areas, following governmental guidelines that are generally adhered to well. Although current scenarios are used to define flood zones, the governmental guidelines say that climate change does need to be considered in spatial planning. Although climate change future scenario maps are available online, there is currently only limited use by planners due to a lack of guidance on how to apply them

appropriately. The preparation of an appendix to the guidance, training and capacity building with planner is ongoing to address practical implementation for development planning. The purpose of the Future Scenario Flood Maps is also to inform the development of 'scheme climate change adaptation plan' (SCCAP), which now are to be created when a scheme is being developed. These SCCAPs indicate what the risks are in case of the Mid-Range and High-End scenarios and which measures can be taken to avert or mitigate those risks. This needs to be worked through at a scheme level, as local considerations are often of high priority and because the risks due to these scenarios can differ significantly between communities. For example, designers need to take into account the local context in terms of how the climate change can be best accommodated for, which is considered in the form of the 'Four As':

- Assumptive – Assume what might happen and build for this now
- Adaptive – provide, plan, monitor for future changes, for example making foundations for defence walls stronger
- Alternatives – prepare to do something different in the future
- Acceptance – accept that climate change will happen and deal with this via resilience measures

All 'Four As' are being developed within the context of adaptive pathways and are considered within the local context. SCCAPs have been piloted in Midleton, where the driver for change is dictated by what is acceptable to the community.

Applicability of Approach

The approach is suitable for MS who wish to gain an understanding of the impact of climate change on flood risk without conducting, potentially onerous, hydrological studies to assess climate change impacts for individual river basins or catchments.

Member States using the approach need to bear in mind that it is scenario-based rather than actual projections. It does not present what will happen and when, what it does is give an indication of potential

extents of climate impact, helping to explore appropriate adaptation approaches, but realising it could be more or less.

The approach also suits MS where there is little geographic variation in hydrogeology and thus a higher likelihood that the climatic projections will converge around similar results.

Benefits of Approach

Mapping and publishing projected flood risk have several benefits to reducing future flood risk. Firstly, the presentation of future flood maps raises awareness for both practitioners and the general public of the need to protect against the impacts of climate change. Secondly, the inclusion of the future alongside present-day flood maps has the potential to improve the planning processes.

In addition, the inclusion of two future scenarios, clearly defined by their impacts (e.g. increase in sea level) rather than their timeline occurrence, improves comprehension and limits the opportunity for contending projected risks. For example, if projections were defined by location and a future epoch, there would be greater opportunity for uncertainty to influence and dispute the results.

Finally, applying a national blanket approach to projections provides more readily available modelling and mapping results without the need to conduct detailed hydrological assessments of climate impacts within each river basin district or catchment, leading to a more efficient process of assessment.

Limitations of Approach

Depending on the way in which the future projections are applied, by land-use planners for example, the use of a uniform climate projection across catchments could result in over-zealous land-use limitations, particularly in the short-term. However, this is an outcome which the SCCAPs aim to avoid and the adaptive management approach in local communities will more likely result in 'no regrets' outcomes.

For other MS or industry practitioners who use definitive epochs or fixed allowances, this may not be a suitable approach.

5.2.3. Italy – Flash Floods in the Northern Apennines

Context

Due to steep catchments many areas in Italy are prone to flash flooding during intense precipitation. This phenomenon is becoming more frequent in the District due to the effects of climate change as also stated in the Italian National Climate Change Adaptation Strategy.

Challenge

Raising awareness of flood risk without over-complicating the content of communications can be challenging. The Northern Apennines River Basin Authority, using traditional methodologies to assess flood risk (such as classical numerical hydrological models), aims to incorporate awareness of the increasing occurrence of heavy and concentrated rainfalls and the consequent flash floods phenomena, which occur as a direct effect of climate change in very steep catchments, in the mapping and planning process. The challenge includes the desire to assess and identify sub-basins which are and will be more prone to flash floods in the future.

What is it?

A Flash Flood mapping service that categorises the risk of flash flooding on a sub-catchments scale.

Approach

The likelihood of flash flooding was mapped at a river basin scale across the Northern Apennines River Basin District to identify flash flood prone areas.

The risk of flash flooding is categorised for each sub-catchment into four qualitative classes: Low (Green), Medium (Yellow), High (Orange) and Very High (Red).

The approach to assessing risk of flash flooding combined hydrological and topographical methods without the need for hydraulic modelling.

Firstly, the sub-basins were divided into sub-catchments, identified using a GIS hydrological analysis function applied to Digital Terrain Model (DTM) data. Secondly, the lag-times for the sub-catchments were derived based on their hydrological parameters to determine the time delay between the storm event and peak river flow. Finally, the statistical likelihood for a range of precipitation events were calculated for the sub-catchments, combined with frequency distributions for intensity and duration, and amalgamated into a scoring matrix to yield a 'Flash Flood Index'.

The Flash Flood Index is categorised for each sub-catchment into one of the four Flash Flood vulnerability categories (Figure 5-2).

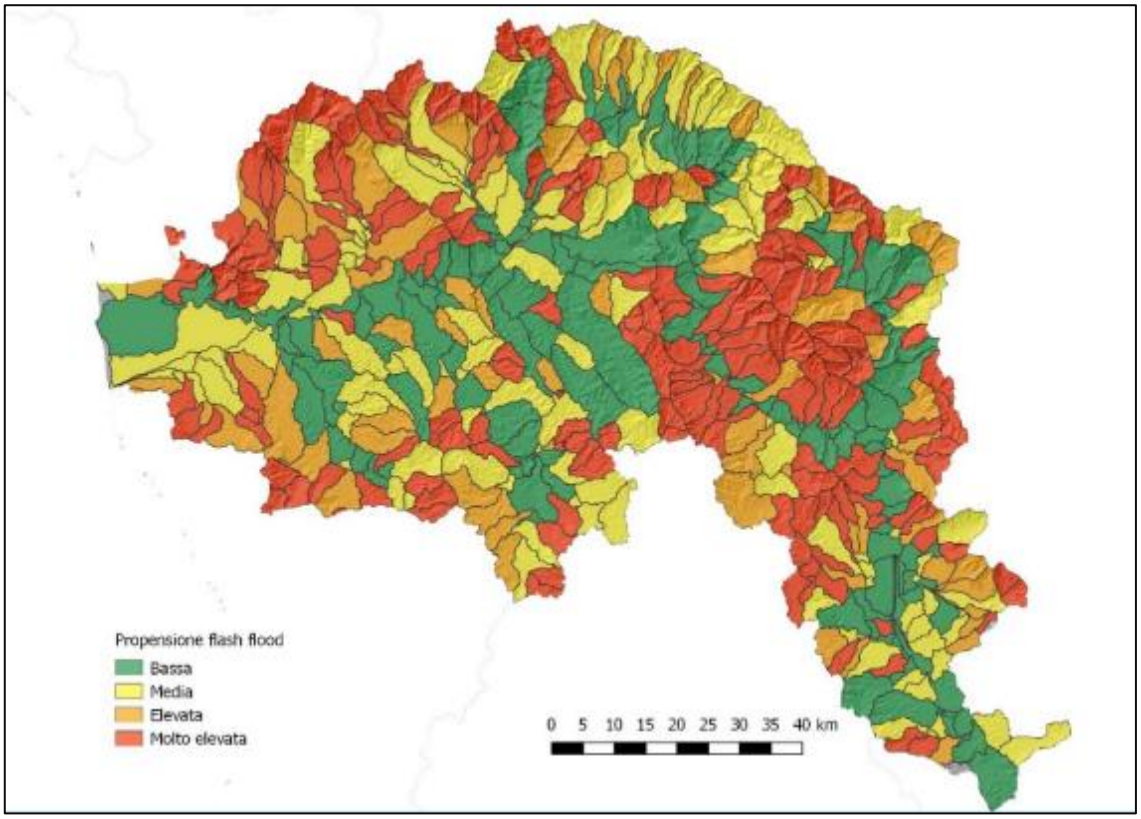

Figure 5-2 Flash Flood risk categorisation in the Arno Sub-Basin

The outputs of this approach were used during the Preliminary Flood Risk Assessment (PFRA) phase in accordance with articles 4 and 5 of the Floods Directive to identify some of the Areas of Potential Significant Flood Risk (APSFR) in the Northern Apennines River Basin District. In particular, the sub-basins classified at "high" and "very high risk" of flash floods were identified as areas where the effects of climate change will concentrate and be more intense in the near future (category "future events"). The methodology was validated at national level by ISPRA, the Ministry of Ecological Transition and was used by other River Basin Authorities.

The methodology for this climate change case study involves the use of hydrological analysis to identify areas at risk of flash flooding which have suffered the direct consequences of climate change in the past decades, and are likely to continue to do so in the future. Explicit hydraulic modelling of future climate change scenarios, as would be normal practice for future climate assessments, proved methodologically difficult given the complex morphological, topographic and sedimentological characteristics of the Northern Apennines, which vary considerably both spatially and temporally. As such it was concluded that the hydraulic modelling of future scenarios would be inherently uncertain in this catchment. Up to the present day, trends for intensification of rainfall as a result of climate change have followed

predictions as expected without explicit hydraulic modelling, which has given the Northern Apennines River Basin District confidence in their approach to the identification of flash flood prone areas.

Benefits of Approach

A high-level approach allows for risk zones to be readily produced over a large scale.

The application of a basin-scale methodology allows for flood risk mapping to be conducted using data obtained through remote sensing, e.g. LiDAR DTM data, without the need for survey information to be collected.

Prioritising areas or catchments that are more prone to flash floods can be conducted integrating full hydrological models and without the needs for full hydraulic modelling studies.

The fast, high level approach can be used to target areas or sub-catchments which are more prone to flash flood risk where the effects of climate change in future will be most pertinent in locations such as the Apennines; as a consequence, those areas should be analysed in detail and specific measures can be considered in the FRMP.

Limitations of Approach

The areas identified by the model are not potentially flooded areas but sub-basins which are identified automatically using a GIS hydrological analysis function applied to DTM data. Other MS should therefore not interpret these flash flood areas as outputs of modelled climate change scenario, rather only indications of areas in which rainfall and associated flash flooding could intensify further in the future.

5.2.4. Spain – Climate Change Study (for APSFR)

Context

Article 14, Chapter VIII of the Floods Directive requires that the "the likely impact of climate change on the occurrence of floods shall be taken into account in the reviews referred to in paragraphs 1 and 3".

Challenge

This APSFR climate change study is being included in the revision of the PFRA and the FRMPs to provide an evidence base for the application of appropriate climate change allowances in the projection of future flood risk.

What is it?

The climate change study for APSFR is a study into a pilot methodology for evaluating the effects of climate change on flood risk and FRM.

Approach

The Floods Directive indicates that a PFRA should consider, in detail:

- Large floods that occurred in the past with very adverse climatological situations
- Future adverse consequences of these extremes
- Impacts of climate change in the occurrence of flooding.

The APSFR climate change research project was carried out to comply with the FD. It consists of two phases: the first one (pilot approach for five APSFRs) started in 2016 and ended in 2017, and the second one (developed to incorporate climate change in PFRA) was carried out in 2018.

In the case of the pilot approach of five APSFRs, a methodology was applied that included three main types of analysis and/or data:

1. Climate model projections (based on five EURO-CODEX simulations of RCP8.5);
2. Distributed hydrological models; and
3. Hydraulic modelling.

The pilot locations were chosen such that they represented the typical main catchment across Spain. Where available, discharges from extreme historical floods were compared with the worse climate change scenario. Based on the conclusions of this pilot, the method was extended to include the whole of Spain and to include predictions based on RCP4.5 in addition to RCP8.5.

1. The full study was carried out as follows, Figure 5-3 shows a schematic of the methodology:

   An analysis of daily maximum precipitation projections was carried out by the Polytechnic University of Madrid, based on 12 combinations of global and local climate models from EURO-CORDEX project. These simulations have been analysed for the RCP4.5 and RCP8.5 emissions scenarios and for both a control period (1951/1971-2005) and a future period 2041-2070. For each grid cell (12.5 km resolution), for each simulation and period, parameters have been determined for a General Extreme Value frequency law (GEV) describing the likelihood of maximum daily precipitation.

Differences between the current climate precipitation and future projections should not necessarily be attributed to climate change action. These changes can be related to the natural variability associated with current climate and it was therefore necessary to assess whether future changes were meaningful. In order to determine the natural variation, a high number of random

2. precipitation series was created (via Monte Carlo simulations) based on the GEV laws determined for the *control period*, using all 12 combinations of EURO-CODEX climate simulations and RCP4.5 and RCP8.5. To each of these timeseries, new parameters for a GEV law were fitted and using this range of laws, a range of predictions for the 100 years return period precipitation was estimated. This process was done for every grid cell and in this way, the natural variability was determined for every grid cell. To determine whether a grid cell would be affected by significant future changes and thus climate change, for each RCP scenario the following thresholds were established:

   a. A prediction for a 100-year return period precipitation, based on one of the 12 GEV laws of the future period, is considered significant if it exceeds the 83-percentile of the range of precipitation determined for that cell via the Monte Carlo simulations based on the control period.

   b. If such a significant change is identified for six or more combinations of the EURO-CODEX simulations, the variation in precipitation between the control period and the future period is considered to be caused by climate change and not

3. by natural variation.

For each cell that fulfils both conditions, the mean of the precipitation changes was calculated using the predictions for the

4. 100-year return period of every EURO-CODEX model. This has been done for the RCP4.5 and RCP8.5 scenarios separately.

5. These mean changes have been applied to the current maximum daily precipitation with a return period of 100 years, changing only the grid cells where significant change has been identified.

6. Based on these updated maximum daily precipitations for RP 100 years, changes in the *accumulated* maximum daily precipitation have been calculated for each greenhouse gas emission scenario,

7. using the flow directions.

All river reaches selected that show at least 10% of change in accumulated maximum daily precipitation. Furthermore, proximity to urban risk areas has been taken into account, as well as whether sections that where classed as APSFR in the first cycle.

For the selected sections, 100-year return period flows have been calculated for both the current and future climates. The output of

the study shows the percentage of change of the accumulated maximum daily precipitation and the percentage change of water flow for each selected section.

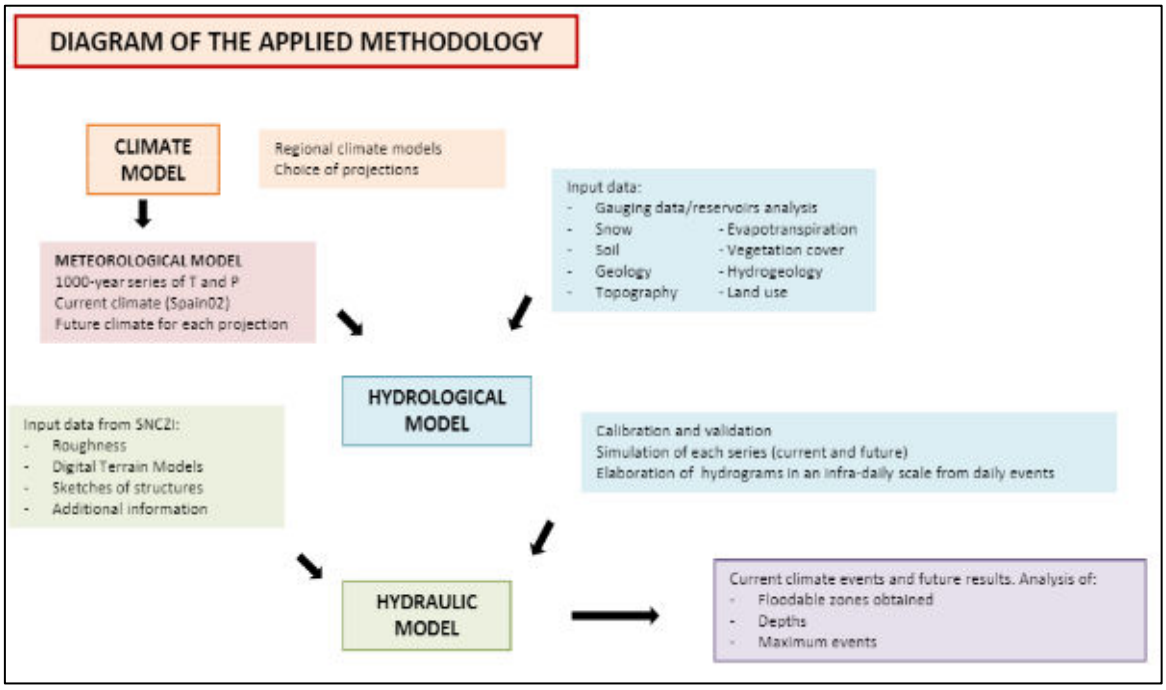

Figure 5-3 Diagram of the applied methodology (source – Incidence of climate change on flood risk presentation)

The study found that the impact on river discharges, and therefore flood risk, due to climate change is highly uncertain. This uncertainty is most attributable to the projections of extreme rainfall predicted by the various climatic models available. However, additional uncertainty is added by the hydrological and hydraulic response of catchments to rainfall. This is, in part, due to limitations in both the current understanding of physical processes and in the availability of the physical data describing a catchment.

Uncertainty in projections are increased further by the inability to calibrate models for extreme rainfall events. Existing data records generally lack information on flooding on the scale predicted by many of the climate change projections. As such, in many cases, observed events with which to provide validity to the climate change projections were not available.

Applicability of Approach

The approach provides a comprehensive method for understanding how uncertainties should be considered in future projections that could be

followed by others, yet to conduct a more thorough assessment of the impact of uncertainty.

Benefits of Approach

This approach provides a detailed assessment of how the inherent uncertainties in climate projections, precipitation intensity and duration, and hydrological response, among others, limit our understanding of how climate change will impact on flood risk. This highlights the necessity to consider the impact of uncertainty on projections and to develop ways of translating this uncertainty into FRMPs.

In addition, the contributions to the uncertainty from inadequate or limited data highlights the importance of collecting meteorological and hydrogeological data to improve the validity in projections.

Limitations of Approach

It is difficult to take into account the cascade of uncertainties that is inherent to this kind of modelling. Flood hazard mapping should take these uncertainties into account; however, it is difficult to communicate this concept in user-friendly flood risk maps. Adaptation measures should therefore be focussed on reducing exposure and vulnerability to flood hazards rather than frequency reduction.

5.2.5. United Kingdom – SEPA Flood Service Strategy

Context

It is recognised that future flood risk in Scotland is likely to be higher than it is currently and this needs to be taken into account when making decisions. However, there are multiple different future scenarios to consider.

Challenge

In Scotland the current aim is for projects to develop an adaptive plan for a scheme. This means the scheme is built for the current conditions but when built acknowledges how and when further work may be required to maintain resilience to future climate change and increasing flood risk. This means new schemes and interventions need a robust understanding of climate change scenarios. Therefore, SEPA has investigated how best to disseminate information about climate change and increased flood risk to developers and Local Authorities.

What is it?

As part of the new Flood Services Strategy SEPA published standard climate change scenarios that planners and developers should use to account for increased flood risk.

Approach

The strategy aims to mainstream the approach to accounting for climate change across Scotland. However, for some communities, a 200-year standard of protection plus climate change allowance is hard to meet due to the topography of the country and the industrial heritage of settlements close to rivers and the sea. It limits the lives of people, and the development of such schemes is too complicated, often due to their scale. For these communities, it is more beneficial to delay risk to a later stage. This, however, makes standardisation difficult.

To make sure that small communities are able to develop flood protection measures and to prevent a 'centre-bias', the 200-year standard of protection has been removed from the central funding regulations, as well as the lower limit for a potential scheme's costs.

SEPA furthermore prioritises schemes based on a large number of metrics, which are not all monetarised, one of which is climate change adaptation. This has resulted in an increase in 'portfolio schemes', as well as schemes that combine FRM with community enhancements, which increases community buy-in into the projects.

Applicability of Approach

While the principles are universal, the particular approach is linked with the requirements in Scotland.

Benefits of Approach

Improved accounting for climate change which will improve resilience to climate impacts and encourage adaptation.

5.3. Limitations of Approach

None identified as the approach is new and developing.

Issues / Key Findings

Various climatic scenarios predict changes to precipitation. There is however, uncertainty in how these changes will manifest across regions and nations in the nature of extreme precipitation events. As such, there is potential for large uncertainty in the projected impacts of climate change on river flows and therefore flood risk.

The inclusion of climate change projections in the management of future flood risk therefore should consider the inherent uncertainties in projecting the impacts of climate change on river catchments and sea levels.

However, the way in which uncertainty is applied and communicated is challenging. Communicating uncertainty, especially to non-practitioners, requires careful consideration to ensure that information is interpreted correctly.

The accounting for climate change is clearly a developing area that will need more improvements in the future.

6. LAND USE PLANNING

Definition and Context

Preventing the building of houses and infrastructure in areas at risk of flooding is the most effective way of limiting future flood risk. Regulators typically use rules and processes to define zones where particular types of building or infrastructure are allowed, often relating flood hazard to flood vulnerability. There are also different ways of communicating and enforcing these rules, either through mapping or written guidance.

6.1.

Seven cases across five MS were reviewed to assess the current practice in land-use planning. The seven cases cover the geographic and hydrogeological variations across the EU, giving opportunity to explore how the nature of flooding impacts on planning approaches.

Cases

6.2. *6.2.1. Overview*

This section presents seven cases which can be grouped into two FRM contexts in which MS address FRM within Land Use Planning, as follows:

- Mapping for Land Use Planning
  - Austria – Flood Hazard Zone Plans (Section 6.2.2)
  - Czech Republic – Flood Danger Maps (Section 6.2.6)
- Developing Land Use Planning Guidance
  - Belgium – Water Assessment (Section 6.2.3)
  - Belgium – Information Plight for Flood Prone Properties (Section 6.2.4)
  - Belgium – Signal Areas (Section 6.2.5)
  - Slovakia – Flood Protection Act (Section 6.2.7)
  - **Error! Reference source not found.** Flood Protection Act (Section **Error! Reference source not found.**)

6.2.2. Austria – Flood Hazard Zone Plans

Context

In Austria, there is, increasingly since the 2002 flood event, an aim to direct development towards areas of lower flood risk. Alongside this,

there is desire to better communicate flood risk to local communities and involve affected citizens.

Challenge

Creating effective planning legislation that minimises flood risk requires the categorisation of flood risk and a differentiation of development types and vulnerabilities.

Communicating legislation and guidance on flood risk planning in a clear and consistent manner can be challenging at a national scale.

What is it?

The Flood Hazard Zone Plans (FHZP) are a set of maps delineating specific zones that are used as decision support by spatial planning to define the types of prohibited development within these zones, respective regulatory requirements for exemptions as well as areas needed for potential flood protection and retention measures.

Approach

As a first step, flood extents of three return periods (HQ30, HQ100, HQ300) are derived from hydraulic modelling, as shown in **Error! R eference source not found.**. The hydraulic models are based on high resolution topographic data, river cross section measurement, land-use type and building datasets. The models are calibrated using known recorded flood and gauge data to validate the outputs against historic events.

Using the HQ100 return period, the FHZPs define areas at risk of flooding by categorising yellow and red zones based on flood intensity (product of water depth and flow velocity). Areas with specific function for retention, conveyance and risk reduction, highlighted in yellow-red shade are based on at least the HQ100 return period. Further, to account for residual risk and extreme events yellow shaded areas are delineated based on the HQ300 without having flood protection measures in this area, and red-shaded if there are flood protection measures in this area (accounting for overtopping and failure).

The requirements are defined in the Austrian Water Act (2011) as well as in the FHZP regulation. Using the flood intensity, the zones define the prohibited development types as well as the regulatory requirements for exemption within areas of flood risk and are used by the different municipalities for decision making processes. For example, Figure 6-2 shows a FHZP which indicates the different areas of intensity for the Flood Hazard Zone (FHZ).

The red and red hatched areas may not be built on, whist in the yellow areas, development is only permitted if flood runoff and retention areas are not significantly impaired and compensation for lost retention areas is ensured. The building land must also not expand into areas with significantly higher risk potential (red areas). If a rezoning of individual pieces of land can be approved in the yellow zone, the development must be built as 'flood-proof', for example the floor levels 50cm above the HQ100 flood event water depth. The FHZPs are developed in a participatory approach with the public and those potentially affected by flooding. This approach leads to spatial plans that are unique to that province, attaining local consent for the implications of the plans at municipal level.

The consequence that each of these zones has for planning policy are specified at the provincial level as spatial planning is regulated provincially. This approach gives a degree of local autonomy to the decision-making process. For example, in Upper Austria, FHZPs are integrated into the provincial spatial planning legislation leading to effective risk reduction and risk avoidance.

Residual risk of flooding is also taken into account in the FHZPs using the HQ300 return period. Existing flood defences are not considered in this scenario, because it is important to understand flood risk if defences are exceeded or do fail.

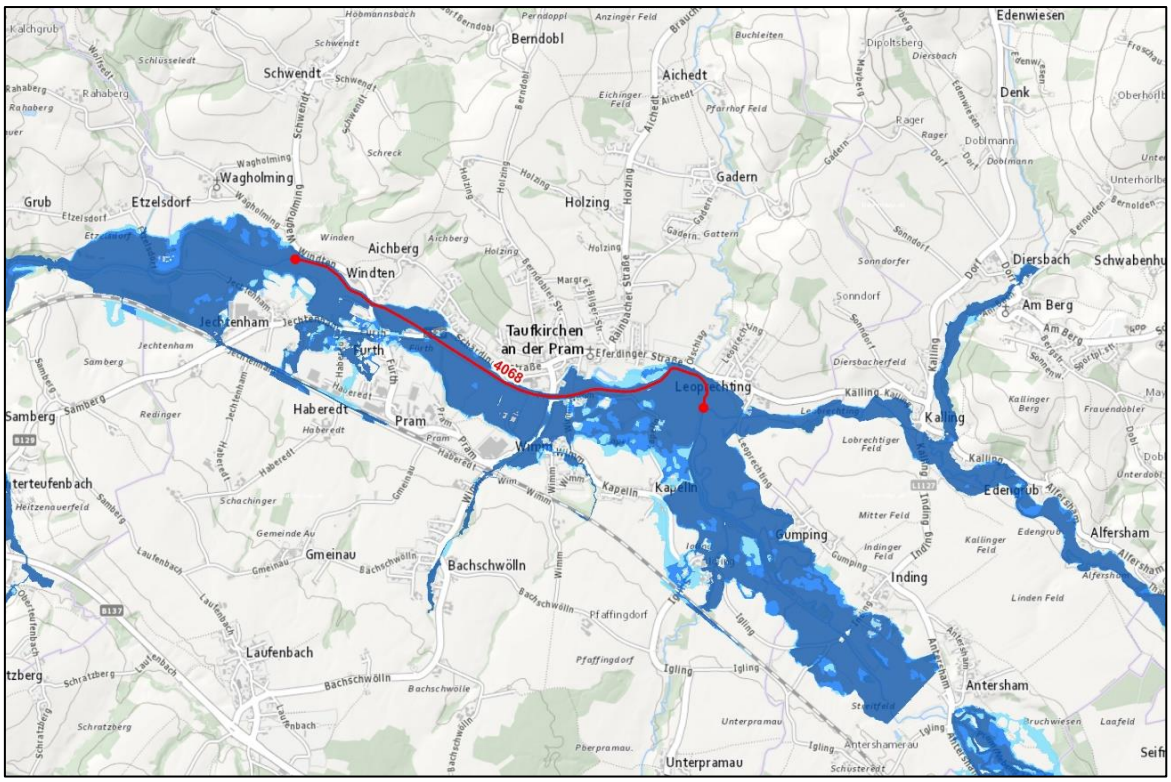

Figure 6-1 An example of the HQ30 (dark blue), HQ100 (medium blue) and HQ300 (light blue) return periods

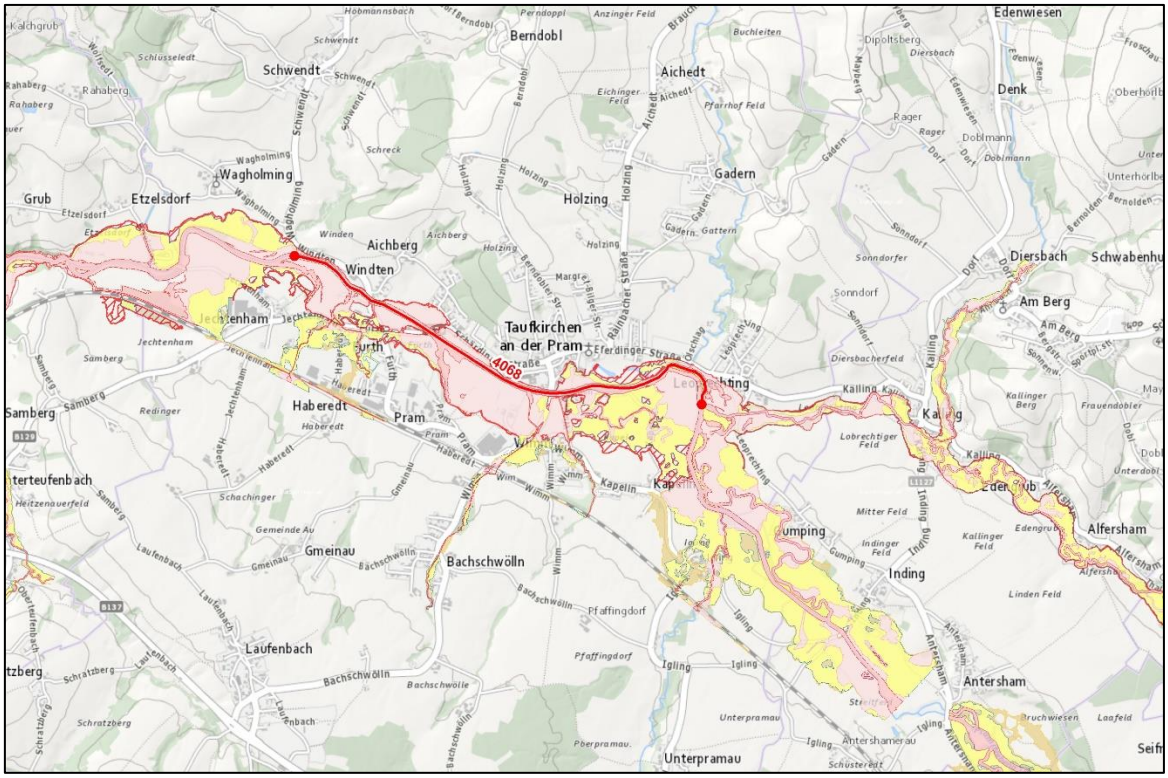

Figure 6-2 An example of Flood Hazard Zone Map (FHZP) based on the HQ100 hydraulic modelling output.

Applicability of Approach

Areas with existing detailed hydraulic modelling data on plot scale can apply the flood hazard approach.

The approach is applicable to MS where there are regional variations (both physically and politically) between regions that require a bespoke, or more community-based means of developing flood planning policy.

The blanket policy of 0.5m above the Yellow Zone (medium hazard) works where flooding is expected for a relatively short duration. Such a policy would not be suitable for regions where flood water may take several days or even weeks to recede. This could lead to stranded people within their homes.

Benefits of Approach

Engagement with locally affected people and the public delivers plans that are bespoke to an area, improving consent for their application and increasing awareness of the consequences of flooding.

Categorising flood zones by flood intensities, rather than flood depth or extent, potentially delivers a more practical approach to managing flood risk, without developing over-zealous or stringent planning criteria. In the case of Upper Austria, the clarity between the zones regarding allowable development and in the required mitigation measures (e.g. no buildings in the Red Zone and Red Shaded Areas in the zone of residual risk; 0.5m above the flood plain in the Yellow Zone) leads to clearer planning policy.

Limitations of Approach

Defining allowable development and mitigation based on flood intensity, rather than depth or extent, in the location of a proposed development, might not consider the immediate risk surrounding the area that could impact on the overall function and safety of the development. For example, while a development might be permitted within a low hazard zone, if access and egress from the development is via areas of medium or high hazard, the functionality of the development may be unsafe.

The FHZP do not take climate change and the future impacts on flood risk into account in their derivation.

6.2.3. Belgium – Water Assessment

Context

To comply with the FD legislation and guidance on planning, consideration of flood risk must be incorporated within development planning. One of the main ways of considering flood risk in development planning in Belgium is to steer new development away from higher flood risk areas.

Challenge

Planning decisions should consider flood risk from all sources.

Preventing future flood risk requires an assessment of the impacts of climate change.

There is a need to better understand and account for pluvial flood risk through detailed modelling assessments and changes to guidance to bring it in line with approaches for fluvial flood risk.

What is it?

The Water Assessment (WA) is a planning permitting process that must be undertaken to ensure that flood risk is considered from all sources, and mitigated for where necessary, for a development.

Approach

The WA was developed in 2003 and has been used in full since 2006. The WA is used in the permitting stage of developments, looking at water in a very broad sense. If the development influences 'water' negatively, then adaptation or mitigation measures are required. If these measures cannot mitigate the negative effects, the planning permit will not be authorised.

The WA is required at the local spatial planning and permitting stage of a development. Based on previous modelling conducted for the WA, maps are available designating areas where permit seekers should ask advice from the local Water Board. The maps supporting the WA are set up in such a way that they are compliant with the requirements of the FD.

As the advice provided to permit seekers is issued by different local authorities per region, guidelines have been developed by the Flemish government for different situations. These guidelines are not legislation and therefore the local authorities are allowed to advise based on their own experiences. Permit seekers are not obliged to follow this advice; however, they do need to challenge and disprove the given advice if not followed.

Climate change is considered in the production of maps that predict flood extents in 2050. Guidance on how to interpret and use the climate change maps is also published given the complexity and potential contention with predicting changes in flood risk. While the aim of the WA is to prevent an increase in flood risk, development is allowable as long as the proposals are resistant against climate change.

Fluvial flood risk was included from the conception of the WA, but in a recent update the risk from pluvial sources has now been incorporated. Up until now, reliable models for pluvial models were not available at the scale of Flanders and thus pluvial floods were not included in the WA. The Flemish Environment Agency made use of JFlow (a modelling and mapping tool to quantify flood risk across a broad scale) to produce the region-wide model that now influences the WA. The increased frequency of pluvial flooding also highlighted the urgency for including flooding from this source into the WA.

The legislation surrounding the inclusion of pluvial floods into the maps, is expected to pass into law later in 2021 via the Information Plight. Flooding from coastal sources has not been included in the WA as Flanders has other strategies to deal with coastal protection.

Applicability of Approach

The approach is applicable where there are pressures to release land for development in areas of flood risk. The opportunity to consider and develop mitigation measures is applicable where simple measures are viable methods for 'future proofing' a development.

The approach relies on previously assessed flood risk and mapping data to determine which areas require the WA.

Benefits of Approach

The approach creates guidance on how to assess and manage flood risk depending on the level of risk in a specific area. This leads to a proportionate approach that can still allow for development, as long as flood risk and the necessary mitigation measures are considered appropriately.

The inclusion of climate change impacts on the production of flood maps also ensures that future development is steered away from areas of high flood risk, and that developments permitted in flood risk areas are adapted to climate change.

Limitations of Approach

The inclusion of pluvial flood risk will be challenging for many municipalities. The areas of influence of this type of flooding is larger than for fluvial floods and therefore more measures will have to be implemented during the coming years to reduce flood risk in vulnerable areas.

The WA does not affect existing buildings in flood prone areas. The ambition, however, is to also protect these houses against floods. Insurers are known to use the WA maps as well. This may have a small but limited influence on the costs of insurances, which are capped to keep them affordable. Insurers can choose, however, not to provide insurance if the flood risk is higher than 1 in 25 years annual probability for new-build properties that are erected following the publication of the maps indicating flood risk zones.

6.2.4. Belgium – Information Plight for Flood Prone Properties

Context

In Belgium, there has been a move to make sure homeowners and potential home buyers are aware of flood risk.

Challenge

Prior to the 2010/11 floods, many homeowners, home-buyers and renters in Flanders, Belgium were not aware of the risk of flooding to their property.

Including information on flood risk could potentially impact the valuation of a property and potentially leave residents unable to sell their homes.

What is it?

A law that requires flooding information to be made available to potential buyers and renters of homes and building plots.

Approach

In 2013 a new law was passed to ensure that information on flooding is made available to existing homeowners and prospective buyers or renters to enhance awareness and understanding of flood risk.

The law requires that information on flooding be made clearly available and include flood risk from various sources such as fluvial, pluvial and tidal flooding. The risk of flooding, in terms of likelihood, must also be provided to inform decision making processes.

An impact that could arise due to Information Plight is the depreciation of the value of houses in flood prone areas, although this impact is not considered significant enough to justify quantification. Therefore, any measures against flooding that have been taken by homeowners are included in the assessment. It is envisioned that two versions will exist to differentiate between houses with and without protective measures. The intention behind this is that owners will adapt their property to flooding, so their property will fall in the other category of the Information Plight and the value of their house will increase. Furthermore, the WA has been around for several years, so many recently built houses are already adapted to the risk of flooding. Contrary to expectation, the real estate sector is involved as well and agrees with the Information Plight being implemented.

Flood maps are used to communicate the areas at risk and the potential consequences of flooding to a property.

Applicability of Approach

The approach is applicable where flood maps have already been defined.

Benefits of Approach

The approach has greatly increased the awareness of flood risk and the potential resilience measures that can be undertaken to reduce the impact of flooding.

The law incentivises homeowners to develop property adaptation measures to ensure that the knowledge of potential flood risk does not cause a depreciation of their house price.

Limitations of Approach

6.2.5. Belgium – Signal Areas

Context

In Belgium, it is seen as important to prevent future development in areas of high flood risk.

Challenge

Preventing development while preserving prices and land rights of those living in high-risk areas.

Steering development away from high-risk areas without creating opportunities for non-compliance to legislation can be challenging.

What is it?

Signal Areas (SAs) are zones demarking areas at greater than a 1 in 100-year chance of flooding where future development cannot occur.

Approach

Since the 1970s, a regional land-use plan exists for Flanders which addresses owners' rights. However, this plan did not take into account the latest knowledge on flood risk. Although the WA (see 6.2.1 the Water Act) has been successful, at present, in preventing new development in flood prone areas, the land-use zoning has not been updated. Using SAs, the Flemish government has tried to bridge this gap in policy implementation.

An SA is defined as an area that floods more frequently than once every 100 years. The decision to proclaim an area as an SA is not purely based on maps, but also on local details. Various agencies are involved at different national levels, as well as the local communities to develop the SA, with local landowners also likely to be involved in future via consultation processes.

Once an area has been designated as an SA no further development is permitted. The purpose of the SAs is therefore to reduce flood risk and to prevent constriction of the river system. Existing buildings in SAs will not be affected by the designation.

Applicability of Approach

The approach is applicable in regions where flood risk policy and policy implementation may be in its infancy and therefore the designation of areas where development is not permitted is a fast way of reducing flood risk.

Benefits of Approach

The approach is potentially a relatively fast method for reducing flood risk as removing the opportunities for mitigation and / or development resilience measures leads to a simpler policy. In turn, this also removes the possibilities to contest the planning decisions or policy, further stream-lining the planning process.

Limitations of Approach

It has proven difficult to progress the SAs into legislation. As the zoning of certain plots of land changes, this can mean that certain owners consequently incur disadvantages. Therefore, owners should be financially compensated. The Flemish government is now in the process of determining the amount for these compensations, before the SAs can be processed any further.

The blanket designation of an SA does not consider mitigation measures that may be applicable and appropriate methods for reducing flood risk whilst enabling development.

The approach does not consider the impacts of climate change on the extent of the 1 in 100-year flood.

6.2.6. Czech Republic – Flood Danger Maps

Context

The 1997 and 2002 floods in the Czech Republic highlighted the need for appropriate and clearer guidance of permitted land-use within areas of flood risk. Land-use within flood areas are required to be based on the likelihood and impact of flooding as well as the vulnerability of the land-use.

Challenge

Decreasing the negative impacts of floods without limiting appropriate development of settlements.

What is it?

The Flood Danger Maps (FDM) divide flood areas into four categories based on level of danger and for each of them recommended rules for area development are specified.

Approach

The methodology was created after the 1997 and 2002 floods. After 2007 these methods have been put in accordance with the requirements of the FD.

This method is based on outputs from hydraulic modelling calculations - flood depth and velocity and their Return Period (RP). This is an indication of the destructive ability of a flood. The flood hazard is expressed by the flood intensity that is a combination of flood depth and velocity. For each scenario (flooding for the 1 in 5, 20, 100 and 500-year return periods), the flood danger per grid cell is then calculated based on the flood intensity and the RP of the flood scenario. Based on the maximum danger level for each of the grid cells, the grid cells are categorised in one of the four Danger Levels; High (red), Medium (blue), Low (orange) and Residual (yellow). The final FDM consists of the grid cells coloured according to their Danger

Level (

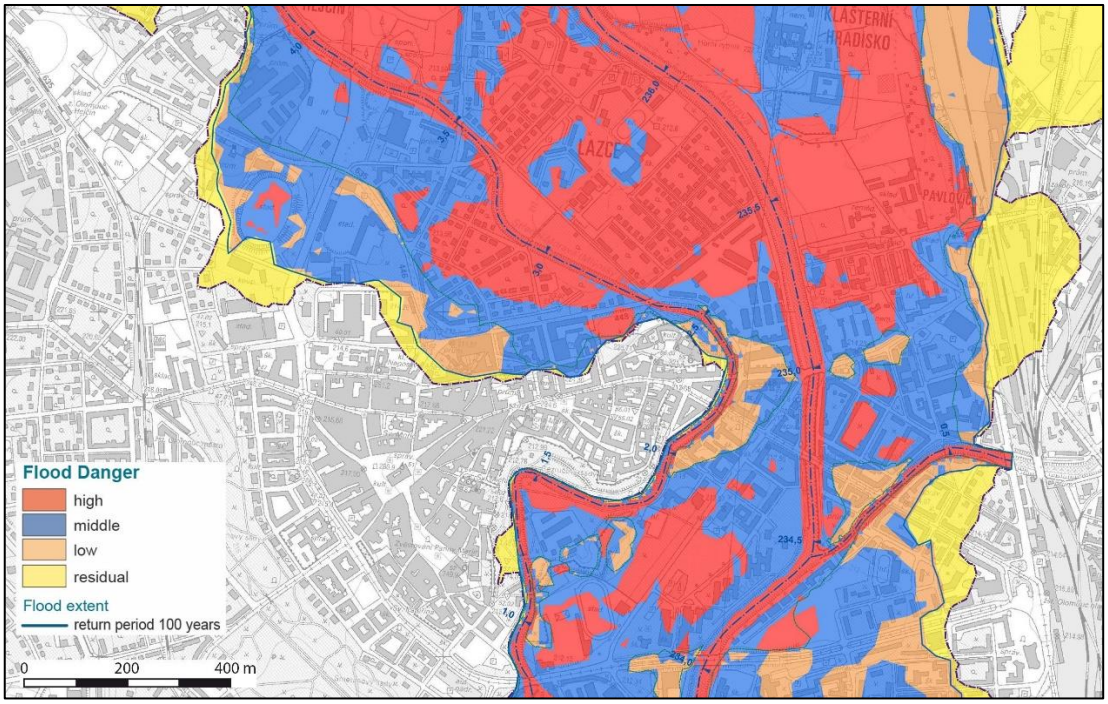

Figure 6-3).

For each Danger Level, recommendations are made as to urban planning and land-use limitations.

Acceptable danger	Recommended land use
(4) High (red)	Water area
	Parks and open space, gardens, woods
	Arable land, meadow, pasture land
(3) Medium (blue)	Sport and recreation
(2) Low (orange)	Residential
	Public services
	Transportation and utility
	Industrial and manufacturing
	Agriculture (structures)
(1) Residual (yellow)	Sensitive structures (health care institutions, fire departments, historical landmarks, etc.)

Figure 6-4 gives an example of the recommended permitted land-use types within each Danger Level category. Only the least vulnerable activities are permitted in the High danger level zone. Into the Medium danger level zone only recreation can be introduced, while residential and industrial activities are acceptable in the Low danger level zone.

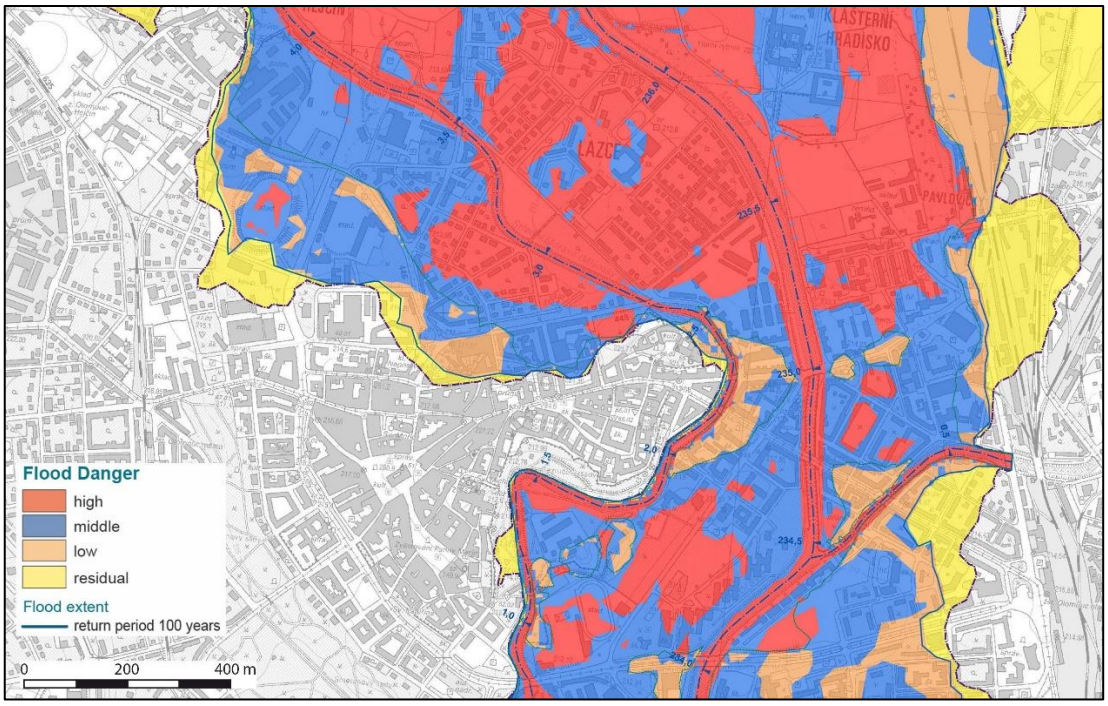

Figure 6-3 Example Flood Danger Map for the river Morava in Olomouc.

Acceptable danger	Recommended land use
(4) High (red)	Water area
	Parks and open space, gardens, woods
	Arable land, meadow, pasture land
(3) Medium (blue)	Sport and recreation
(2) Low (orange)	Residential
	Public services
	Transportation and utility
	Industrial and manufacturing
	Agriculture (structures)
(1) Residual (yellow)	**Sensitive structures** (health care institutions, fire departments, historical landmarks, etc.)

Figure 6-4 Permitted land-use types within each Flood Danger Zone.

Applicability of Approach

The approach is generally suitable for watercourses where DTM and necessary data for hydraulic modelling are available.

Benefits of Approach

The FDMs simplify the decision-making process, as only one map is to be consulted to take into account all the information from Flood Hazard Maps rather than inspecting 9 individual maps of flood depth, velocity and extent.

Furthermore, the assignment of an acceptable danger level for all potential land-use zones, with consideration for the vulnerability of class of development helps to steer more vulnerable land-uses away from areas of higher flood risk.

These vulnerability and land-use categorisations assist planning authorities in their decision-making process by giving them clear guidance.

The use of flood danger considers the potential consequences of flooding more practically than, say, the use of flood extents alone. The previous standard practice of implementing restrictions in flood areas consisted of determining Flood Plain Areas, for the same RPs that are now used for the FDMs (except 500 years). Since the implementation of the Water Act in 2001, these Flood Plain Areas have been determined for approximately 13,000 km of water courses. For many of these areas an Active Zone has been determined as well. Within the Active Zone, strong restrictions on development are in place in accordance with this Water Act.

The FDMs were primarily created in the APSFRs during the application of the FD. However, since 2018, FDMs have been also set as a key input in the process of determination of the Active Zones. Flood Plain Areas and their Active Zones still have stronger legal status for decision-making than FDMs based on The Water Act. Nowadays the process of harmonisation of the two above mentioned instruments used in sphere of flood protection is about to be initiated.

Limitations of Approach

The information in the FDMs is, in general, not challenged by stakeholders. However, the land-use limitations guidance can sometimes cause tension between landowners and developers and the regulating authorities. As a consequence of this sensitivity it is necessary to aim at high accuracy of input data for hydraulic modelling.

6.2.7. Slovakia – Flood Protection Act

Context

Previously, The Construction and Spatial Planning Act (implemented following the extensive floods in 1974) stated that flooding should be considered in local planning. However, this was often disregarded at a local planning level. As the Slovak constitution grants every citizen a right to the same environmental quality, there was a need to harmonise flood risk legislation at a national level.

Challenge

Prohibiting development within areas of medium to high flood risk that would act to increase the flood risk to others.

Translating information on flood hazard and risk into land-use policy and municipal planning requires the categorisation of risk and defining land-use vulnerabilities.

Encouraging authorities to consider flood risk at the planning stage is challenging without a legal framework.

What is it?

The Flood Protection Act provides a legal framework to transpose flood hazard maps into municipal planning legislation.

Approach

In 2010, the Flood Protection Act was put in place that advises municipalities to take account of flood inundation maps in their spatial plans during subsequent reviews. The Flood Protection Act then defines the permitted land-uses within the flood zones.

The Slovak Water Management Enterprise (SVP) produces the flood inundation maps that inform the application of the Flood Protection Act. The SVP is a national organisation with four branch offices that maintains all waterways in the country. The company secures its own funding and is not dependent on the national or local government. It works together closely with municipalities on spatial planning in relation to flood risk.

The flood inundation maps are produced based on fluvial hydrodynamic modelling. They lay out the extents and depths of the 1 in 100-year return period flood. The inundation maps therefore define the Natural Flooding areas, areas that will be flooded by at least the 1 in 100-year return period event.

The Flood Protection Act prohibits new developments in the Natural Flood Areas. From the inundation maps, natural retention areas are also determined. These areas provide the flood retention capacity for flood water and are therefore designated to be flooded during the 1 in 100-year return period event. Furthermore, where a flood defence is present and forms the border of an inundation area, the Act requires that this defence have a design standard up to and including the 1 in 100-year flood.

The inundation maps are updated during every cycle of the FD (every six years). However, major developments allow for changes to be implemented sooner. In the second cycle of developing the inundation maps, the maps will be updated to include modelling results from pluvial events.

Applicability of Approach

An efficient approach was facilitated given the relatively small geographic size of the Slovak Republic.

Benefits of Approach

The Act clearly defines the obligation to incorporate flood hazard maps into the documentation of spatial planning at a municipal level. Simultaneously, the Act stipulates prohibited activities within the designated inundation areas and areas with flood retention potential.

The simplicity of the legislation creates an easy-to-interpret framework that reduces opportunities for non-compliance, potentially streamlining the planning review process.

Limitations of Approach

The Flood Protection Act does not grant SVP enforcement powers, therefore encouraging municipalities to take account of the inundation maps is challenging. It should be noted however, that the state is not liable for any flooding damages if the municipality decide not to implement the inundation maps in spatial planning.

The 1 in 100-year standard is a necessary requirement in cities to ensure access to European Commission funding. This poses a problem in some cases, as this standard of protection is either technically or financially unfeasible. In case of a positive Benefit-Cost Ratio, the SVP will perform the necessary upgrade of a flood defence. However, in case of a negative Benefit-Cost Ratio, residents are required by law to fund their own flood defences within the next year. This could lead to inability to fund or carry out required upgrades.

Freeboard is incorporated but climate change scenarios are currently not accounted for.

6.2.8. Spain – Land Use Limitations in the Spanish Water Act

Context

In Spain, in order to reduce flood risk to vulnerable land-uses there is an aim to harmonise land-use and flood risk regulation at a national scale while maintaining public access to waterways.

Challenge

Prior to the modifications to the Spanish Water Act, land-use limitations varied nationally leading to an approach in the management of flood risk.

Developing a consistent definition of vulnerable land-use is challenging at a national scale.

What is it?

The modified Spanish Water Act defines various flood risk zones and permitted land-uses within those zones.

Approach

An amendment to the Spanish Water Act was adopted to harmonise flood risk guidance across Spain and to comply with the EU FD. In particular, the following aspects were improved through amending the Act:

- Land-use planning limitations and permitted land-use types are defined for specific 'River Areas';
- Criteria were developed to define "non-urban" land; and
- Development criteria were defined for those buildings located in flood prone areas.

Before the amendment to the Act, land-use limitations were regulated either by Autonomous Communities or by the various River Basin Districts, with different levels of land-use regulation. Previous regulations concerning the Hydrological Plans (Spanish: *Plan Hidrológico de la Cuenca,* PHC) established that vulnerable uses could be regulated in areas of greatest flood risk. However, a definition of 'vulnerable use' was not developed at the time.

The definition and authorisation of vulnerable land-uses was previously held by the River Basin Districts. It was, therefore, necessary to

coordinate planning instruments with a common basic regulatory framework, applicable to the whole of Spain, with the aim of achieving greater transparency and legal certainty.

River Areas are used to define limitations to land-use within areas of flood risk. The Spanish Water Act and the Hydraulic Public Domain Rule specify the River Areas with the use of Flood Hazard Maps, with the following categorisations:

- **Hydraulic Public Domain (riverbed):** Land covered by water under maximum 'normal flow' conditions.
- **Easement Use Area:** a 5m-wide strip of land either side of the riverbank under maximum normal flow conditions. Land uses in these areas are limited to protect river ecosystems and ensure public passage.
- **Preferential Floodway:** areas where the flood flow is concentrated (for 100-year return period) and where the flood hazard is high (high velocity and depth for a 100-year return period). Only 'non-vulnerable' activities and activities that do not reduce the outflow capacity are allowed in these areas.
- **Flood-Prone Area:** areas covered by flood events with a 500-year return period. Limitations to most vulnerable activities and less restrictive conditions apply in these areas.
- **Police Area:** a 100m-wide strip on both sides of the riverbank. This can be wider in some cases to include the Preferential Floodway. Any activity in these areas must be authorised by the River Basin Authority.

Error! Reference source not found. provides a graphical r epresentation of the different River Areas as defined in the Spanish Water Act.

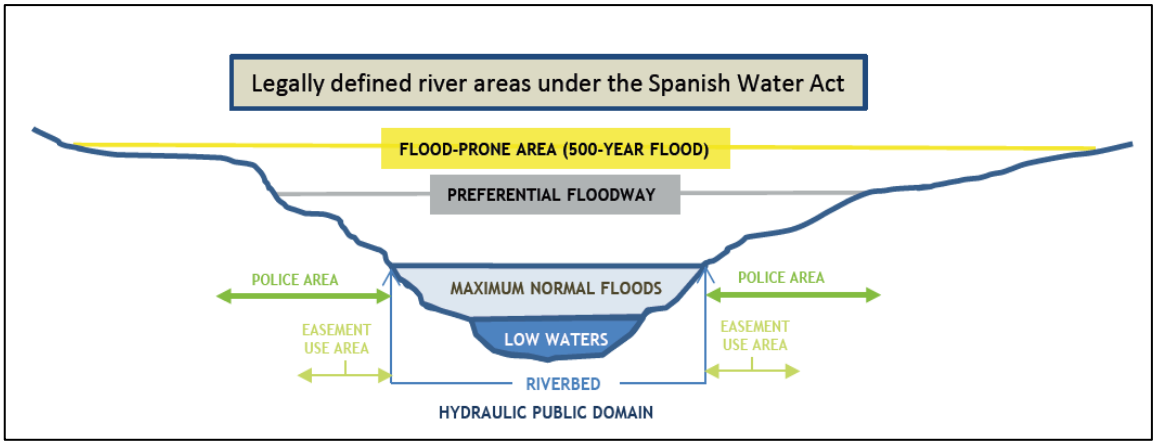

Figure 6-5 Spanish Water Act River Areas shown in channel cross-section

Flood risk mapping is the responsibility of the River Basin Authority in the area of the demarcation, in compliance with the FD. This information is submitted to a public consultation process, after which the Committee of Competent Authorities of each River Basin Authority issues a report. Revisions are issued as per the FD.

These maps do not include climate change, as research indicates that, although the frequency of flooding will increase, the spatial flood extents will not change significantly.

The modification of the law also introduced 'urban' and 'rural' classifications in the determination process of land-use limitation. There is, in addition to urban and rural land, a third category; a special regime for municipalities with a high likelihood of flooding. This includes municipalities that have more than one-third of their land included in the Preferential Floodways and municipalities where future expansion outside of the Flood-Prone areas is not possible.

Error! Reference source not found. tabulates the land-use l imitations for each of the Flood Areas, differentiating between 'urban' and 'rural' areas, and showing the types of land-use that is permitted within each area. The land-use limitations are determined for areas that are located within either the Flood-Prone areas or the Preferential Floodway. For the latter, the limitations are more restrictive.

In some cases, conditional requirements are specified for certain land use vulnerabilities in the different Flood Areas. Within these categories, further distinction is made based on the urban-rural classification and the 'special regime municipalities' with high likelihood of flooding. In this way, vulnerability of certain land-uses is combined with actual flood risk.

These limitations are mandatory, and they form the minimum criteria at the national level.

The first priority of this legislation is to prevent the increase of flood risk in the future. The government is now working on increased resilience of existing developments and has produced guidelines on increasing the resilience of houses, infrastructure and agricultural land. Technical solutions are available; however, the government is now working with insurers to find ways to fund these solutions. Furthermore, flood forecasting systems are a high priority as well as flood reduction measures in, and upstream of, municipalities (as many lack the space to develop green infrastructure).

The information on land-use and flood risk is available on the Ministry for the Ecological Transition's website. A brochure has been developed that outlines the land-use limitations (e.g. **Error! Reference source not found.**). Furthermore, several conferences have been organised throughout Spain to publicise the regulations among municipality officials. For the public, a national map viewer is available as well that includes the Flood-Prone areas, Preferential Floodways and all other available flood related information.

<table>
<tr><th rowspan="2">Land Use</th><th colspan="3">Preferential floodway</th><th colspan="2">Flood-prone area</th></tr>
<tr><th>Rural land</th><th>Urbanized land</th><th>Special regime for municipalities with high likelihood of flood</th><th>Rural land</th><th>Urbanized land</th></tr>
<tr><td>School or health centres, retirement homes, disability care homes, sports centres, penitentiary facilities, fire stations, Civil Protection facilities</td><td>No</td><td>No</td><td>Only if there is no alternative location and if it is designed with security conditions</td><td rowspan="2">To be avoided, unless there is no alternative location and if it is designed with security conditions</td><td rowspan="2">Can be permitted if security conditions are considered to the possible extent</td></tr>
<tr><td>Large commercial areas where crowds of people could gather</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td>Buildings, repair works, rehabilitation or change of use, underground garages, basements and surface car parks, and other underground constructions</td><td>No</td><td>Yes, with security conditions</td><td>Yes, with security conditions</td><td>Yes, with security conditions</td><td>Yes, if security conditions are considered to the possible extent</td></tr>
<tr><td>Facilities where products likely to be hazardous to human health and the environment are handled such as gas stations, industrial treatment plants, waste stores or electrical facilities for high and medium tension</td><td>No</td><td>No</td><td>No</td><td>Yes, with security conditions</td><td rowspan="3">Can be permitted if security conditions are considered to the possible extent</td></tr>
<tr><td>Campsites, accommodations areas and buildings associated with campsites</td><td>No</td><td rowspan="6">These activities do not usually occur in urbanized land. If they happen to exist, at least the corresponding security conditions must be guaranteed</td><td>Yes, with security conditions and outside the police area</td><td rowspan="2">To be avoided, unless there is no alternative location and if it is designed with security conditions</td></tr>
<tr><td>Urban waste water treatment plants</td><td>Only if there is no alternative location or if systems are compatible with floods</td><td>Only if there is no alternative location or if systems are compatible with floods</td></tr>
<tr><td>Greenhouses, non-permeable enclosures and fences, material or waste storage</td><td>No</td><td>No</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Changes in land morphology that could alter the capacity of discharge</td><td>No</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Livestock breeding farms</td><td>No</td><td>Yes, with security conditions and outside the police area</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Linear infrastructures in parallel to the riverbed</td><td>Only if there is no feasible alternative to these infrastructures and if the latter have been designed minimising risk</td><td>Only if there is no feasible alternative to these infrastructures and if the latter have been designed minimising risk</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Sanitation and water supply infrastructures and other underground pipes; works for maintenance, enhance and protection of existing infrastructures</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Buildings for agricultural use with a maximum of 40 m² and works associated with water uses allowed by Spanish Water Act</td><td>Yes, with security conditions</td><td>Yes, with security conditions</td><td>Yes, with security conditions</td><td>Yes</td><td>Yes</td></tr>
</table>

Figure 6-6 Flood Areas land use limitations as defined by under the Spanish Water Act.

Applicability of Approach

This approach is applicable where there is a good understanding of current flood risk determined through hydraulic modelling and mapping. The conditional criteria for different vulnerability classes in each Flood

Area require clear definition of the conditions and therefore is applicable where agreement on these criteria can be reached.

Benefits of Approach

The comprehensive categorisation of permitted land-use for each Flood Area creates a clear framework which practitioners (e.g. land-use planners) can use to assess development proposals. This practical framework also allows for efficient strategic planning and prioritisation by municipalities who can apply the land-use limitations and Flood Areas as a screening tool.

The inclusion of the Easement Use and Police Areas within the River Areas framework also acts to reduce uncertainty for potential developers and regulatory authorities by defining areas where development is not permitted.

Limitations of Approach

The national government has developed a technical guidance to help local authorities implement these new limitations. As these are minimum criteria, Autonomous Communities (informed by the River Basin Authorities) can establish additional land-use limitations in Flood-Prone areas in accordance with their competence in spatial planning. Some Autonomous Communities have already approved their own regulations and although an attempt has been made to ensure that the basic national regulations do not collide with already existing regional regulations, this has caused issues in some regions.

The use of the 1 in 500-year flood extent to define the Flood-Prone areas may be considered to be conservative in its judgement of flood risk. This could pose disproportionate mitigation requirements onto less vulnerable land-uses, such as campsites or commercial areas.

It is not clear how the demarcation of the Easement and Police areas would affect changes to existing development that may already be located within these areas. This may be the case in Urban centres where watercourses would be closer to existing buildings.

It is not clear how tidal influences are considered in coastal areas. Moreover, it is not clear how the potential for pluvial flood risk, particularly in urbanised catchments, has been considered.

The approach does not include for the impacts of climate change. While this may not increase flood depths in fluvial dominant floodplains, in tidal reaches, sea level rise due to climate change is likely to considerably increase flood risk.

Issues / key findings

In general, the transformation of flood risk into planning policy can be broken down into four distinct methods, increasing in comprehension and complexity:

6.3.

- Awareness of flood risk is raised in a broad sense, often at the stage of purchasing a property (e.g. Belgium, the Netherlands);
- Flood Risk is translated into a 'flood zone' defining an area where development activities are not permitted (e.g. Slovak Republic);
- Flood Risk is translated into 'flood zones' with differing likelihoods and impacts with regional defined land-use limits (e.g. Belgium, Austria); and
- Flood Risk is translated into 'flood zones' with differing likelihoods and impacts with nationally defined vulnerability classes and regulated limitations on land-uses (e.g. Spain, Republic of Ireland, Czech Republic).

Raising awareness of flood risk can be achieved during the purchase of a property, moving the responsibility from central, or local government and onto developers. In Belgium, for example, legislation was introduced to ensure that potential purchasers and renters of property are made aware of the associated flood risk before any contractual agreements are made. This approach brings attention to flooding and the potential risks and encourages home sellers to implement domestic-scale resilience measures to increase the value of their assets.

Preventing new development from worsening future flood risk can be achieved relatively quickly by limiting all development activities within a defined 'flood zone'. In the Slovak Republic, land-use planning is simplified by preventing any future development within the pre-defined 1 in 100-year flood zone.

In contrast, Belgium has a defined flood zone with regional variations in land-use limitations as defined by the local municipality. This approach ensures that land-use planning and risk mitigation are grounded in a local context. In Austria, a more complex method for differentiating between flood zones is applied using variations in flood hazard for the 1 in 100-year storm. However, much like Belgium, there are regional variations in the way in which these zones limit land-use.

The most comprehensive approach limits land-use by the type and vulnerability of its use in combination with the likelihood of flooding. In Spain, for example, land-use permitting is regulated at a national level

and considers the combination of the vulnerability of its use (e.g. schools, or residential housing) and the demarcation of a specific flood risk zone (e.g. preferential flood areas or flood prone areas). Legislation in Spain includes an additional level of consideration taking into account the setting of the site, either within a rural or urban context, giving a nuanced set of land-use limitations and development conditions.

The Czech Republic follows a similar approach to Spain in creating a range of land-use limitations based on the vulnerability of a development and the likelihood of flooding.

A secondary consideration to the development of land-use planning policy is the methods of interpreting flood risk data. Of the seven MS reviewed there are two approaches for translating flood risk data into flood zones:

- Using the flood extent(s) of a particular likelihood event(s); or
- Using the calculated flood hazard as the combination of flood depth and velocity.

Both methods of defining flood zones have their merits. Using the overall flood extents ensures that all future development is steered away from the floodplain and prevents locating more vulnerable land-uses within 'dry-islands' or in areas that would become isolated by floodwater. However, using flood hazard acknowledges that many areas of the floodplain, while inundated, may still be safe and suitable for many land-use practices.

7. PLANNING AND IMPLEMENTATION OF MEASURES

Definition and Context

7.1. Flood risk management measures can cover the full range from prevention and protection to response and recovery. It can be challenging to determine the right package of measures, balancing benefits, costs, impacts and opportunities and working with available funding.

At the planning level of FRM measures, there is a trend to work more risk- and evidence-based than has been done previously. Instead of basing planning and investment decisions solely on historic flooding, a larger appreciation for the actual flood risk of communities and the consequences of those floods forms the basis of the allocation of efforts and resources. At a local scale, when considering the implementation of flood protection and mitigation measures, it is becoming increasingly important to define a package of measures that meets a broad range of objectives and requirements, which are not solely confined to FRM. This requires consideration of wider benefits, rather than just flood risk reduction, to a larger group of recipients than the stakeholder group that would historically have been considered.

7.2. Six cases across three MS have been reviewed to assess the current practice in planning and implementation of FRM measures. The six cases cover the geographic and hydrological variations across the EU, giving opportunity to explore how approaches within different MS differ in their implementation of FRM aspects, from community engagement and resilience, to economics, to climate change.

Cases

7.2.1. Overview

This section presents six cases in which MS address various aspects of implementation planning, as follows:

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7.2.2. Austria - River Development and Risk Management Concept (GE-RM)

Context

The severe flood event along the Danube River and its tributaries in Europe 2002 initiated substantial revisions in flood protection and flood management in Austria.

An integrated risk management approach comprising a broad bundle of structural and non-structural measures is key, and FRM needs to be dealt with at a catchment scale.

Challenge

The main challenge is to coordinate between the objective of both directives (EU Floods Directive and EU Water Framework Directive) which might be significantly different or even contradictory. This, however, ties in with the wider challenge of balancing the interest of different stakeholders, communities and the environment in large river basins.

What is it?

GE-RM, or River Development and River Management Concepts (German / Austrian: *Gewässerentwicklungs- und Risikomanagementkonzept*), is a planning instrument that Austria uses for coordination of flood risk measures at a regional level with other sectors to prevent conflicts and create win-win solutions.

Approach

The eligibility check for funding of flood protection measures in Austria has to be conducted based on the GE-RM. These Concepts are coordinated with the objectives, measures and priorities of the National FRMP according to the FD as well as the goals of the National RBMP.

1. The integrated management approach follows a four-stage process,
2. which is also illustrated in Figure 7-1:

A preliminary study: reviewing existing data and determining which stakeholders should be involved.

Inventory taking: collecting the required data in relation to flood risk (FD), water quality (WFD) and 'boundary conditions' (other sectors such as nature, water use, land use, recreation). This inventory identifies the need for action and supplies missing data necessary to determine deficits, objectives, and measures in a later stage of the process.

Definition of objectives: working with all sectors to identify opportunities and challenges, and to identify a common target state in order to define objectives.

Creation of GE-RM: based on the common target state, the intended set of measures is selected from an extensive national catalogue.

3.

4.

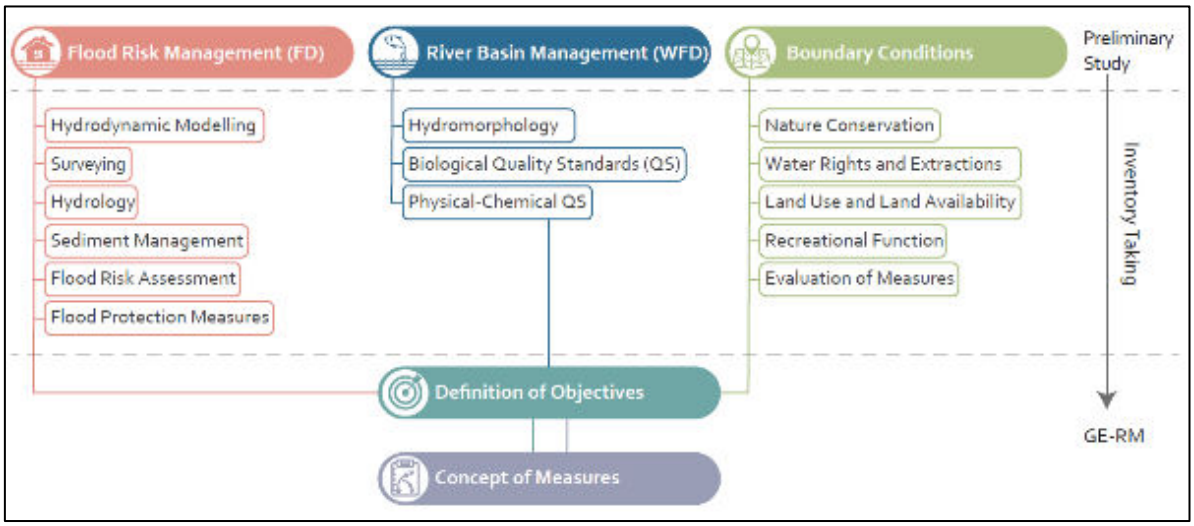

Figure 7-1: Schematic overview of the GE-RM process.

Although the GE-RM has only been carried out fully for one catchment; all nine provinces are starting to use it. Eight pilot projects are being developed for more challenging cross-province catchments, as part of LIFE IP project IRIS, and this will lead to improved guidance.

Applicability of Approach

A GE-RM is created primarily for water bodies and catchment areas with a need for action regarding FRM and river basin management. Other than flood hazard, ecological status, land use, zoning and third-party rights are also considered. The early inclusion of a wide range of stakeholders, aiming to define interdisciplinary objectives and measures, prevents clashes between stakeholders with different interest at a later stage of the project, and increase the chances of a successful implementation. This approach could work in MS with larger catchments, where catchment-wide approaches have the most benefit. It can also be beneficial for MS where communities struggle to gain funding – this approach could be a tool to get all stakeholders around the table, opening the way for partnership funding.

The final selection of potential measures is based on a national catalogue of measures. Most MS will not have such a catalogue, which will have to be developed specifically for type of river basins / catchments that are characteristic for that MS. Implementation will be easiest for MS similar to Austria, which limits the applicability.

Benefits of Approach

The tool developed allows for catchment-based planning, independent of administrative borders and therefore supports multi-level risk management.

The preparation of the GE-RM includes obligatory stakeholder involvement and participatory processes in order to increase awareness of flood risk, ecological state, and further relevant water management needs.

The process includes sectors, such as agriculture, which were not included in project planning before. Furthermore, there is a far closer (and institutionalised) inter-sectoral co-ordination and co-operation between flood risk managers, river basin managers, spatial planners, and emergency managers.

Limitations of Approach

The GE-RM has only been carried out fully for one catchment, which means that there is limited guidance on more complex catchment issues, as well as little experience with using this tool. The tool currently does not include prioritisation of measures.

7.2.3. Republic of Ireland – Calculation of Flood Damages using UK's Multi Coloured Manual

Context

The estimation of flood damages is an important parameter in determining the benefits of FRM measures, as well as to justify funding. A nationally established, standardised method can create consistency in the approach and valuation of potential projects.

Challenge

A robust and nationally consistent method for the calculation of flood related damages, both tangible and intangible, to inform the justification of government funding.

What is it?

To calculate economic risk / potential damages, the Republic of Ireland uses the publication Flood and Coastal Erosion Risk Management - A Manual for Economic Appraisal, called the Multi Coloured Manual (MCM), developed by the Flood Hazard Research Centre and The Environment Agency in the UK: a method and guidance that provides calculation rules and associated data to be used in developing business cases for government funding.

Approach

The economic risk (potential damages) in each of the APSFRs is calculated for each climate scenario (current, and two future scenarios) based on the flood extents, levels and types of property potentially affected for up to eight flood event magnitudes / probabilities. The event damage for each probability is then integrated against probability to determine an Annual Average Damage, which is then discounted to provide a Net Present Value (NPV) (damages) and a potential NPV (benefits). The latter is compared to the NPV costs to derive a benefit-cost ratio (BCR).

The MCM is a manual that provides a range of techniques and data that can be used to assess the benefits of fluvial and coastal flood risk and coastal erosion. The data is underpinned by research on damage and impact of flooding and coastal erosion. The main reasons for adapting the MCM to the Irish situation and not developing a specific Irish method, are the lack of recorded damage data in Ireland and the similarity of property types between Ireland and the UK. Instead, the damage data from the UK is used, converted to Irish prices using the OECD Purchasing Price Parity data and corrected for the Irish inflation.

In some respects, the Irish method has evolved from the standard UK MCM and has been adapted for application in Ireland. The calculation of intangibles has been simplified; the allowance for intangibles is taken equal to the direct damages; this is intended to provide for a range of indirect and intangible damages, as well as just mental health and stress. Furthermore, the costs for emergency response are different in Ireland and these differences have been accounted for in the Irish method. Additionally, no agricultural damages are currently included and, as Ireland has no deprivation index, the factor derived from the deprivation index is excluded from calculations as well. There were no major costs involved with adapting the UK method to the Irish situation.

The Office of Public Works (OPW) has recently commissioned a project to assess options for incorporating a wider range of impacts and benefits of flood relief, such as with regards to the public realm, environment, cultural heritage and amenity, into the CBA and project appraisal process. This project should be completed in the Summer of 2021 and may well inform updates and amendments to the project appraisal process.

Applicability of Approach

The analysis in the MCM requires certain datasets as input (property data, height data, etc). Although the general method of the MCM can be applied to any MS, the specific data on damage impacts and types of buildings and infrastructure should be readily available; otherwise it

will have to produce it in the process of adapting the MCM to the specific MS. This is especially true for the damage data, which based on building types, build-up of society, economy, types of damages etc. in the UK (and Ireland); especially the transferability of this dataset from the UK was one of the reasons to implement the MCM in Ireland. Where the construction types, methods and materials are very different to that in UK or Ireland, then direct transfer of the data could lead to significant errors.

Benefits of Approach

This practice has been established and used in Ireland for many years. However, in its absence, the estimation of flood damages would be a lot more difficult and less robust.

The extensive dataset and common methodologies have been built up and refined over a number of decades. Their application on a national scale helps to ensure consistency of approach and valuation.

The similarity between the Republic of Ireland and the UK enables the direct use of the dataset of damages to properties. If this hadn't been the case, significant investment in the development of a bespoke, similar dataset would have been required.

Limitations of Approach

The original method relies on a number of datasets (damages dataset, deprivation index) that are not applicable or available to other MS. This may make the application of this method to other nations more elaborate and will cost more effort than in the Irish case.

In the Irish version approach to economic CBA, intangible damages are simplified. Although this makes for an easier application, it does remove a layer of detail from the approach. Other MS can also focus on a core set of data and methods of most relevance to them, thereby reducing the limitations.

7.2.4. Republic of Ireland – Multi-Criteria Analysis (MCA) to Assess Flood Risk Management Measure across a Range of Objectives

Context

To justify the investment of implementing (a suite of) FRM measures and to compare the cost-effectiveness of different suites of options for the same location, the costs of the measures need to be weighed against the benefits and impacts such measures deliver. This can be done using a cost-benefit analysis (CBA). Traditionally, these weighed

the costs of the FRM measures against their direct monetary benefits of providing flood protection to homes and infrastructure.

Challenge

The traditional, straight-forward CBA does not take the additional benefits of implementing FRM measures to other sectors into account. As wider benefits can lead to wider acceptance of FRM measures and potentially different, additional sources of funding, it is important to value these appropriately in cost-effectiveness comparisons (and even prioritisation) and thus a different method of assessing potential suites of measures was needed.

What is it?

The Multi Criteria Analysis (MCA) for the Catchment Flood Risk Assessment and Management (CFRAM) Programme was developed to identify overall benefits and impacts of potential schemes within the programme across a broad range of multi-sectoral objectives. The MCA provides a decision-support system for selecting preferred measures for a given location, but can in theory also be applied for the prioritisation of measures at, for example, a national level.

Approach

The MCA sets nation-wide Basic Requirements and Aspirational Targets for a range of objectives that schemes should aim to achieve (Table 7-1). These objectives fall within three pillars; people (social), economy and the environment. The Basic Requirement represents a neutral status or 'no change'; in this case, an option has either no negative impact on the objective or meets the minimum requirements for acceptability. The aim is defined as the Aspirational Target; this either represents the full removal of a risk, or full achievement of another benefit.

The objectives within each pillar are only weighted against other objectives in that same pillar. This reflects the societal value of these objectives at two different levels; global (nation-wide) and local. Each of the three pillars has the same weighting overall.

- The global weightings were informed by wide-spread public consultation to reflect the societal values of the objectives to Irish society as a whole.
- The local weightings are based on local considerations and these weightings should be taken into account when the scheme is in the local consultation phase. These local weightings are applied on top of the global weightings to reflect the local importance of that objective.

The assessment of a scheme or project is based on a numeric, but non-monetarised assessment of the options against the range of objectives, whereby indicators are set for each objective. These indicators are used to define scores for that objective based on the degree to which the option goes beyond the Basic Requirement for that objective towards meeting the Aspirational Target. The degree to which an option achieves the objective is an indication of the 'success' of the option, and equally, the more an option achieves across all of the objectives, then the greater the preference that will be given to that option relative to others, taking account also of the cost of each of the options. Scoring is defined in Table 7-1**Error! Reference source not found.**.

The final Criteria Scores for each of the pillars can be derived using the scores and global / local weightings for the objectives in that pillar. The MCA Benefit Score is derived by summing the Criteria Scores for the social, economic and environment pillars – this represents the net benefits of the options. Adding the Criteria Score of the technical pillar gives the Option Selection MCA Score.

Table 7-1 FRM objectives in the MCA, and their associated Global Weightings (as defined in OPW (2018). Technical Methodology Note - Option Appraisal and the MCA Framework).

CRITERIA		OBJECTIVE		SUB-OBJECTIVE		GLOBAL WEIGHTING
1	Social	a	Minimise risk to human health and life	i)	Minimise risk to human health and life of residents	27
				ii)	Minimise risk to high vulnerability properties	17
		b	Minimise risk to community	i)	Minimise risk to social infrastructure and amenity	9
				ii)	Minimise risk to local employment	7
2	Economic	a	Minimise economic risk	i)	Minimise economic risk	24
		b	Minimise risk to transport infrastructure	i)	Minimise risk to transport infrastructure	10
		c	Minimise risk to utility infrastructure	i)	Minimise risk to utility infrastructure	14
		d	Minimise risk to agriculture	i)	Minimise risk to agriculture	12
3	Environmental	a	Support the objectives of the WFD	i)	Provide no impediment to the achievement of water body objectives and, if possible, contribute to the achievement of water body objectives.	16
		b	Support the objectives of the Habitats Directive	i)	Avoid detrimental effects to, and where possible enhance, Natura 2000 network, protected species and their key habitats, recognising relevant landscape features and stepping stones.	10
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	i)	Avoid damage to or loss of, and where possible enhance, nature conservation sites and protected species or other know species of conservation concern.	5
		d	Protect, and where possible enhance, fisheries resource within the catchment	i)	Maintain existing, and where possible create new, fisheries habitat including the maintenance or improvement of conditions that allow upstream migration for fish species.	13
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	i)	Protect, and where possible enhance, visual amenity, landscape protection zones and views into / from designated scenic areas within the river corridor.	8
		f	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting	i)	Avoid damage to or loss of features, institutions and collections of architectural value and their setting.	4
				ii)	Avoid damage to or loss of features, institutions and collections of archaeological value and their setting.	4
4	Technical	a	Ensure flood risk management options are operationally robust	i)	Ensure flood risk management options are operationally robust	20
		b	Minimise health and safety risks associated with the construction, operation and maintenance of flood risk management options	i)	Minimise health and safety risks associated with the construction, operation and maintenance of flood risk management options	20
		c	Ensure flood risk management options are adaptable to future flood risk, and the potential impacts of climate change	i)	Ensure flood risk management options are adaptable to future flood risk, and the potential impacts of climate change	20

Table 7-2: Scoring against objectives (as defined in OPW (2019) TMN Option Appraisal and the MCA Framework).

Degree of "Success" of Option	Score
Meets the Basic Requirements	0
Meets the Aspirational Target, or exceeds this target	+5
Performs somewhere between Basic Requirement and Aspirational Target	Score between 0 and +5 proportional to the degree of success
Performs worse than the Basic Requirements	Score between 0 and -5 proportional to the degree of success
Performance unacceptable.	-999 to exclude option from further consideration

Applicability of Approach

The MCA framework is rigorous and works well. It can therefore, in theory, be applied in any MS; tailored as necessary to the local contexts. While this rigour could make the MCA framework a time-consuming method, it is usually time well spent.

A key feature of the MCA framework is that it should represent societal values. To this end, nationally representative quantitative research was undertaken to determine global weights that reflect the perceived importance of each of the objectives for reducing economic, social and environmental / cultural risks in flood management strategies. These societal values, and thus the global weights, will differ in each MS. Therefore, any MS adopting this MCA framework would need to agree weightings suitable for them through consultation with a range of stakeholders, for example, in workshop format. This may be less robust than the detailed research applied in this case example, but much easier to apply.

Benefits of Approach

The MCA works well; in most instances the case selected by the MCA would also be the recommended case. The MCA result has proven to be societally accepted as well in most cases. There is room for professional judgement and local considerations that are difficult to reflect in the otherwise rigid CBA.

Objectives regarding people, environment and economy are valued within their own pillar. This means that economic considerations will not affect the weighting of the environmental objectives and their impact on the outcome of the analysis.

Although the CFRAM programme was initiated before the implementation of the FD, with a few tweaks it was able to deliver the requirements set by the FD. The MCA is also likely to be used for monitoring progress in the 3rd FRMP cycle.

Limitations of Approach

Although the MCA works well, it is rigorous and thus time consuming.

Due to the complexity of the method, the MCA was not used for prioritisation in the end – it would have been overly complex to explain the prioritisation process based on the MCA to, for example, the public.

- United Kingdom – Communities at Risk Register (CaRR) (Section 7.2.9)

- United Kingdom – SEPA Flooding Services Strategy (Section 7.2.10)
- United Kingdom – Working with Natural Processes (WWNP) (Section **Error! Reference source not found.**)

The Austrian River Development and Risk Management Concept (GE-RM) is also described in Chapter 10 Measuring Progress.

7.2.5. Austria - River Development and Risk Management Concept (GE-RM)

Context

The severe flood event along the Danube River and its tributaries in Europe 2002 initiated substantial revisions in flood protection and flood management in Austria.

An integrated risk management approach comprising a broad bundle of structural and non-structural measures is key, and FRM needs to be dealt with at a catchment scale.

Challenge

The main challenge is to coordinate between the objective of both directives (EU Floods Directive and EU Water Framework Directive) which might be significantly different or even contradictory. This, however, ties in with the wider challenge of balancing the interest of different stakeholders, communities and the environment in large river basins.

What is it?

GE-RM, or River Development and River Management Concepts (German / Austrian: *Gewässerentwicklungs- und Risikomanagementkonzept*), is a planning instrument that Austria uses for coordination of flood risk measures at a regional level with other sectors to prevent conflicts and create win-win solutions.

Approach

The eligibility check for funding of flood protection measures in Austria has to be conducted based on the GE-RM. These Concepts are coordinated with the objectives, measures and priorities of the National FRMP according to the FD as well as the goals of the National RBMP. The integrated management approach follows a four-stage process, which is also illustrated in Figure 7-1:

A preliminary study: reviewing existing data and determining which stakeholders should be involved.

Inventory taking: collecting the required data in relation to flood risk (FD), water quality (WFD) and 'boundary conditions' (other sectors such as nature, water use, land use, recreation). This inventory identifies the need for action and supplies missing data necessary to determine deficits, objectives, and measures in a later stage of the process.

Definition of objectives: working with all sectors to identify opportunities and challenges, and to identify a common target state in order to define objectives.

Creation of GE-RM: based on the common target state, the intended set of measures is selected from an extensive national catalogue.

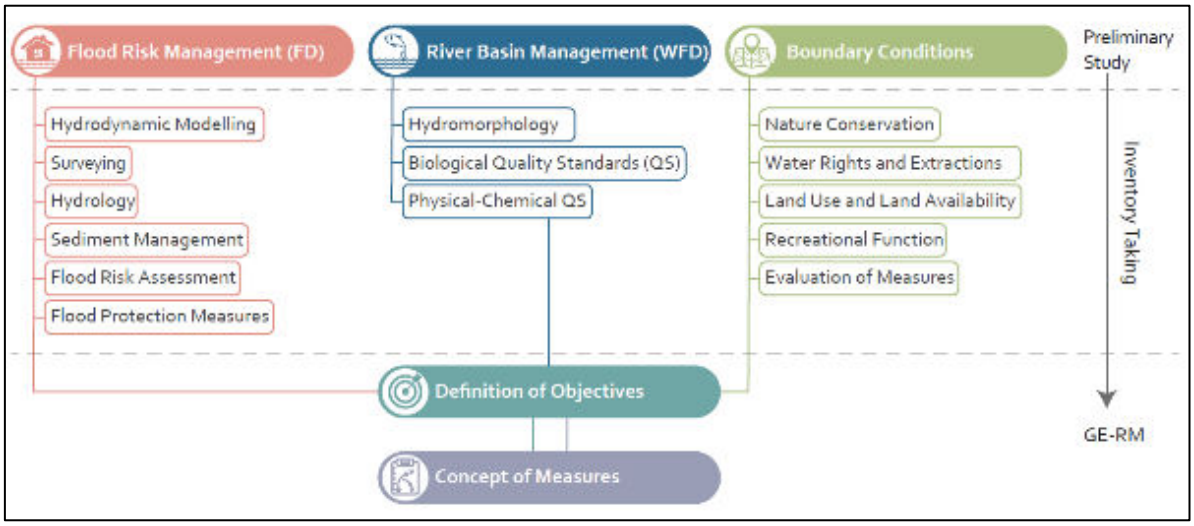

Figure 7-1: Schematic overview of the GE-RM process.

Although the GE-RM has only been carried out fully for one catchment; all nine provinces are starting to use it. Eight pilot projects are being developed for more challenging cross-province catchments, as part of LIFE IP project IRIS, and this will lead to improved guidance.

Applicability of Approach

A GE-RM is created primarily for water bodies and catchment areas with a need for action regarding FRM and river basin management. Other than flood hazard, ecological status, land use, zoning and third-party rights are also considered. The early inclusion of a wide range of stakeholders, aiming to define interdisciplinary objectives and measures, prevents clashes between stakeholders with different interest at a later stage of the project, and increase the chances of a successful implementation. This approach could work in MS with larger catchments, where catchment-wide approaches have the most benefit.

It can also be beneficial for MS where communities struggle to gain funding – this approach could be a tool to get all stakeholders around the table, opening the way for partnership funding.

The final selection of potential measures is based on a national catalogue of measures. Most MS will not have such a catalogue, which will have to be developed specifically for type of river basins / catchments that are characteristic for that MS. Implementation will be easiest for MS similar to Austria, which limits the applicability.

Benefits of Approach

The tool developed allows for catchment-based planning, independent of administrative borders and therefore supports multi-level risk management.

The preparation of the GE-RM includes obligatory stakeholder involvement and participatory processes in order to increase awareness of flood risk, ecological state, and further relevant water management needs.

The process includes sectors, such as agriculture, which were not included in project planning before. Furthermore, there is a far closer (and institutionalised) inter-sectoral co-ordination and co-operation between flood risk managers, river basin managers, spatial planners, and emergency managers.

Limitations of Approach

The GE-RM has only been carried out fully for one catchment, which means that there is limited guidance on more complex catchment issues, as well as little experience with using this tool. The tool currently does not include prioritisation of measures.

7.2.6. Republic of Ireland – Calculation of Flood Damages using UK's Multi Coloured Manual

Context

The estimation of flood damages is an important parameter in determining the benefits of FRM measures, as well as to justify funding. A nationally established, standardised method can create consistency in the approach and valuation of potential projects.

Challenge

A robust and nationally consistent method for the calculation of flood related damages, both tangible and intangible, to inform the justification of government funding.

What is it?

To calculate economic risk / potential damages, the Republic of Ireland uses the publication Flood and Coastal Erosion Risk Management - A Manual for Economic Appraisal, called the Multi Coloured Manual (MCM), developed by the Flood Hazard Research Centre and The Environment Agency in the UK: a method and guidance that provides calculation rules and associated data to be used in developing business cases for government funding.

Approach

The economic risk (potential damages) in each of the APSFRs is calculated for each climate scenario (current, and two future scenarios) based on the flood extents, levels and types of property potentially affected for up to eight flood event magnitudes / probabilities. The event damage for each probability is then integrated against probability to determine an Annual Average Damage, which is then discounted to provide a Net Present Value (NPV) (damages) and a potential NPV (benefits). The latter is compared to the NPV costs to derive a benefit-cost ratio (BCR).

The MCM is a manual that provides a range of techniques and data that can be used to assess the benefits of fluvial and coastal flood risk and coastal erosion. The data is underpinned by research on damage and impact of flooding and coastal erosion. The main reasons for adapting the MCM to the Irish situation and not developing a specific Irish method, are the lack of recorded damage data in Ireland and the similarity of property types between Ireland and the UK. Instead, the damage data from the UK is used, converted to Irish prices using the OECD Purchasing Price Parity data and corrected for the Irish inflation.

In some respects, the Irish method has evolved from the standard UK MCM and has been adapted for application in Ireland. The calculation of intangibles has been simplified; the allowance for intangibles is taken equal to the direct damages; this is intended to provide for a range of indirect and intangible damages, as well as just mental health and stress. Furthermore, the costs for emergency response are different in Ireland and these differences have been accounted for in the Irish method. Additionally, no agricultural damages are currently included and, as Ireland has no deprivation index, the factor derived from the deprivation index is excluded from calculations as well. There were no major costs involved with adapting the UK method to the Irish situation.

The Office of Public Works (OPW) has recently commissioned a project to assess options for incorporating a wider range of impacts and benefits of flood relief, such as with regards to the public realm, environment, cultural heritage and amenity, into the CBA and project appraisal

process. This project should be completed in the Summer of 2021 and may well inform updates and amendments to the project appraisal process.

Applicability of Approach

The analysis in the MCM requires certain datasets as input (property data, height data, etc). Although the general method of the MCM can be applied to any MS, the specific data on damage impacts and types of buildings and infrastructure should be readily available; otherwise it will have to produce it in the process of adapting the MCM to the specific MS. This is especially true for the damage data, which based on building types, build-up of society, economy, types of damages etc. in the UK (and Ireland); especially the transferability of this dataset from the UK was one of the reasons to implement the MCM in Ireland. Where the construction types, methods and materials are very different to that in UK or Ireland, then direct transfer of the data could lead to significant errors.

Benefits of Approach

This practice has been established and used in Ireland for many years. However, in its absence, the estimation of flood damages would be a lot more difficult and less robust.

The extensive dataset and common methodologies have been built up and refined over a number of decades. Their application on a national scale helps to ensure consistency of approach and valuation.

The similarity between the Republic of Ireland and the UK enables the direct use of the dataset of damages to properties. If this hadn’t been the case, significant investment in the development of a bespoke, similar dataset would have been required.

Limitations of Approach

The original method relies on a number of datasets (damages dataset, deprivation index) that are not applicable or available to other MS. This may make the application of this method to other nations more elaborate and will cost more effort than in the Irish case.

In the Irish version approach to economic CBA, intangible damages are simplified. Although this makes for an easier application, it does remove a layer of detail from the approach. Other MS can also focus on a core set of data and methods of most relevance to them, thereby reducing the limitations.

7.2.7. Republic of Ireland – Multi-Criteria Analysis (MCA) to Assess Flood Risk Management Measure across a Range of Objectives

Context

To justify the investment of implementing (a suite of) FRM measures and to compare the cost-effectiveness of different suites of options for the same location, the costs of the measures need to be weighed against the benefits and impacts such measures deliver. This can be done using a cost-benefit analysis (CBA). Traditionally, these weighed the costs of the FRM measures against their direct monetary benefits of providing flood protection to homes and infrastructure.

Challenge

The traditional, straight-forward CBA does not take the additional benefits of implementing FRM measures to other sectors into account. As wider benefits can lead to wider acceptance of FRM measures and potentially different, additional sources of funding, it is important to value these appropriately in cost-effectiveness comparisons (and even prioritisation) and thus a different method of assessing potential suites of measures was needed.

What is it?

The Multi Criteria Analysis (MCA) for the Catchment Flood Risk Assessment and Management (CFRAM) Programme was developed to identify overall benefits and impacts of potential schemes within the programme across a broad range of multi-sectoral objectives. The MCA provides a decision-support system for selecting preferred measures for a given location, but can in theory also be applied for the prioritisation of measures at, for example, a national level.

Approach

The MCA sets nation-wide Basic Requirements and Aspirational Targets for a range of objectives that schemes should aim to achieve (Table 7-1). These objectives fall within three pillars; people (social), economy and the environment. The Basic Requirement represents a neutral status or 'no change'; in this case, an option has either no negative impact on the objective or meets the minimum requirements for acceptability. The aim is defined as the Aspirational Target; this either represents the full removal of a risk, or full achievement of another benefit.

The objectives within each pillar are only weighted against other objectives in that same pillar. This reflects the societal value of these objectives at two different levels; global (nation-wide) and local. Each of the three pillars has the same weighting overall.

- The global weightings were informed by wide-spread public consultation to reflect the societal values of the objectives to Irish society as a whole.

- The local weightings are based on local considerations and these weightings should be taken into account when the scheme is in the local consultation phase. These local weightings are applied on top of the global weightings to reflect the local importance of that objective.

The assessment of a scheme or project is based on a numeric, but non-monetarised assessment of the options against the range of objectives, whereby indicators are set for each objective. These indicators are used to define scores for that objective based on the degree to which the option goes beyond the Basic Requirement for that objective towards meeting the Aspirational Target. The degree to which an option achieves the objective is an indication of the 'success' of the option, and equally, the more an option achieves across all of the objectives, then the greater the preference that will be given to that option relative to others, taking account also of the cost of each of the options. Scoring is defined in Table 7-1**Error! Reference source not found.**.

The final Criteria Scores for each of the pillars can be derived using the scores and global / local weightings for the objectives in that pillar. The MCA Benefit Score is derived by summing the Criteria Scores for the social, economic and environment pillars – this represents the net benefits of the options. Adding the Criteria Score of the technical pillar gives the Option Selection MCA Score.

Table 7-1 FRM objectives in the MCA, and their associated Global Weightings (as defined in OPW (2018). Technical Methodology Note - Option Appraisal and the MCA Framework).

CRITERIA		OBJECTIVE		SUB-OBJECTIVE		GLOBAL WEIGHTING
1	Social	a	Minimise risk to human health and life	i)	Minimise risk to human health and life of residents	27
				ii)	Minimise risk to high vulnerability properties	17
		b	Minimise risk to community	i)	Minimise risk to social infrastructure and amenity	9
				ii)	Minimise risk to local employment	7
2	Economic	a	Minimise economic risk	i)	Minimise economic risk	24
		b	Minimise risk to transport infrastructure	i)	Minimise risk to transport infrastructure	10
		c	Minimise risk to utility infrastructure	i)	Minimise risk to utility infrastructure	14
		d	Minimise risk to agriculture	i)	Minimise risk to agriculture	12
3	Environmental	a	Support the objectives of the WFD	i)	Provide no impediment to the achievement of water body objectives and, if possible, contribute to the achievement of water body objectives.	16
		b	Support the objectives of the Habitats Directive	i)	Avoid detrimental effects to, and where possible enhance, Natura 2000 network, protected species and their key habitats, recognising relevant landscape features and stepping stones.	10
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	i)	Avoid damage to or loss of, and where possible enhance, nature conservation sites and protected species or other know species of conservation concern.	5
		d	Protect, and where possible enhance, fisheries resource within the catchment	i)	Maintain existing, and where possible create new, fisheries habitat including the maintenance or improvement of conditions that allow upstream migration for fish species.	13
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	i)	Protect, and where possible enhance, visual amenity, landscape protection zones and views into / from designated scenic areas within the river corridor.	8
		f	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting	i)	Avoid damage to or loss of features, institutions and collections of architectural value and their setting.	4
				ii)	Avoid damage to or loss of features, institutions and collections of archaeological value and their setting.	4
4	Technical	a	Ensure flood risk management options are operationally robust	i)	Ensure flood risk management options are operationally robust	20
		b	Minimise health and safety risks associated with the construction, operation and maintenance of flood risk management options	i)	Minimise health and safety risks associated with the construction, operation and maintenance of flood risk management options	20
		c	Ensure flood risk management options are adaptable to future flood risk, and the potential impacts of climate change	i)	Ensure flood risk management options are adaptable to future flood risk, and the potential impacts of climate change	20

Table 7-2: Scoring against objectives (as defined in OPW (2019) TMN Option Appraisal and the MCA Framework).

Degree of "Success" of Option	Score
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Performs worse than the Basic Requirements	Score between 0 and -5 proportional to the degree of success
Performance unacceptable.	-999 to exclude option from further consideration

Applicability of Approach

The MCA framework is rigorous and works well. It can therefore, in theory, be applied in any MS; tailored as necessary to the local contexts. While this rigour could make the MCA framework a time-consuming method, it is usually time well spent.

A key feature of the MCA framework is that it should represent societal values. To this end, nationally representative quantitative research was undertaken to determine global weights that reflect the perceived importance of each of the objectives for reducing economic, social and environmental / cultural risks in flood management strategies. These societal values, and thus the global weights, will differ in each MS. Therefore, any MS adopting this MCA framework would need to agree weightings suitable for them through consultation with a range of stakeholders, for example, in workshop format. This may be less robust than the detailed research applied in this case example, but much easier to apply.

Benefits of Approach

The MCA works well; in most instances the case selected by the MCA would also be the recommended case. The MCA result has proven to be societally accepted as well in most cases. There is room for professional judgement and local considerations that are difficult to reflect in the otherwise rigid CBA.

Objectives regarding people, environment and economy are valued within their own pillar. This means that economic considerations will not affect the weighting of the environmental objectives and their impact on the outcome of the analysis.

Although the CFRAM programme was initiated before the implementation of the FD, with a few tweaks it was able to deliver the requirements set by the FD. The MCA is also likely to be used for monitoring progress in the 3rd FRMP cycle.

Limitations of Approach

Although the MCA works well, it is rigorous and thus time consuming.

Due to the complexity of the method, the MCA was not used for prioritisation in the end – it would have been overly complex to explain the prioritisation process based on the MCA to, for example, the public.

7.2.8. United Kingdom – Communities at Risk Register (CaRR)

Context

Numerous communities are in need of the implementation of FRM measures. With only limited funding and resources available, central government needs to prioritise to which projects the funds are allocated and their relative priorities for implementation.

Challenge

The flood risk of a community has historically been assessed based on what was already known and using subjective measures that are difficult to repeat consistently. This assessment was often undertaken 'per source' with little consideration given to the relative risk from the different sources of flooding. It was chasing historic floods to prioritise FRM works, rather than following a proper risk and evidence-based approach. A new method was needed to be able to prioritise and take forward FRM measures more effectively based on the probabilities of floods occurring and the consequences those floods might have.

What is it?

The Communities at Risk Register (CaRR) is an internal planning tool within Natural Resources Wales (NRW) to determine which areas in Wales need to be prioritised for resources for FRM, based on a flood risk approach rather than a reactive approach to historic floods. CaRR is currently used for two purposes: not only by NRW for its original aim of prioritising its work plans, but also by the Welsh Government as one of the factors for allocating funding.

Approach

This methodology is based on the Flood Risks to People study by Defra and the Environment Agency for England. CaRR uses outputs from flood models to consider the number of people at risk from Fluvial, Tidal and Pluvial water, the hazard they are exposed to over a range of probabilities, the speed of onset of flooding and their ability to respond in terms of social vulnerability to flooding, as well as factors such as availability and standard of flood warnings and flood defences. This data comes from the national database of the Flood Risk Assessment Wales (FRAW). This database is generated by a single 2D model for the whole of Wales, rather than from different, local models; the use of this database provides more consistency to CaRR. Based on the data, "Danger" scores are calculated at an individual receptor (property) level (**Error! Reference source not found.**). For r esidential properties, the property-level score is derived by multiplying the scores of the four metrics in

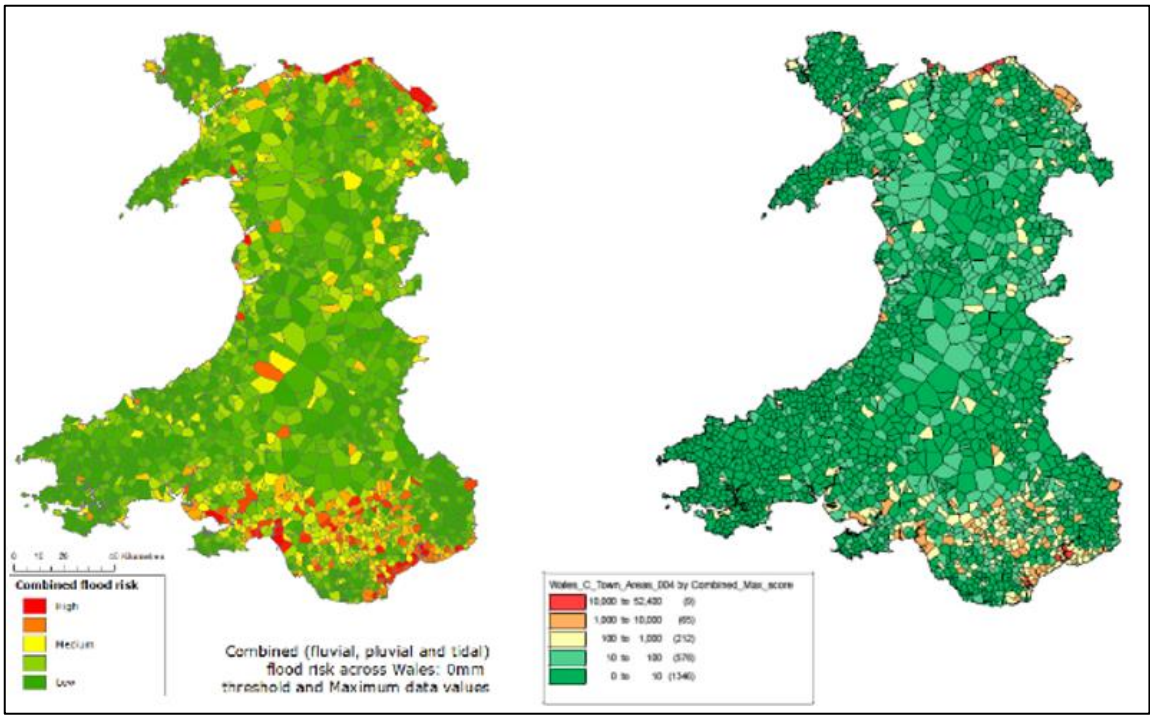

Figure 7-2 The Combined Flood Risk per community (left; adapted from NRW (2019a). Flood Risk Assessment Wales: Communities at Risk Register, Information Sheet, NRW – April 2019) and Combined Max Danger Score per community (right; adapted from NRW (2019b) Analysing Danger from Flooding 007, FRAW project 2019).

Table 7-3.

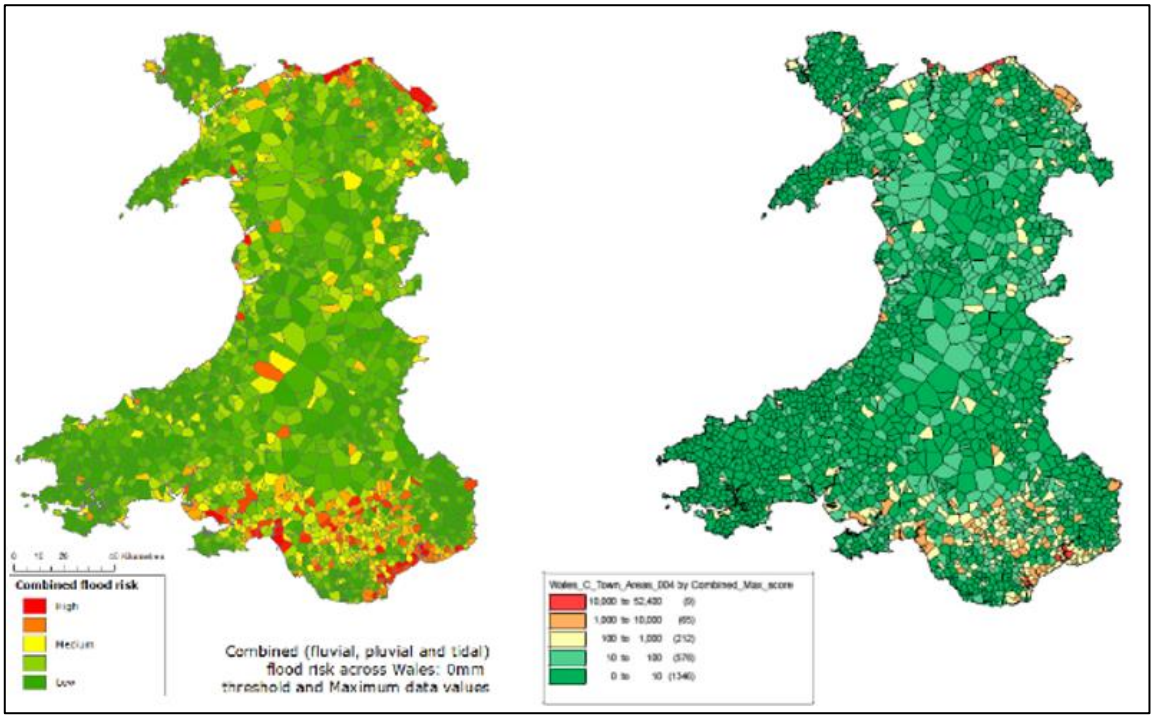

Figure 7-2 The Combined Flood Risk per community (left; adapted from NRW (2019a). Flood Risk Assessment Wales: Communities at Risk Register, Information Sheet, NRW – April 2019) and Combined Max Danger Score per community (right; adapted from NRW (2019b) Analysing Danger from Flooding 007, FRAW project 2019).

Table 7-3: Attributes determining the Property Scoring.

Attribute	Score
Number of people at risk [number of people per household]	n
Hazard = ((velocity – 0.5) * depth) + Debris Factor [Debris Factor = 0.5 for depth < 0.25 m; 1.0 for depth >= 0.25 m]	Range 1 to 4
Speed of Onset – derived from 'Time to Peak'	Range 1 to 3
Vulnerability	Range 1 to 5

For non-residential properties, the monetary value of the damages is converted to an equivalent of the property scoring for residential properties, based on the data on damages in the Multi-Coloured Manual. Using the National Receptor Dataset, non-residential properties have been classified as "Business", "Education", "Emergency", "Health", "Home", "Transport" and "Utility".

The property-level scores are annualised and aggregated to a Community level (as taken from the Ordnance Survey 1:250,000 towns definition). This results in a **Max** score (natural, undefended scenario)

and a **Min** score (for a mitigated scenario based on the presence of defences and flood warning systems) per community. Based on those community scores, the communities are ranked in order of absolute danger.

As flood defences and mitigation measures are included in CaRR, the register is rerun annually to update for completion of new or improved major flood risk infrastructure or other developments, such as new flood warning schemes. This generates a new ranked list and thus an updated CaRR. The underlying data from the FRAW database and the National Receptor Database (NRD) will be updated annually. Therefore, the Impacts Analysis of CaRR needs to be updated annually as well. No local validation has taken place of the national models that are used as input for CaRR. Local input and feedback will, however, be included in the annual updates via the FRAW process (for example because local models will be included in this database after an intervention has taken place).

For the prioritisation of NRW's work plans, the danger scores from each community are ranked for each risk source (Fluvial, Tidal, Pluvial) and this forms the basis for developing work plans and consideration of initiating further local analysis which could lead to flood schemes being proposed. Through this approach the highest risk communities (50 for each of the three Welsh regions) are prioritised and plans are identified to reduce flood risk in each of these highest ranked communities.

CaRR is now also used by the Welsh Government to allocate Flood and Coastal Erosion Risk Management (FCERM) funds to NRW and the Local Authorities. To prioritise Outline Business Cases (OBCs) and Business Justification Cases (Pre OBC; BJCs) to be undertaken, the Max rank of a community is used as a criterium to score proposed projects, in combination with the following other metrics:

- Actual flood event (frequency and impact);
- Number of homes expected to benefit from future scheme;
- Potential opportunities for partnership funding;
- Potential opportunities for wider benefits.

CaRR and the Actual flood events criteria each represent 40 points out of 100. This is a political decision to enable investment in reactive work to address recent and recurrent flooding as well, that otherwise might not qualify. For a Full Business Case (FBC) to be undertaken, additional economic factors are taken into account (including BCR and Cost per home). Furthermore, the weight of CaRR and Actual flood events is less heavy in this case (30/100 each), reflecting the increased importance of economics at the level of an FBC.

Applicability of Approach

Applicable to MS where a risk and evidence-based approach to prioritisation of FRM measures or FCERM funding has not yet been implemented, or where consistency between regions could be improved.

The approach relies on a number of specific receptor datasets. In MS where these is not readily available, this will form an extra challenge to implementing this approach. The same holds for the availability of suitable model data; although the method can be implemented using local flood models, the consistency will be improved significantly if a nation-, or even region-wide flood risk model is used.

Benefits of Approach

The main advantage of CaRR to NRW is that it highlights medium- and long-term investment needs in FCERM and it helps with developing a long-term investment strategy.

CaRR furthermore provides more consistency in the way information is generated. It improves the transparency in the decision-making; even at the national level (where CaRR has only been included to a limited extent), the quality around decision-making regarding FCERM funding allocation has improved significantly. It is now a more risk and evidence-based process, rather than chasing historic floods.

Limitations of Approach

CaRR should not be used just on its own, but rather as a tool to support scheme development initiated based on local considerations. The Danger score is not the complete story; communities with a high danger score might expect action to be a certainty, even where that might be unjustified. A large population at risk, for example, will always lead to a high danger score, even if significant flood defences have already been implemented. CaRR is therefore currently aimed at a professional / practitioner audience as it is complicated to explain to the public and communities.

The inclusion of actual flood events in the national allocation of FCERM funds makes it difficult to steer investments proactively at a national level. Rather than only following a risk and hazard informed approach, the method is equally driven by historical flood evidence.

In some instances, confidence in utilising the national scale modelling is challenged by stakeholders, whilst this approach provides consistency at a national scale, concerns are raised when improved localised modelling is available. It is expected however, that when local data starts to feed back into the CaRR, this will initiate more engagement between Risk Management Authorities and thus reduce these concerns.

7.2.9. United Kingdom – SEPA Flooding Services Strategy

Context

Flooding is likely to increase in the future, particularly due to rising sea levels, increased surface water and from rivers. The uncertainty in climate change predictions affect the certainty with which future floods can be predicted as well.

In Scotland, communities, through their local government, have the authority to build and maintain FRM measures. It is part of SEPA's role to support communities to avoid flood risk where they can, adapt where they cannot and act when warned of flooding.

Challenge

To make sure that Scottish communities have a suite of adaptation measures in place enabling them to be successful in the face of future flood risks.

What is it?

SEPA is in the final stages of producing a Flooding Services Strategy. This provides a direction and ambition in the delivery of their flood duties. Its vision is that "Scotland's people and places are resilient to flooding". Its key themes are on being future-focussed, people centred and extended partnership working.

Approach

The new strategy supports a transition from plan-led FRM to adaptive FRM (Figure 7-3). Climate uncertainties influence flood risk and therefore SEPA is now moving to plan for a range of possible futures. The aim is to create successful, resilient places, which will have infrastructure that is well adapted to the changing climate and where communities are able to collaborate with agencies and public bodies to enhance their environment. The strategy recognises that climate change disproportionately affects those who are most disadvantaged, and therefore aims to put people at the heart of the decision-making about their places. A key principle is partnership and going beyond the traditional 'suite' of partners. Although it takes significant effort to actively involve all actors and stakeholders, this is happening increasingly in many major places in Scotland. The strategy is a first step to mainstream this approach for the whole of Scotland.

Figure 7-3: Transition in approach to Flood Risk Management. From SEPA (2020) SEPA Flooding Services Strategy Consultation Draft.

The strategy recognises that successful, resilient places will have infrastructure that is well adapted to the changing climate and where communities are able to collaborate with agencies and public bodies to enhance their environment. The actions defined in the strategy are summarised in **Error! Reference source not found.**. SEPA will work in partnership with communities so they have information tailored to their local needs and the support required to fully engage and influence FRM in their area. The aim is to build resilience now, developing no-regret actions so that communities can act without locking-in future generations to decisions that prevent adaptation. Therefore, climate adaptation needs to be built into new schemes and interventions. Communities' flooding adaptation plans will require a balanced approach where measures may include a combination of flood infrastructure, natural flood management (NFM), individual property resilience or the relocation of community assets, preferably operating in combination.

SEPA prioritises schemes and projects based on a large number of metrics, which are not all monetised, and one of which is climate change adaptation. There is still outstanding work to align the metrics being used to prioritise schemes with the system of central funding, which will ensure that small communities are able to develop flood protection measures. The lower limit for the scheme has now also been removed.

Applicability of Approach

This approach could be applied in any MS where local communities are responsible for the implementation of FRM measures, and can thus drive this process to create a portfolio of solutions that fits their own community. A necessity is the availability of support and reliable information on flood risk, from for example a specialised agency like SEPA.

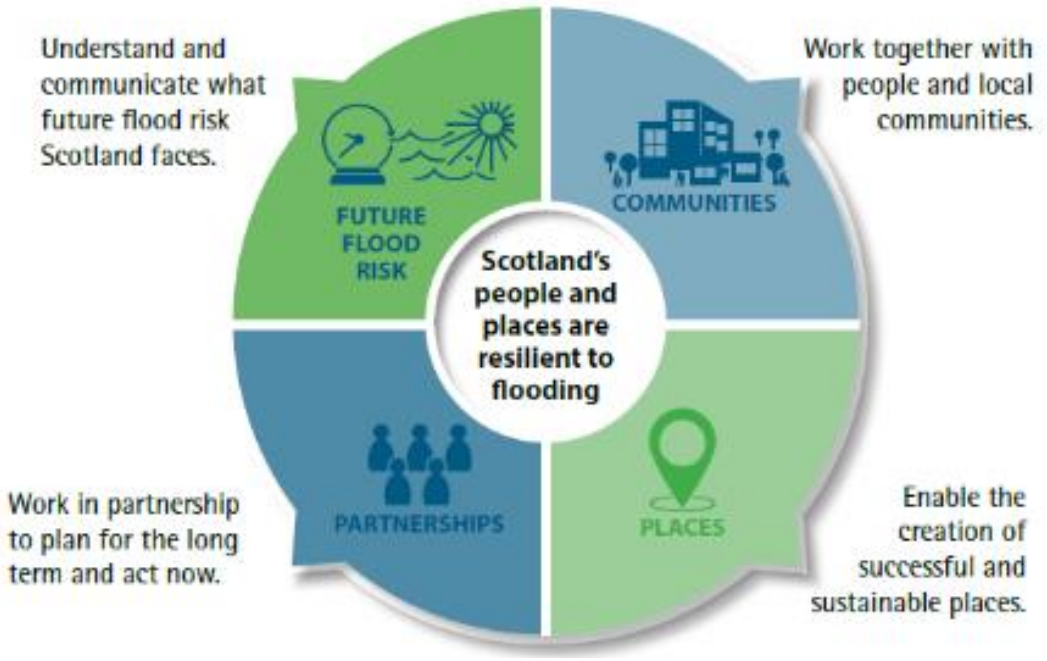

Figure 7-4: Actions defined in the Strategy to achieve SEPA's vision. From SEPA (2020) SEPA Flooding Services Strategy Consultation Draft.

Benefits of Approach

The adaptation of communities is driven by the communities themselves. This will create community buy-in.

The focus is on a suite of adaptation measures, fitted to the local situation of specific communities. By specifying this from the onset, the process of developing the portfolio of measures is more open to multi-disciplinary and adaptive solutions.

The larger number of metrics used in the prioritisation of schemes has resulted in an increase in 'portfolio schemes', as well as schemes that combine flood risk management with community enhancements, which increases community buy-in into the projects.

Smaller communities will be able to implement flood protection that better suit their scale and situation more easily, due to relaxation of the central funding regulations.

Limitations of Approach

Communities need to have access to high quality, reliable information on flood risk. They will also need people with the right competence, as well as the resources, to create flood adaptation plans.

7.2.10. United Kingdom – Working with Natural Processes (WWNP)

Context

Natural Flood Management (NFM) fits well with the Environment Agency's objectives. It can often move floods from 'disaster' to 'nuisance' and can reduce carbon (less construction locally and downstream; more capture).

Challenge

There has been much research on the technical implementation of NFM and the associated benefits, but this has never been synthesised into one location. This has meant that it has been hard for flood risk managers to access up-to-date information on NFM measures and to understand their potential benefits, which has the potential to be a living document, to be updated when new insights become available.

Natural Flood Management approaches have been proven to help to reduce flood risk, however, additional research is needed to show how NFM approaches can be used most effectively.

What is it?

Through the Working with Natural Processes (WWNP) research project, the Environment Agency collated available research on measures' effectiveness in reducing flooding at different scales, their costs and wider impacts, and their potential for multiple benefits into a structured Evidence Base, supported by 65 case studies. It furthermore includes England-wide broad-scale suitability for floodplain reconnection, run-off attenuation and woodland planting. The Evidence Base is now being used as a reference and starting point for those considering NFM (See Figure 7-5).

In the Evidence Directory, research gaps were identified that need to be addressed to move this form of FRM into the mainstream. The Environment Agency subsequently made £15M available via the NFM programme to support the implementation of NFM projects; practical experience from these projects will be used to fill important parts of the research gaps identified in the WWNP Evidence Directory.

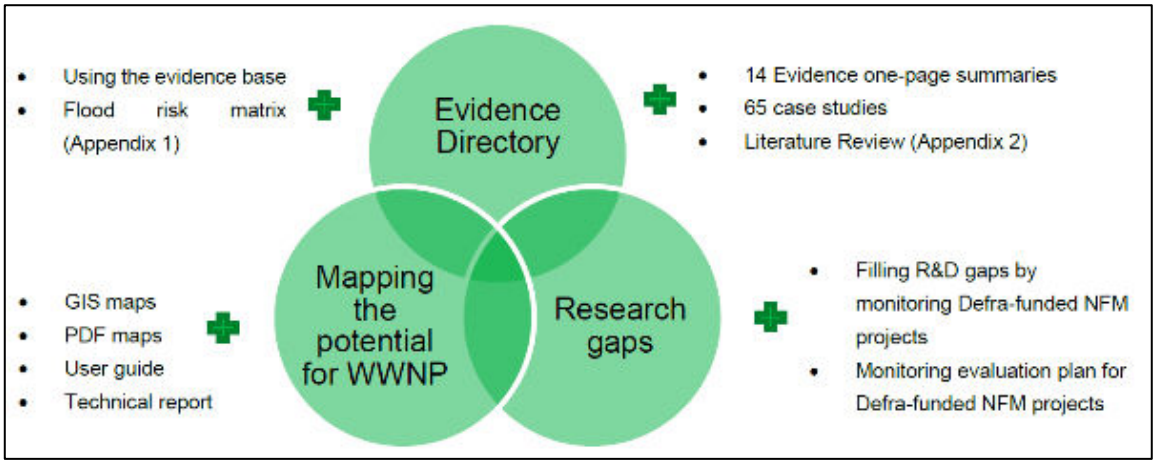

Figure 7-5: Overview of the three interconnected projects making up the WwNP Evidence Base. From Environment Agency (2017) Working with Natural Processes – Evidence Directory SC150005 Technical Report

Approach

The WWNP research project reviewed a total of 525 pieces of evidence, of which over 370 were considered relevant for WWNP and FCERM. The data gathered during this review has been structured into the following topics and covers the measures listed in Figure 7-6:

1. River and floodplain management
2. Woodland management
3. Run-off management
4. Coast and estuary management

For each of the measures, the flood risk science is summarised as well as the multiple benefits that underpin the measure. For each of the measures, a one-page summary is produced as well, which provides a high-level overview of the material in the directory.

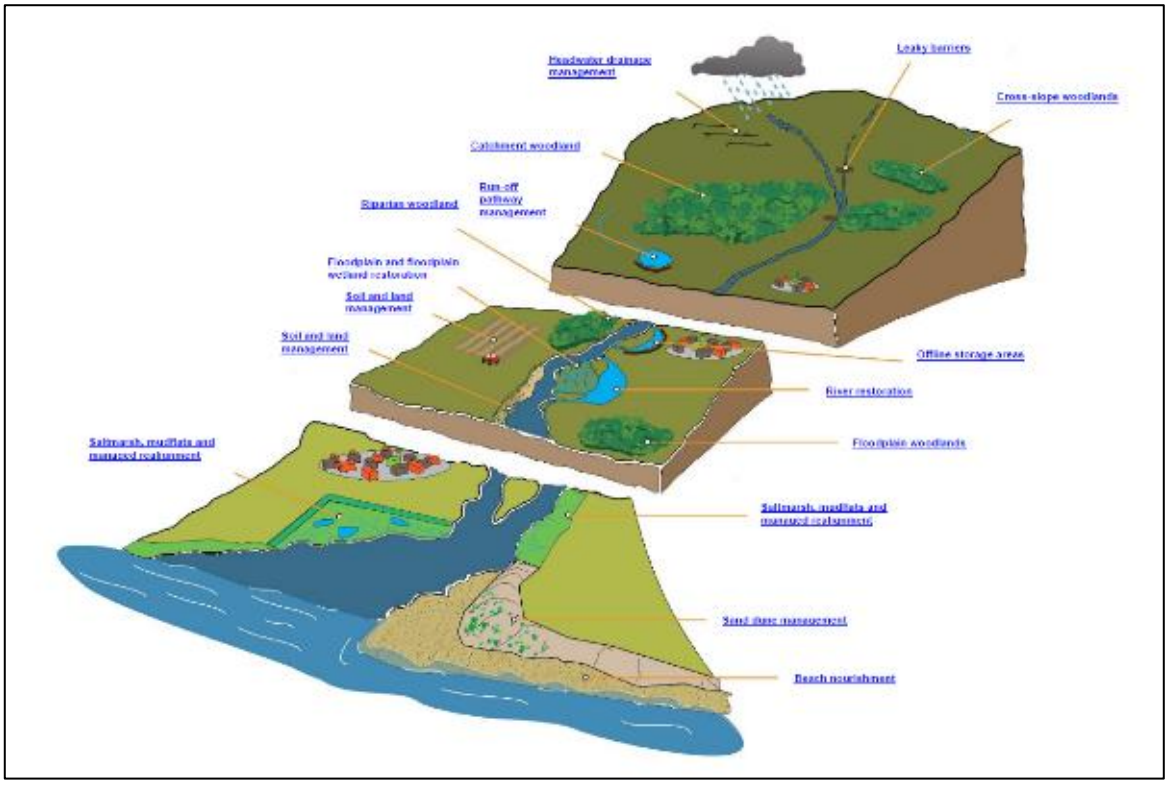

Figure 7-6: Measures covered in the Evidence Base of the WWNP research project. From Environment Agency (2017) Working with Natural Processes – Evidence Directory SC150005 Technical Report

For each topic, the level of confidence in the science that underpins the individual measures is defined based on the degree of agreement of scientific studies and the amount of information available (Figure 7-7, left). Furthermore, a "Multiple Benefits Wheel" is included for each measure, covering 10 benefit indicators ranked on a scale from 1 to 5 to give an indication of the relative contribution the measure can make to the provision of such a benefit (Figure 7-7, right). Links to relevant case studies (out of the total of 65) are included per measure as well, which can be accessed separately and are structured around the four aforementioned topics.

This evidence can be used, together with the mapping of the potential for WWNP (for the whole of England), to build a business case for the implementation of NFM measures. The project also generated guidance to support this.

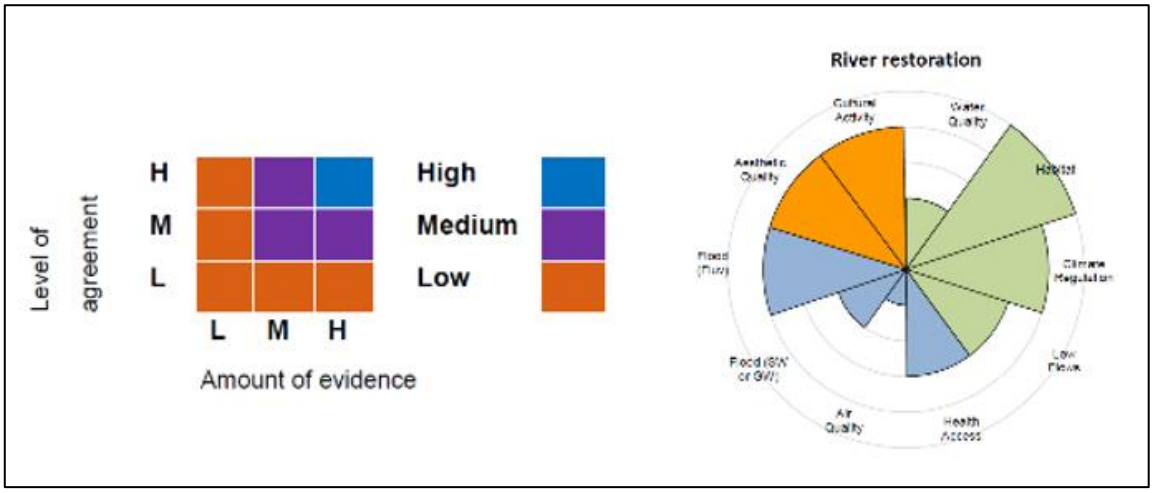

Figure 7-7 Indicator for confidence in science indicator (left) and example of the Multiple Benefits Wheel (right). From Environment Agency (2017) Working with Natural Processes – Evidence Directory SC150005 Technical Report

As part of the thorough literature review, the gaps in the research were identified based on the perceived research needs of a wide group of stakeholders, summarised in broad research questions which were assessed using the literature available. The identified research gaps formed the basis of the NFM programme; £15M allocated to 60 projects, each of which needs to identify how it contributes to the following objectives of the programme through partnership working via community groups:

1.
2. Reduce flood and / or coastal risk
3. Improve habitats and increase biodiversity
4. Contribute to research and development by reducing the evidence gap for NFM

   Promote partnership working.

The 60 projects are split as 26 Catchment Scale (led by Flood Risk Management Authorities) - and 34 Community Scale projects - led by community groups and charities. In doing so, the programme supported community projects that were not able to attract funding for 'traditional' flood risk schemes. For most of the projects that are part of the programme, the programme formed the major source of the funding. The programme is summarised in Figure 7-8, and Figure 7-9 provides an overview of the projects that are part of the programme.

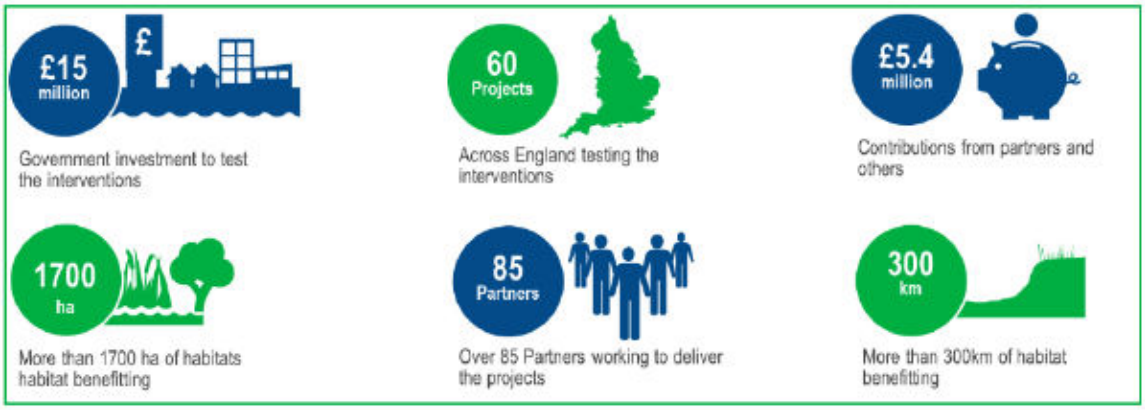

Figure 7-8: NFM programme statistics. From Environment Agency (2019) Natural Flood Management Programme: Interim Lessons Learnt

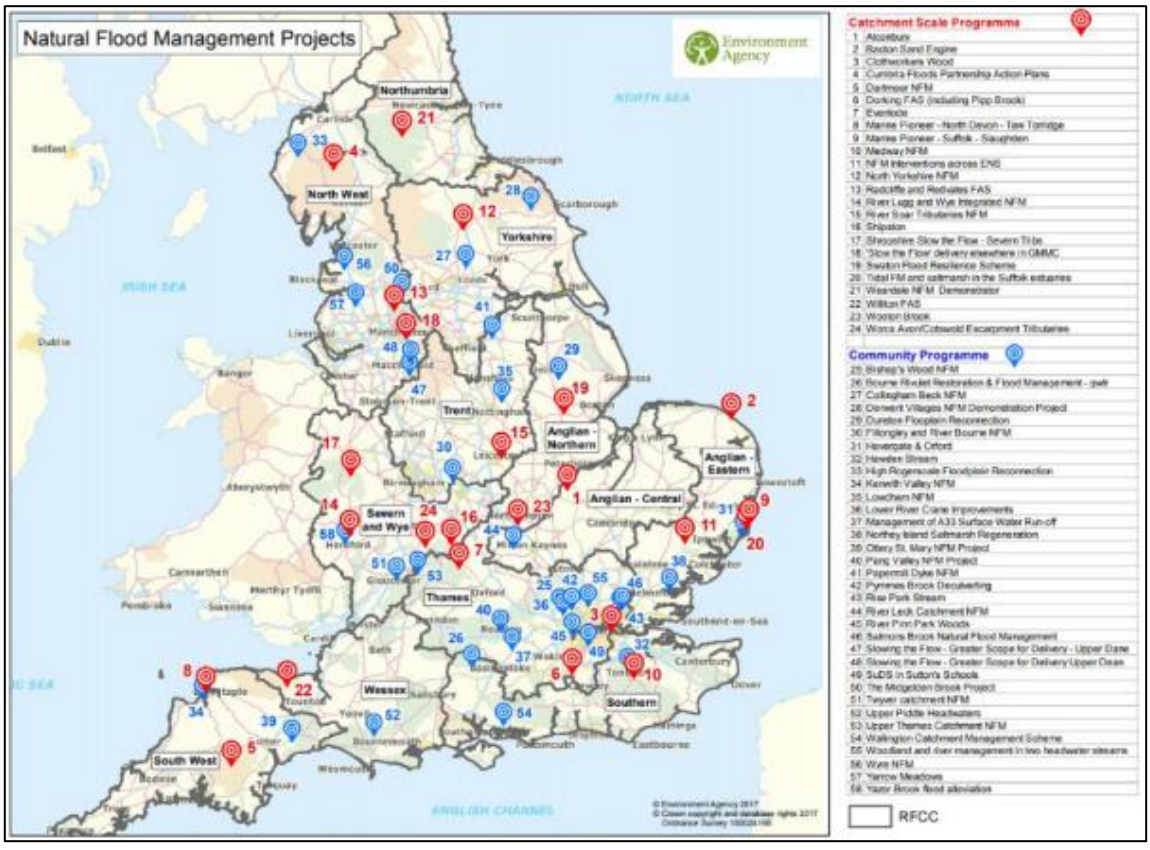

Figure 7-9: Map of the different project implemented through the NFM funding. From Defra (2020). The Enablers and Barriers to the Delivery of Natural Flood Management Project - Final report FD2713

To gather evidence to see how well NFM interventions stand up against other measures, and capture lessons throughout the NFM programme, three "lessons learnt" reports will be developed over the course of the programme. The aim is to embed these lessons as part of the business as usual activities.

An important early lesson from Environment Agency (2019), which presents the first 'lessons learnt' from the NFM programme, first "lessons learnt" report, is that project teams found it difficult to produce evidence of the proposed benefits as part of their business cases for NFM investment, and would need further information and expertise in how to assess and value the benefits and costs of NFM work. It was furthermore signalled that there is a clear need for investment of time and funding in engagement, which is crucial to gain support for the NFM measures. It was also noted that organisations that do not have flood risk reduction as one of their organisational priorities may still have the ability to implement NFM. An amount of funding can often encourage organisations to seek out additional funds and deliver NFM and other benefits.

Applicability of Approach

The Evidence Directory provides a comprehensive overview of NFM measures. Although the mapping for potential is only available for England, the principles and information in the Evidence Base itself on the different NFM measures can be used in any MS and forms therefore a good starting point for practitioners all over the EU.

The availability of the funding of the NFM programme, although the main driver was for research purposes, has clearly encouraged the development and implementation of NFM measures, particularly for smaller communities that might not be eligible for traditional FRM funding. Such a fund could help out in other MS to kick start the implementation of NBS, where this is difficult via the normal funding routes.

Benefits of Approach

The Evidence Directory provides the FRM practitioner with a comprehensive overview of many of the available NFM measures and their potential multiple benefits.

The availability of funding via the NFM programme has kick started many NBS projects, especially in smaller communities that otherwise would not have been able to implement FRM measures.

Limitations of Approach

Although the NFM programme benefits flood risk in a sustainable manner, many in the local community would prefer hard defences, even where they may not be as effective or affordable. More needs to be done to address the perception of NFM so that NFM becomes part of the regular portfolio of options.

Issues / key findings

7.3. The focus in planning and implementing FRM is shifting from sets of measures with flood risk reduction as the primary driver, to full portfolio schemes, including adaptation measures in conjunction with flood risk reduction strategies. These portfolio schemes are driven by the wider benefits they deliver and providing evidence of those wider benefits is key to securing funding as well as community acceptance.

Many of the risk-based allocation and prioritisation methods mentioned in this section have a tendency to be 'centre-biased' and thus a correction needs to be applied to help smaller communities to become flood resilient. This section has shown that there are various methods to do so, but key to this is the need to empower local communities

Most of the approaches in this section are quite advanced and rely on increasingly more elaborate / complex datasets that may not be easily copied between MS.

8. WORKING IN PARTNERSHIP

Definition and Context

8.1. Flood risk touches many aspects of society. As a result, there are often many different organisations with a role in FRM. There is typically a lead organisation with an overview role, but they have to work together with others that might be responsible for managing particular sources; play a role in land use planning; are responsible for emergency response, and there can be various other dimensions. Working in partnership aims to improve effectiveness, clarity for public and stakeholders, and can help achieve win-win outcomes.

Cases

8.2.1. Overview

8.2. This Chapter presents seven cases which can be grouped into four FRM contexts in which organisations work in partnership, as follows:

- River contracts
  - Kerkebeek Valley - Flanders, Belgium (Section 8.2.2)
  - Middle Tiber - Italy (Section 8.2.5)
- Emergency response
  - Jelgava – Latvia (Section 8.2.5)
- Large complex projects
  - Room for the Waal, Nijmegen – The Netherlands (Section 8.2.68.2.6)
  - Zandmotor – The Netherlands (Section 8.2.78.2.7)
  - River Arga restoration – Spain (Section **Error! Reference source not found.**8.2.8)
- Coastal flood risk management
  - Flood Management Groups – Finland (Section **Error! Reference source not found.Error! Reference source not found.**)

Three further cases, Angelholm (Sweden), Gothenburg (Sweden) and Climate Ready Clyde Glasgow (Scotland, UK), also describe current practice for working in partnership, but in the specific context of urban FRM. They are discussed separately in Section 12.

8.2.2. Belgium – Kerkebeek Valley River Contract

The main discussion of the Kerkebeek Valley case is provided in this section, but the case is also included to illustrate the aspect of Working with the public, see Section 9.2.2.

Context

The Kerkebeek is a small river with a catchment of ~80km^2. It flows through two municipalities, which despite measures already taken by the government, are at significant flood risk. Flood protection is not the responsibility of the government alone, but shared, and therefore the government in Flanders aims to implement a multi-layered safety approach. In such an approach, additional preventative measures need to be taken by individual stakeholders and the public, and a certain amount of public awareness is necessary.

Challenge

Although the flood risk in the municipalities is significant, the last severe flood was in 1964 and therefore the awareness of flood risk among residents was very small. The driver to initiate the Kerkebeek project was the disconnection with local stakeholders that in the past has often led to problems in the final stages of proposed projects, when there is very limited room for change.

A related challenge was that bottom-up approaches to stakeholder engagement were untried in this field, and for lead organisation the Flemish Environment Agency itself.

What is it?

The Kerkebeek project is a pilot programme led by the Flemish Environment Agency to trial bottom-up stakeholder engagement in the design of a programme of flood risk reduction measures (a mix of protection, prevention and preparedness).

The river contract is a non-legally binding but shared commitment which outlines the measures (shared responsibility of water managers, local communities, inhabitants, other government agencies) to be taken by which date and which actor in order to reach the partnership's goals.

Approach

Kerkebeek was chosen as the pilot project mainly because the number of municipalities that the river affects is limited which reduced the number of stakeholders to be engaged.

The project was led by the Flemish Environment Agency, who were supported by a consultant with experience in consultation and communication. The Project Manager was part of the Agency but acted as a neutral leader to make sure all parties felt heard. The stakeholders in the Kerkebeek project included all levels of government (political and civil servants; national and local), the local community and private companies/industries. These were united into the steering group. In the later stages of the project, the steering group was expanded to include chosen members of the local public.

The project started off with the signing of a Charter, which can be seen as a declaration of engagement. It outlines the common goal of the stakeholders and the promise to take forward any measures resulting from the project into a river contract. The Charter described which topics were to be included in the project and which definitely would not be included.

The first stage of the project was the ideation stage. For each local community a launch event was held to make the residents aware and start generating ideas. The project website was also important at this stage of the project; it functioned as the central participation platform and had a bigger role than only communication, including an online test for residents and a successful platform for ideas from local inhabitants.

After the ideation stage, the Kerkebeek forum was held for the stakeholders and the general public. The ideas from the ideation stage were evaluated. This led to several local bilateral follow-up meetings to firm up over 50 measures. Numerical models were used to evaluate the measures where possible, but for other measures the pros and cons were discussed within the steering group before a decision was made as to whether to take the measure forward. For some of the measures it was concluded that further study was necessary, which was taken forward as an action. The selected measures have been summarised in a signed 'River Contract' which described all the measures, responsible parties for the measures and timings for the execution of the measures. The measures included in the Kerkebeek River Contract can be seen in **Error! Reference source not found.**.

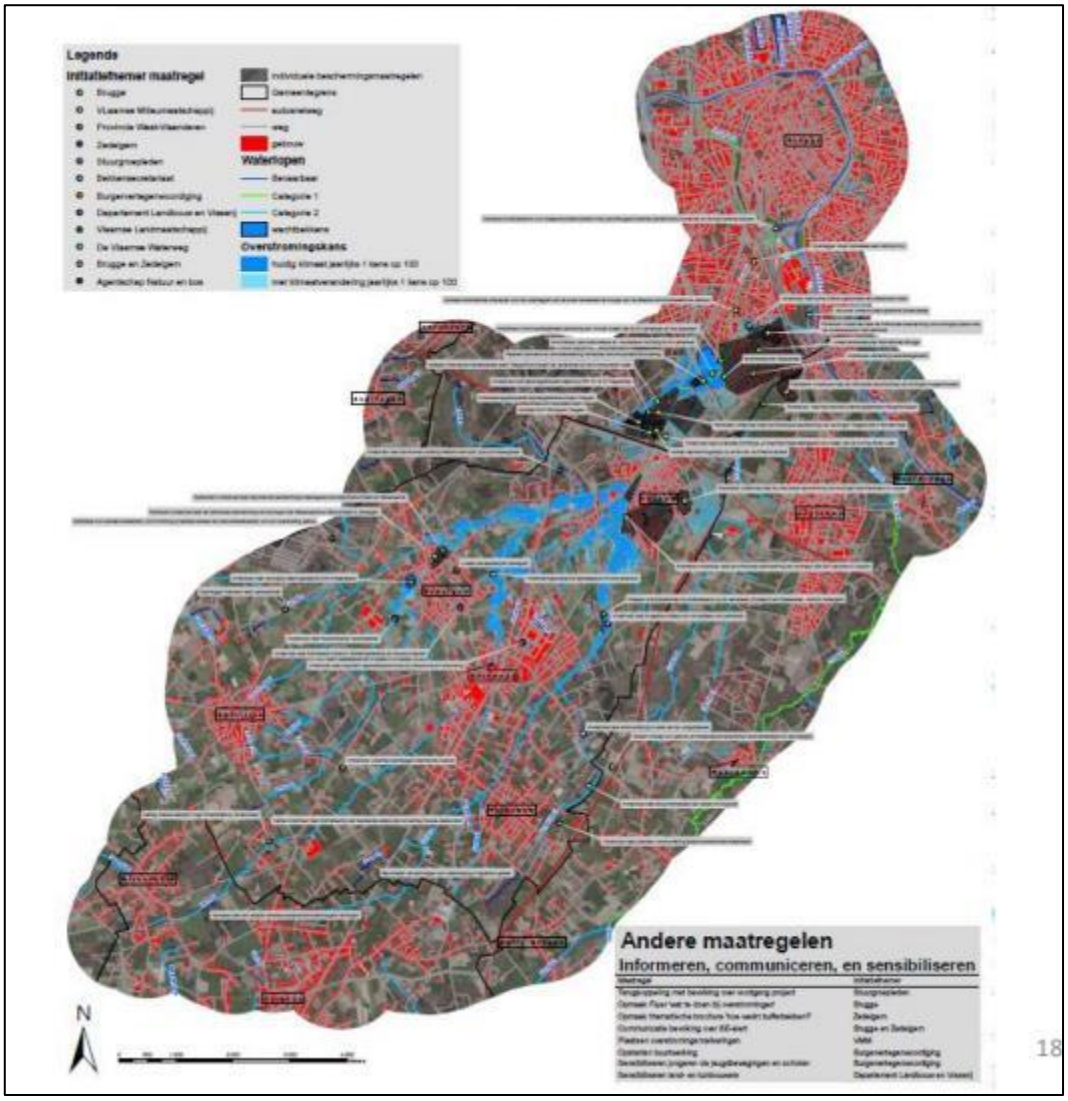

Figure 8-1: Map of measures in the Kerkebeek River Contract

The River Contract is not legally binding. It has a duration of five years, with follow up meetings to assess progress taking place every six months. Most measures have been planned to be delivered within these five years. It is a living document and as such measures can be deleted and added. There are currently 70 measures in the contract and only two have been deleted since the signing of the contract. All parties are still engaging, local communities and stakeholders are always present, but coordination is still required to maintain momentum.

Applicability of Approach

The case study suggests that the approach taken in the Kerkebeek project can work for any project where:

- There is significant flood risk in the catchment;

- Government measures alone are not going to solve the issues; and
- Proposed measures might not be fully supported by the public.

Due to the success of the pilot, the approach is now used in five other projects in Flanders. These projects have tried to take a broader view than just flood risk and to take, for example, drought, land-use or water quality into account as well, which makes the process more ambitious but also more complex.

Benefits of Approach

Engaging stakeholder and the public from the beginning in a bottom-up approach means their wishes can be incorporated into the programme. This generates support for flood risk reduction measures and reduces the likelihood of opposition.

The early engagement activated the stakeholders and gave them the chance to play an active role in the programme.

Limitations of Approach

The Kerkebeek project found that it was difficult to reach certain sectors; for example, farmers were not well represented in the steering group and the involvement of the industry community was less than expected. It was also difficult to engage certain age groups, especially younger people.

The project required a significant investment of time by the Agency coordinator. A lesson learned was that it is preferable that some coordination tasks are shared with other stakeholders.

8.2.3. Finland – Flood Management Groups

Context

Finland is prone to flooding, particularly spring/snowmelt floods and ice jam floods. The estimated annual damages (without additional measures) are approximately €30 million with on average over 500 homes inundated; typically, the actual annual damages range from €1 to €20 million.

Finland has a long tradition of FRM which has involved lake water level regulation, flood embankments and dredging, with strong interactions with hydropower and timber floating. Finland has implemented management and regulations for land use planning and construction. Legislation at both the European and national levels are implemented. The processes of the FD (Assessment, Maps and Plans) are actively used

to structure FRM, linked to legislation related to land use planning, construction, environmental protection, civil contingencies and water use.

In terms of administration and organisation of flood risk in Finland, there are 13 Economic development, Transport and Environment (ELY) centres that are responsible for fluvial and coastal flood management. In terms of leading emergency operations and coordinating work of other authorities during a flood incident, the rescue department are responsible. The ELY Centres report to the Ministry of Agriculture and Forestry on the issues related to FRM. The local municipalities are primarily responsible for pluvial and urban FRM and land use planning in their own area. The Finnish Environment Institute (SYKE) is responsible for coordinating FRM, EU reporting, and hydrological modelling. The SYKE own and operate the national hydrological model, and provide expert services and support to ELY centres. The production and provision of flood mapping is a collaboration of the ELY centres with SYKE.

In the PFRA for Finland, 22 APSFR were identified, of which five are on the coast, and one of these is Hamina Kotka on the southeast coast of Finland. Following this, flood risk maps were produced, and these are available interactively online for the general public. These showed that approximately 1600 residents live in the area at risk of coastal flooding from the 1 in 1000-year flood event.

Under the Finnish Flood Risk Management Act, a Flood Management Group (FMG) was established at the start of the current FD cycle for every river basin and coastal area where one or several significant flood risk areas have been designated. The FMGs are appointed by the Ministry of Agriculture and Forestry for up to six years (or one FD cycle) to prepare and follow-up FRMPs. During the first FRMP cycle, the FMGs were also responsible for organising sufficient interaction between authorities and different stakeholder groups during the preparation of the plans. The Flood Management Group for Hamina-Kotka is comprised of representatives from the regional ELY Centre, Regional Council, Rescue Department, Hamina and Kotka municipalities and Port of Hamina Kotka.

There is currently a bill under review that would allow appointment to be made indefinitely or for an appropriate period of time (more than six years). This is because in the first FRMP cycle, FMGs were appointed mainly for the preparation of FRMP whereas for the second cycle, the groups will also be involved in the follow up of the implementation of FRMPs.

Challenge

The challenge addressed is the lack of implementation of the measures identified in the first FRMP cycle.

During the first FRM cycle, SYKE developed a multi-criteria analysis framework to assess regional FRM options and it was subsequently up to the FMGs to use this analysis and determine what measures were to be incorporated in the FRMP document. In the Hamina Kotka region, there were no significant conflicts of interest between stakeholders because in most cases, the FMG devised a solution that works for everyone.

However, a couple of key issues prevented the desired implementation of the measures identified in the 1st cycle of the FRMPs. The document was not widely read and was not well known in many organisations. It was not taken particularly seriously by the key stakeholders in the Hamina Kotka region given the lack of resources available, and the undertaking the measures' implementation was typically not obligatory. Although stakeholders understand the need for better FRM, it was usually not their priority. Therefore, application of the measures was largely dependent on the ELY centre's own activity and personal engagement with stakeholders, which itself lacked due to inactive follow-up and coordination by ELY. It was also not ideal that the FRMP document was a standalone document.

What is it?

The lack of implementation was addressed in the second FRMP cycle by adopting a different way of working between the organisations: giving the local FMG the responsibility to follow-up the implementation of the plan, in addition to the preparation. In addition, better engagement of key stakeholders during the preparation of the plan led to more realistic measures, with more local ownership, including FMG members promoting the FRMP measures to their own organisations.

Approach

In the second FRM planning cycle, there was a need to change the stakeholders' perspectives of FRM. The FMG obtained the responsibility to implement the plan in addition to preparing it. They decided that a strategy that focuses on preparedness planning was the best option to reduce flood risk in the region.

This is because of two main reasons. Firstly, the Hamina-Kotka region is relatively small so it is easier to cater for all the key stakeholders, which would be more difficult for other larger regions. Secondly, there is little investment for FRM in Hamina-Kotka. Whilst the ELY possess funds, it is not enough to implement significant structural flood risk

measures; in addition, these are often not cost-beneficial or acceptable to stakeholders. Finally, the specific nature of coastal flooding in this area (short warning times, potentially large consequences, short flooding duration) makes it important to focus on preparedness and collaborative response.

To improve stakeholder engagement for the second cycle of FRM planning, the FMG organised workshops for key stakeholders with the aim of establishing objectives and measures for FRM. The workshop aimed to gather more information about the stakeholders' views on the reasonable and realistic measures for FRM as well as their willingness and ability to commit to the goals of the FRMP. In addition, the ability of the stakeholder organisations to deal with flood risk was identified, as well as their level of preparedness.

Furthermore, a flood emergency exercise was organised by ELY, SKYE and Emergency services academy in the first FRM planning cycle to help the local authorities and all key stakeholders who operate in the area. The exercise involved approximately 100 participants from 30 organisations. The exercise also helped the Rescue Department practice their actions and leadership in the event of a flood. This exercise proved beneficial as it created better relations between the participants.

For the second FRM cycle, organisation of flood emergency exercises or flood meetings for single stakeholder groups are put forward. The aim is to improve FRM at organisational level and help key stakeholders to identify flood risks and to improve their own preparedness. The idea is that floods and flood risks should be better considered and incorporated into existing preparedness plans. For this, ELY centre (and Flood group) commits to provide stakeholders the necessary flood information and, where possible, other support needed to review and update the preparedness plans.

Climate change is a big focus in these workshops and events. It is used to sell the idea of FRM as the general public are aware of the effects of climate change, e.g. rising sea levels in coastal areas and warmer winters. Also, flood risk maps are promoted actively to stakeholders as they provide a good visualisation and overview of the potential flood risks and inundation areas (Figure 8-2**Error! Reference source not found.**).

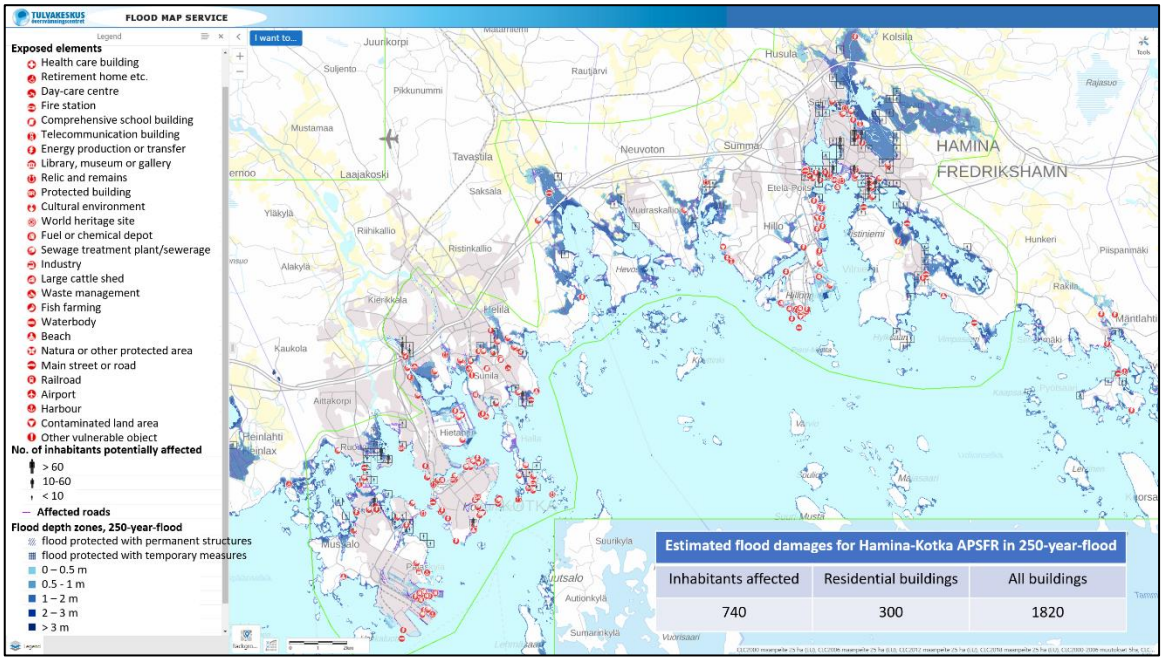

Figure 8-2: Flood hazard map of Hamina, illustrating features at risk

Applicability of Approach

The concept of creating local ownership for planning, and of integrating planning and implementation in the same groups, is applicable anywhere. This case shows that it was particularly important and effective in Hamina-Kotka, because the FRM Plan was not statutory and there was no single solution with a clear driver and lead organisation.

Benefits of Approach

The collaboration in the FMGs has increased understanding between organisations' roles and views, which is important for achieving integrated FRM.

The flood emergency exercise proved beneficial as it created better relations between the participants and the collaboration in the FMGs has increased understanding between organisations' roles and views, which is important for achieving integrated FRM.

Limitations of Approach

The non-statutory nature of the FRMPs is still a limitation. A future aim of the FMG is to integrate FRM into general preparedness planning and industry plans, which is important because these mandatory plans and processes are more strongly established and embedded than FRMPs.

8.2.4. Italy – River Contract Middle Tiber

The main discussion of the Middle Tiber case is provided in this section, but the case is also included to illustrate the aspect of working with the public, see Section 9.2.3.

Context

The Middle Tiber Valley is located just north of the city of Rome. It spans two regions: Lazio and Umbria. It is a high-profile area, as it is the last stretch of the river before it enters Rome. The valley is prone to flooding and contains major highway and rail infrastructure, as well as significant nature and historic conservation areas. It is also important to underline that this area should be kept free from further settlement: the water storage capacity of the floodplains is needed to reduce flood risk to the city of Rome, located immediately downstream.

Challenge

The importance of the area and the wide range of features and interests means that many different organisations are involved, each with their own objectives. As part of this, there is a particular challenge of integrating approaches for FRM and water quality (driven by the WFD).

What is it?

The River Contract is a tool that aids in combining environmental policy with social-economic development; it is described as an act of joint commitment by public and private parties for sharing working methods aimed at environmental and socio-economic regeneration of river systems. The goal of the River Contract in practice is to bring people together to create a shared vision for the management of the river. This shared vision is translated into a shared Action Plan. These actions are to be taken away and progressed by individual parties.

Approach

The River Contract Committee is organised like an institutional body. It consists of national and regional governmental bodies, local municipalities, research institutes, farmers organisations, representatives of national regional and local businesses and different NGOs. It is chaired by a president (one of the mayors of the municipalities) and meets once a year. The governance is as horizontal as possible. That means that all parties are equal in the decision-making process without prejudice to their responsibility level. In its ambition to put in place integrated measures, it tries to include benefits for a variety of sectors, including nature and cultural heritage and improve the integrated implementation of FRMPs and River Basin Management Plans (RBMPs). The general public is also involved, see Section 9.2.3.

Day to day activities of the River Contract throughout the year are carried out by the staff of the partner organisations, in particular from the municipalities – there is no separate organisation of civil servants.

The Action Plan resulting from the River Contract is legally binding if it complies with all planning strategies of the local communities and all national sectoral plans, and as long as it is endorsed by all parties. This is one of the main strengths of the River Contract; it cross cuts through the complexity of local, regional and national legislation which enables measures to be planned much more effectively. It also guarantees the implementation of the FD as well as the WFD. The River Contract of Middle Tiber does not have many completed actions yet. There are still other steps that have to be made to get to actual implementation.

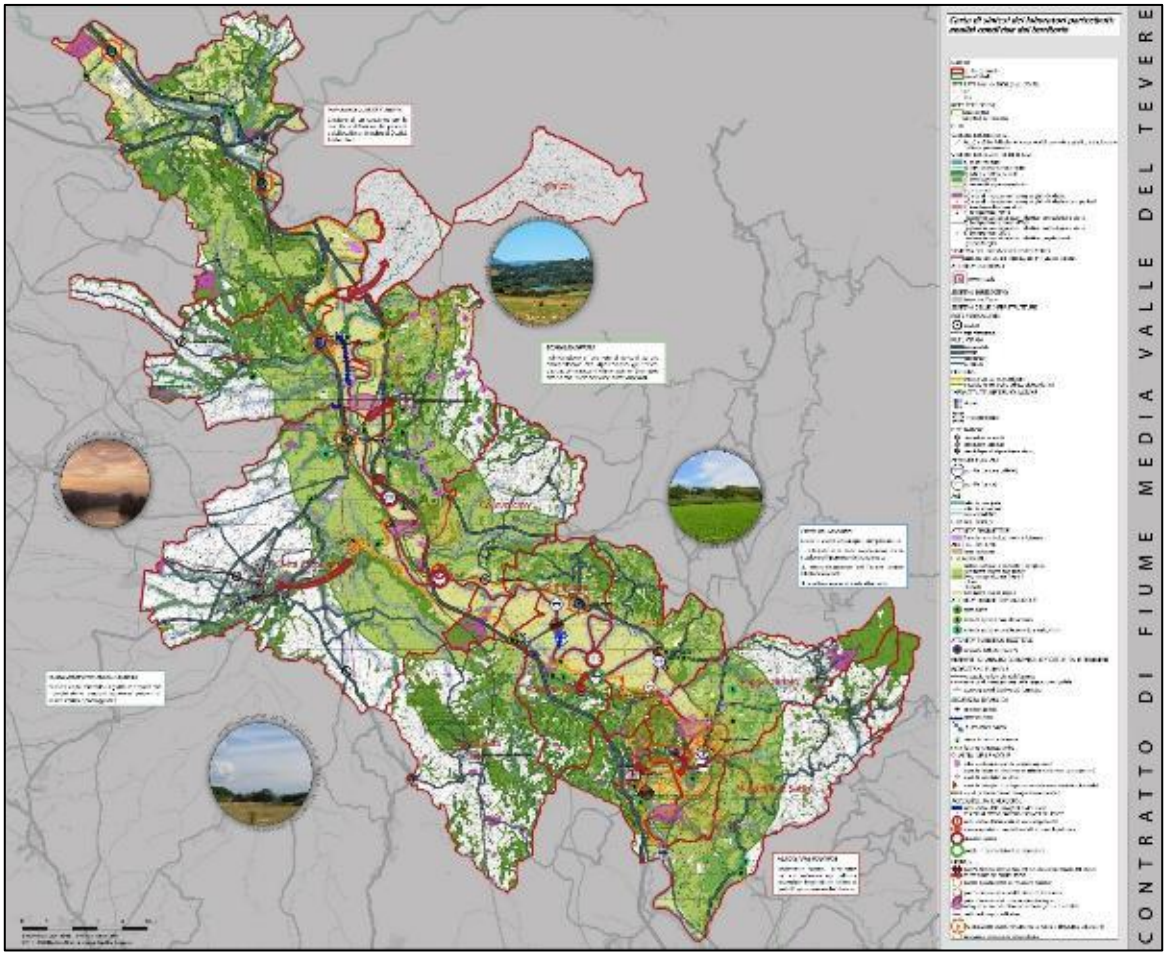

Figure 8-3: Synthesis map of participating initiatives in Middle Tiber River Contract

The action programme for the Middle Tiber Valley is aimed at the following objectives:

- Improving the quality of the water and river ecosystem;
- Identifying shared measures to reduce flood damages;
- Increasing security and usability;
- Developing economic and tourist activities in respect of the river;
- Initiating care and self-maintenance practices (farmers are the custodians of the territory); and
- European Territorial Quality Mark; territorial recognition and promotion.

Applicability of Approach

Since its introduction in 2006, 15 regions within Italy have signed a River Contract charter. It has now been included in Italian legislation since 2015 to increase its effectiveness and to enhance its capacity to be implemented.

River Contracts also exist in other EU countries (e.g. Belgium, see Section **Error! Reference source not found.**). This wider application s hows that the concept can work in multiple contexts.

Benefits of Approach

The River Contract's partnership approach can help effective planning of measures.

In the case of the Middle Tiber, it forms a firm basis for the implementation of the FD as well as the WFD, and integration between the two.

The River Contract can act as a means of attracting funding for measures, because it combines the different authorities with their objectives and associated funding streams.

Benefits for public engagement are discussed in Section 9.2.3.

Limitations of Approach

The Action Plan resulting from the River Contract is legally binding if it complies with all planning strategies of the local communities and all national sectoral plans, however there is a restriction as it requires to be endorsed by all parties.

8.2.5. Latvia – Jelgava's Operative Information Centre (POIC)

Context

Major flood events happen in Jelgava's territory about once every ten years, causing damage to properties and businesses. Flooding occurs from the River Svete which runs through the city.

Challenge

This case describes how the city of Jelgava addressed some of the typical challenges of emergency response: ensuring the right information is available to the right people at the right time, to support their decisions about communication and about deployment of staff and materials.

What is it?

Jelgava's Operative Information Centre (POIC) was developed around 2011 to enable and enhance cooperation between the different civil protection services, as well as the different municipalities that they serve.

Approach

The POIC was set up following a decision to monitor city infrastructure. This was not in response to any particular event, rather it was agreed it was the right thing to do; crisis response would be faster and more effective through one institution. Jelgava's Civil Protection Committee (CPC) serves 140,000 residents divided over three municipalities. POIC is funded directly by the municipality and running this organisation costs €400-500k annually.

The POIC coordinates information for everyday business as well as crisis situations, as shown in **Error! Reference source not found.**. It is f urthermore involved in the monitoring of critical assets and works with other Baltic states on cross-border projects. One of the centre's purposes is to make decision-making easier for the CPC by providing them timely with the required information.

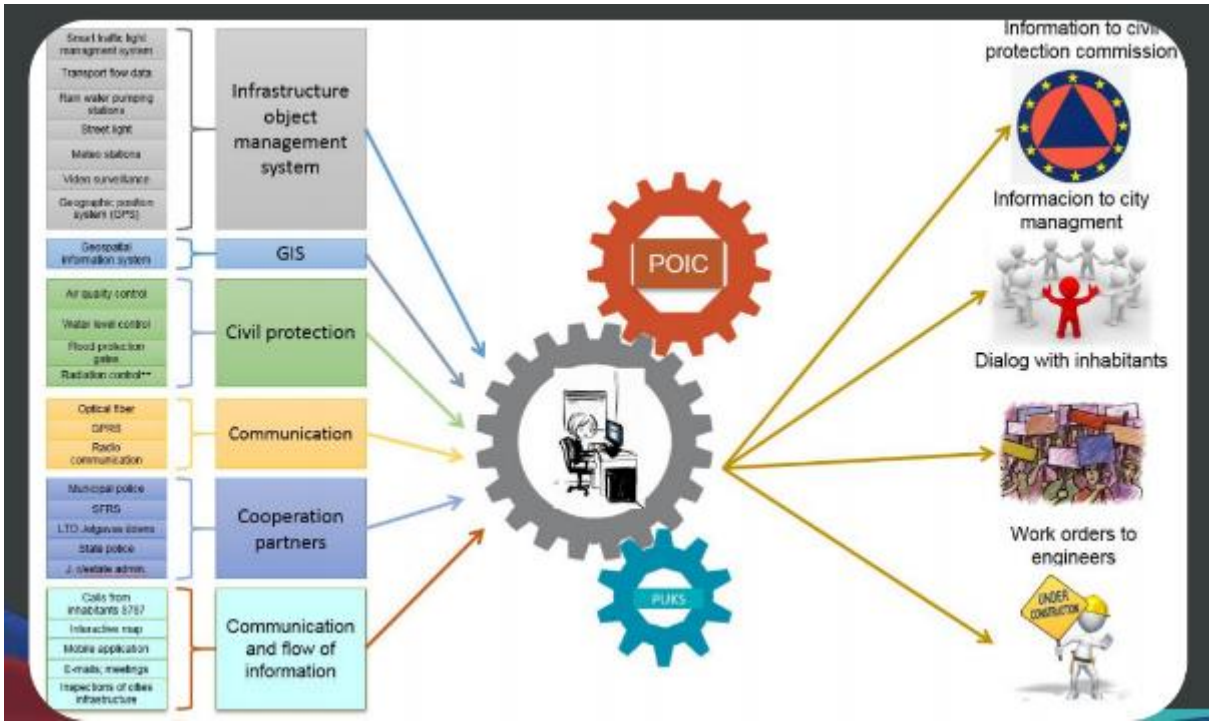

Figure 8-4: Elements and information flow related to Jelgava's POIC

POIC has cooperation agreements with State Fire and Rescue services, State police, Municipal police, State Environmental service, Emergency Response Medical service and critical infrastructure maintaining organisations. These organisations all communicate via POIC's Common Information Exchange System. All reports and incidents are logged within the system so the appropriate organisation can respond.

The data that is used for monitoring the POIC is available via online mapping (Figure 8-5). POIC also created an early warning system, based on its data; this system sends out a warning for various hazards via sms and email. For flood mapping specifically, POIC uses a LiDAR dataset (to be updated in future using drones) to determine the terrain levels.

There are several algorithms in place for dealing with incidents, developed by POIC. In the first instance, the local operatives, supported by POIC, will try to resolve the situation. If the severity of the incident increases, the CPC is notified, which potentially leads to a meeting for decision-making in response of the crisis. If the incident becomes too severe to handle locally, the CPC can escalate the incident to a national scale to receive external help. Close collaboration between State institutions and municipality increase the reaction-time in any given situation. The information exchange is crucial for fast decision-making processes.

In the future, POIC aspires to integrate their system with the national prediction models for ice dam breaks. In that way, the big picture is combined with local information, making it more applicable to the wider country.

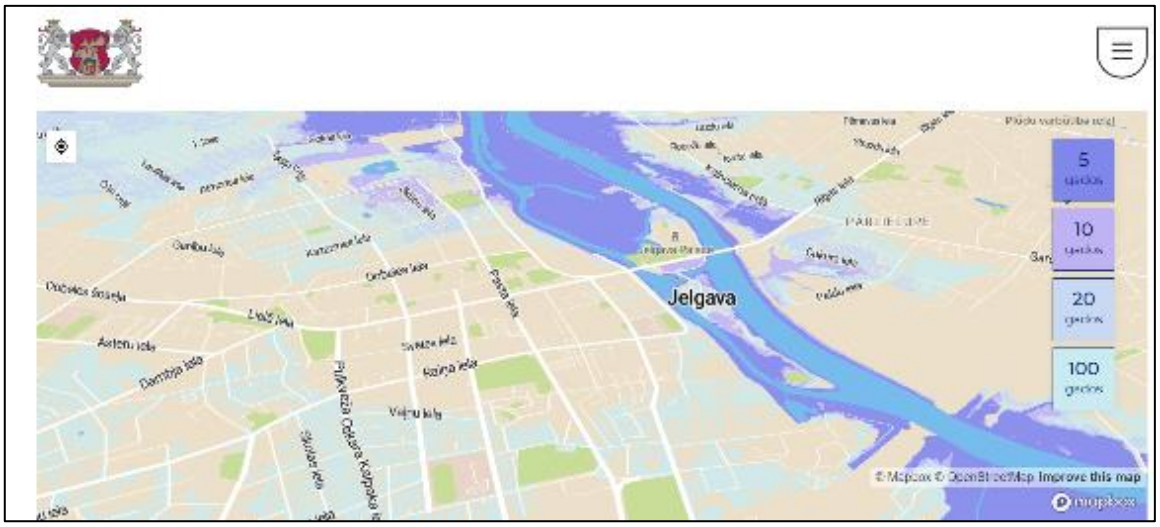

Figure 8-5: Interactive flood map of Jelgava on POIC website

Applicability of Approach

In principle the model of a combined emergency response information system can be applied anywhere.

In practice it requires political will from the different organisations to set up the collaboration (especially challenging if this is not driven by recent flood events). It also requires a funding commitment to set up and continue the operation.

Benefits of Approach

The obvious direct benefit of the centralised information service is that information is collated and presented professionally, unambiguously and uniformly to all emergency responders. This will improve the response, ultimately reducing the negative impacts of flooding and other hazards.

8.2.6. The Netherlands – Nijmegen – Lent: Room for the Waal Project

The main discussion of the Room for the Waal case is provided in this section, but the case is also included to illustrate the aspect of Working with the public, see Section **Error! Reference source not found.**.

Context

In 1993 and 1995, high water levels in the river Waal caused 200,000 people to be evacuated. Those events ultimately led to a national approach to improving the fluvial flood risk safety standard through the Room for the Rivers programme: reduce river water levels that occur during extreme high flow events by measures such as lowering flood plains setting-back embankments and constructing flood bypass channels.

In 2007, the national government decided to widen the Waal at Nijmegen. Nijmegen is at the downstream end of a wide section of the river (up to 1500m width between the embankments), but the city formed a bottleneck in the river (350m width in the city, in combination with a sharp 90-degree bend). On the left bank is Nijmegen's city centre, with an important waterfront and ship mooring facilities. On the other side of the river, the village of Lent is situated directly behind the flood embankment that protects a very large area from flooding. Removing the bottleneck was essential for achieving the flood risk reduction objectives locally and for the river section upstream from Nijmegen, as part of the national Room for the Rivers programme.

Challenge

The Room for the Rivers approach is a departure from the Netherlands' historical approach to FRM, recognising that continued raising of flood defences will become unsustainable. In a densely populated country like the Netherlands, giving room to the rivers will affect how people use the land. Therefore, in addition to the significant technical challenges, working with stakeholders was a key challenge for the Room for the Rivers programme: how to design and implement local and regional scale interventions that achieve multiple objectives: not only to reduce flood risk at a regional scale, but also to enhance spatial quality locally for people, nature and landscape.

Specifically at Nijmegen, the decision to widen the Waal came as a shock to the local community, in particular for the village of Lent as people were living in the area that was considered for the widening.

What is it?

The Room for the Waal project concerned widening of a major river at a local pinch point, reducing flood risk as part of the national Room for the Rivers programme, while also enhancing spatial quality by creating a 'Park for the People'.

Approach

The selected option was to set-back the flood embankment away from the river, and to create a lateral flood channel through the floodplain between the main channel and the relocated flood embankment. This meant that 50 people would have to leave their homes. This led to strong resistance from the local community.

The municipality of Nijmegen took the concerns of the community to heart as they were developing their collaboration with national government. This collaboration was an important factor in making the project work and address the challenge resulting from this impact on the homeowners. The municipality was the lead partner and responsible for integrating the project with the city and improving spatial quality; national government was heavily involved, supporting the project and providing the budget that would have been needed for a technical flood risk solution. Due to the importance of the project for the overall Room for the Rivers programme, and the high impact of the works on the local community, it was essential that the project would achieve stronger spatial quality benefits.

As the project took place in the middle of the city, many people were involved both in the local municipality and public. It was clear that this required very strong stakeholder engagement. The approach to public participation in this project is discussed in more detail in Section **Error! R eference source not found.**.

The initial plans for the river widening were strongly technical; sheet piles, straight channels and functional bridges, focused on and limited to the project's flood risk reduction objective. These plans did not achieve the ambitions for enhanced spatial quality. The municipality of Nijmegen, in its leading role, then amended the plans to include as much additional benefit and spatial quality enhancement as possible, and also invested significantly in the new bridges and urban development on and around the newly created city island, integrated with the river widening project.

An example of the improvements to the initial design is the longer lateral channel, suggested by the project's landscape architects. This was not merely a decision made on a technical basis, but it was recognised that a longer lateral channel would be good for nature as well, and would furthermore be beneficial for the project budget as the extra dredging material could be sold by the contractor. The stance of the local municipality led to a shift in mindset; the river improvement became a "Park for the People". The implementation started in 2012 and was completed in 2016 (with ongoing urban development since). Figure 8-6 gives an overview of the project under construction.

Figure 8-6: Room for the Waal during implementation

Applicability of Approach

Any large flood risk project has a significant impact on the local place and its functions and land uses.

If flood risk funding is a strong driver, then this can be used to enable local enhancements of spatial quality (even turning potentially negative impacts into benefits). This requires the right collaboration arrangements between organisations at different levels and with different roles.

Benefits of Approach

Both Rijkswaterstaat and the municipality had clearly defined objectives, roles and funding streams. This allowed the municipality, in its leading role, to design a project that worked locally while also achieving the wider programme's flood risk reduction objectives.

Limitations of Approach

Collaboration to achieve multiple objectives beyond flood risk reduction can be more difficult at first sight: it takes time to engage, combine objectives and organise roles and responsibilities. When successful, the benefits far outweigh these issues.

8.2.7. The Netherlands – Zandmotor (Building with Nature)

The main description of this case is under the aspect of Nature-Based Solutions, see Section **Error! Reference source not found.**.

The Zandmotor was implemented in 2011 as an experiment for more efficient and sustainable management of coastal erosion and flooding. The Zandmotor is a mega-beach nourishment, designed to sustain the Netherlands' coastal foundation locally, but also feed sediment to the neighbouring sections through the waves and tides, while also improving nature and creating recreation potential, and developing knowledge about the wider applicability of this innovative approach.

The Zandmotor is a large, very visible and multi-purpose project that influences many existing land uses. This introduces the challenge of having to consider many different interests and working with multiple organisations, each with their own objectives. In the development of the Zandmotor, a large number of parties was involved:

- Ministry of Environment and Water Management
- Rijkswaterstaat
- Province of South-Holland
- Ecoshape (private-public-academic partnership aiming to promote Building with Nature)
- Delft University of Technology (NatureCoast; 12 PhDs)
- Water Boards
- Municipalities (mainly The Hague and Westland)
- Water Company (water supply installations present in the dunes)
- Local communities
- Swimmer safety organisations

In the initial development from idea to implementation, the 'golden triangle' collaboration between government, business and academia was very important. This was organised through the Ecoshape partnership which still actively promotes the concept of Building with Nature.

The actual decision to implement the scheme required willingness and vision from the two leading public authorities that ended up co-funding the scheme: Rijkswaterstaat and the Province of South Holland. They

were able to align their objectives (coastal management and knowledge development, nature, recreation) to drive the design, and made available the funding.

After implementation, the 'golden triangle' of Ecoshape formed a steering group to coordinate the monitoring and research, including research programme NatureCoast with 12 PhDs.

Communication has proven to be key to this project. Initially there was quite some resistance against the concept. However, by being open about the process and the subsequent monitoring programme, negative opinions were turned around.

Some issues emerged after construction and were addressed in close collaboration with all relevant stakeholders; this included maintenance of the Zandmotor after construction, as well as swimmer safety. Both these issues have been solved by involving all relevant stakeholders to come to a joint solution.

An identified lesson learned was that communication should have been even more intense during the earlier phases of the project to ensure that every partner had sufficient time to input.

8.2.8. Spain – Arga River Restoration (using Nature-based Solutions)

The main description of this case is under the aspect of Nature-Based Solutions, see Section 11.2.5.

The Arga River Restoration project consists of a range of measures to recover the natural dynamics of the river with the combined aims of reducing flood risk and restoring water quality and habitats.

Ministry for the Ecological Transition and the Demographic Challenge (MITECO) and the Ebro RBD initiated the project, and organised it in collaboration with the Navarra Region (Autonomous Community) and the municipality of Funes (Figure 8-7). The main role of the national government has been to approve the budget for the project as well as to validate the technical aspects of the project. The project was funded by the General Directorate of Water of the Ministry, which was feasible because there was confidence in the project based on the longstanding collaboration between the Ebro RBD, the Navarra Region local government and the municipality.

The leading parties have tried to include all stakeholders in the process. Several meetings, workshops and field visits have been arranged for the general public, public administrations, technicians, etc. It has proven to be difficult to explain how river dynamics work. The restoration works have now been seen to work during real flood events, with inhabitants seeing the actual difference they make.

At the beginning, people living in Funes were reluctant to accept the implementation of this restoration project. However, after the implementation, they have realised the effectiveness of this plan because it actually reduced damages caused by the floods. The engagement combined with the actual demonstration of the project's benefits has improved the stakeholders' sentiment about the river: they understand the measures that were taken, the reason behind them and they feel part of the picture.

8.3. **Figure 8-7: River Arga River Restoration – view upstream toward Funes**

Issues / key findings

Collaboration from start is key for successful implementation.

Allowing all stakeholders and affected parties to be involved in communications and decision making throughout the project reduces chances of opposition which can affect progress.

There have been many instances (Kerkebeek, Gothenburg & Climate Ready Clyde) where the successful implementation of FRM has led to further initiatives across the countries. This highlights the potential for more initiatives to be implemented that can benefit many communities across Europe.

Resistance from partners occurred on some projects but due to collaboration throughout the projects, issues and concerns were listened to and respected.

Government are beginning to invest more money into FRM due to increased water levels and the more regular occurrence of flooding and erosion.

9. WORKING WITH THE PUBLIC TO MANAGE FLOOD RISK

Definition and Context

9.1. An active role of the public in FRM is beneficial because it can lead to better measures that fit in the local setting and more acceptable. The resulting awareness can also reduce flood vulnerability. Working with the public can include making use of local knowledge, taking account of local views, or even an active role from landowners and communities, for example in maintenance and emergency response.

Cases

9.2.1. Overview

9.2. This section presents four cases that illustrate challenges and current practice for public participation in FRM. Three of these cases are also presented in Chapter 8. Working in Partnership: engagement within the public often comes from, or is embedded in a wider partnership between organisations.

The cases are:

- River contracts
  - Kerkebeek Valley River Contract- Flanders, Belgium (Section 9.2.2)
  - Middle Tiber River Contract- Italy (Section 9.2.2)
- Large complex projects
  - Room for the Waal, Nijmegen – The Netherlands (Section 9.2.4)
- Emergency response
  - Regional Community Resilience Group – Northern Ireland, UK (Section **Error! Reference source not found.**)

For three of them, the main story is told in Section 8, and this Section 9 only focuses on the public participation elements. For case Regional Community Resilience Group, the primary focus is on public participation, so the main story is told in this section.

9.2.2. Belgium – Kerkebeek Valley River Contract

The main description of this case is under the aspect of Working in partnership, see Section **Error! Reference source not found.**.

The Kerkebeek project, led by the Flemish Environment Agency, is a trial for bottom-up stakeholder engagement in local FRM. The project produced a River Contract which is a joint commitment for carrying out a mix of protection, prevention and preparedness measures.

The project engaged with a full range of stakeholders, and the community was represented in the project's Steering Group.

Launch events were held for each community. The residents would receive information on the project and could share their ideas with the Steering Group and each other, and choose their representative 'community ambassador' for the Steering Group. These start-up meetings were visited by approximately 200 people.

During the ideation stage the project website was used to present an online test for residents to check their individual risk of flooding and how this will develop in the future due to climate change. This test was used to raise awareness amongst the general public. The website was also used successfully for generating ideas: 120 ideas were submitted, some of which were elaborated later in the process.

Members of the public were then also involved in the subsequent Kerkebeek Forum (Figure 9-1), generating further community input and evaluating the results of the ideation stage. Fifty measures were selected for development into the River Contract.

Lessons learned with specific relevance for public participation:

- The bottom-up river contract approach can work if measures to reduce flood risk may not be fully supported by the public
- It was difficult to reach certain sectors, and this included younger people especially.

Figure 9-1: Idea generation with residents, Kerkebeek River Contract

9.2.3. Italy – River Contract Middle Tiber

The main description of this case is under the aspect of Working in partnership, see Section 8.2.2.

The Middle Tiber is just upstream from Rome; it has many different functions and its storage capacity is important for managing flood risk to the city of Rome. The River Contract creates joint commitment by public and private parties for creating and implementing a shared vision for the management of the river.

The River Contract combines all relevant public, private and academic organisations, but also includes the general public in the decision-making process (in addition to their elected representatives). Once a year, a public meeting is convened so that the general public can have its say. Furthermore, excursions are organised for local communities to reconnect with the river and the local heritage (see Figure 9-2). This is to stimulate participation in the region and to enlarge the community's knowledge and awareness about their own land. One of the River Contract's aims is to initiate self-maintenance practices for landowners.

Figure 9-2: Excursions to help the public reconnect with the river, Middle Tiber River Contract

9.2.4. The Netherlands – Nijmegen – Lent: Room for the River Waal Project

The main description of this case is under the aspect of Working in partnership, see Section 8.2.6.

The Room for the Waal project concerned widening of a major river at a local pinch point, reducing flood risk as part of the national Room for the Rivers programme, while also enhancing spatial quality by creating a 'Park for the People'.

The specific challenge for public participation was the fact that 50 people would lose their homes as a result of the project. From the start this led to strong resistance from the local community of the village of Lent, on the opposite bank from the city of Nijmegen.

As the project took place in the middle of the city, many people were involved both in the local municipality and public. As a result, stakeholder engagement and very open discussions were at the heart of the project. In addition to the normal statutory requirements for stakeholder engagement through the Strategic Environmental

Assessments, stakeholders and the local community were engaged through newsletters, information meetings and interactive workshops. The interactive workshops gave community members opportunities to provide their ideas and suggestions. This broad and active involvement of stakeholders, and detailed responses to address and incorporate their inputs, strongly helped to address the stakeholders' doubts and opposition.

A lesson learnt from the project was to involve stakeholders at a very early stage, even when there is not much known from a technical perspective. This serves not only to hear the stakeholders' problems, but also to work together to explore new and different solutions. The affected community was already well organised at the start of the project, and the project made money available to support this. In case of people having to leave their homes, a very individual approach was taken.

9.2.5. United Kingdom – Regional Community Resilience Group

Context

Following a significant rainfall event in June 2012, which impacted the Greater Belfast Area of Northern Ireland, a review of the response to the flooding made a number of recommendations. One of the recommendations was to consider how to deliver appropriate flood warning and information for Northern Ireland. To address this a four stage 'Flood Warning and Information Strategy' was developed.

Challenge

Flooding often happens at a very local scale, and local, focussed information is necessary to allow an effective response.

What is it?

The Regional Community Resilience Group (RCRG) is a multi-agency group that works directly with over 30 local communities, helping them prepare for severe weather.

Approach

The RCRG was formed in 2013 to deliver the Flood Warning and Information Strategy by developing a regional standardised approach, focusing on communities in a prioritised way, and helping them prepare for and respond to weather related emergencies. The group brings together over 15 partner organisations to develop a Community Resilience Delivery Programme across Northern Ireland.

The RCRG is jointly chaired by Local Government and the Department for Infrastructure (Rivers), with coordination via quarterly meetings. It works with over 30 local communities, many of which have been pre-identified as 'at-risk' based on a prioritisation matrix that takes into account a combination of flood history, number of properties affected, and other relevant factors. Other communities have also been approached by the RCRG based on their knowledge of past flood events and others have proactively contacted the RCRG seeking assistance.

One of the main goals is to support the communities in developing their Community Plans. The templates for this allows each community to develop tailored plans to suit the individual needs of their community with annual refresher engagement to ensure key information remains relevant. The RCRG reports to the Northern Ireland Emergency Preparedness Group (NIEPG), within the civil contingencies structure in Northern Ireland.

Figure 9-3 Fermanagh and Omagh District Council hosts a Community Convention in 2019 (source -https://www.fermanaghomagh.com/app/uploads/2019/07/rcrg-newsletter-summer-2019.pdf)

Reliable weather forecast and river level information is used to inform and support communities at known flood risk so they can be prepared for flooding. Local resilience groups are advised of weather information, based on the forecast developed by Met Office. These weather warnings are directly communicated to the local communities and in this way the information reaches the right people at the right time. Water level alert

stations can be installed which issue text messages to key contacts when pre-defined river threshold levels are reached enabling vigilance to be maintained during severe weather events.

Personal relationships with key residents play an important role, with the success of the approach benefitting from pro-active lead residents. This tends to be easier in regions that have experienced more recent flooding impacts. Experience of flooding and real life impacts also help illustrate technical flooding parameters such as return periods.

By explaining the flood risk faced and outlining the limitations of the response from government, communities are better informed and can determine if they need to put in place self-help measures. For example, the pre-deployment of sandbags which are provided in suitable storage facilities for access by local people enables the community to self-help.

Applicability of Approach

The RCRG approach is used across Northern Ireland and could be applied to any community at risk of flooding. It is important to note that Community Resilience is not in any way a method by which Government Departments or the emergency services may reduce their response or service to the community, rather it provides an additional layer of support for those communities at risk.

Benefits of Approach

Communities are now forewarned of predicted severe weather via e-mails, text messages and phone calls. Given the relationship built up with the RCRG communities, contact can be made directly with key residents to ensure the severe message is understood and is being actioned appropriately.

The Community Plan provides a structured approach to preparation for a response to flood emergencies. This allows local communities to initiate self-help measures so that they can respond quickly at times when the demand on government resources can be stretched, and which may release resources to deliver a more effective response.

9.3. Limitations of Approach

In areas where there has not been a recent flooding impact it can be more difficult to establish effective local community engagement.

Issues / key findings

In the Kerkebeek Valley, Belgium, effective public engagement has led to over 70 flood risk mitigation measures being agreed for implementation. In Italy a River Contract for the Middle Tiber was used

to improve the dialog between all stakeholders, including members of the public, and this has increased awareness of flood risk and how it can be managed. Effective public engagement in Nijmegen, the Netherlands turned an initially unpopular river realignment scheme into a project which not only reduced the flood risk but also enhanced the local area. In Northern Ireland public partnership with the Regional Community Resilience Group has improved public understanding of flood risk and the local community response to flood events.

The cases presented in this section show that public engagement can lead to improvement in the design of flood risk reduction measures and help to deliver additional benefits such as improvement in cityscape. A key theme of all the examples is that engagement with the public should start at the very beginning of a project, as early engagement leads to better participation and more meaningful input.

It has been highlighted that it is difficult to engage communities in areas where there has not been any flooding (even if they are known to be at high risk) and younger people who may not have any memory of significant flood events. This is because being able to provide real life examples is more effective to non-technical members of the public than numerical models and predictions.

10. MEASURING PROGRESS

Definition and Context

10.1. Annex B.2 of the FD requires 'assessment and documentation of the progress made towards the achievement of the objectives.' Measuring progress in a project is essential to tracking the performance of the project over time. This aspect, "Measuring progress", explores different methodologies for measuring progress during a project, set against national standards. In order to measure the progress made on a project, it is first necessary to set objectives in key areas, develop measures linked to these objectives and identify how it will be shown that these objectives have been achieved.

Once objectives have been set and measures developed to deliver these objectives, there are various tools which can be used to support the measurement and reporting of progress towards the achievement of the objectives, for example through identification and measurement of performance indicators. Measuring the progress made on the measures enables MS to assess the delivery of their FRM objectives.

Two cases have been identified which each use different methods for assessing the progress made towards the achievement of objectives. They are described below.

10.2. Cases

10.2.1. Overview

This section presents two cases which measure progress in FRM, as follows:

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10.2.2. Austria – River Development and Risk Management Concept (GE-RM)

Context

The severe flood event along the Danube River and its tributaries in Europe 2002 initiated substantial revisions in flood protection and flood management in Austria. Lessons learnt from the event identified the need for an integrated risk management approach comprising a broad bundle of structural and non-structural measures. Integrated FRM is implemented in accordance with the FD, with a need for close coordination with the WFD.

While the Austrian government has not made the use of integrated approach mandatory, it is a pre-requisite for obtaining national funding.

It requires creation of multiple outcomes for flood risk and the wider environment. A process has been set up requiring these to be developed through objectives through to development and delivery of measures.

Challenge

The main challenge is to coordinate between the objectives of both directives (FD and WFD) which might be significantly different or even contradictory.

The process of cross sectoral coordination at a national level in Austria is working well, as for both directives the competent authority is the same federal ministry. Major challenges arise when it comes to the implementation of distinct local measures. Flood protection measures have to be analysed at a catchment scale to identify potential conflicts as well as synergies with other sectors and policies including the WFD.

What is it?

GE-RM means River Development and River Management Concept. It is a planning instrument that Austria uses at a regional level for coordination of flood risk measures with other sectors (WFD/water quality but also all relevant others) to prevent conflicts and create win-win solutions.

Approach

The eligibility check for funding of flood protection measures in Austria has to be conducted based on the planning tool called 'River Development and Risk Management Concepts'. These concepts are coordinated with the objectives, measures and priorities of the National FRMP according to the FD as well as the goals of the National RBMP.

1. The integrated management approach which was used was a four-stage process. A schematic representation of this is shown in Figure 10-1 **Error! Reference source not found.**.

2. A preliminary study, reviewing existing data and determining who should be involved. Existing data was reviewed and tasks for the subsequent revision were specified.

3. An inventory, collecting required data in relation to flood risk (FD), water quality (WFD) and 'boundary conditions', was created. This inventory identifies the need for action and supplies missing data necessary to determine deficits, objectives, and measures.

   Working with all sectors to identify opportunities and challenges and identify a common target state in order to define objectives. Based on the inventory taking and cross linking to the goals of river basin management as well as the objectives of FRM potential

deficits can be identified. By this approach an integrated reference is defined, serving as a common target state to be reached.

The river development and risk management concept is created, which describes the intended measures based on a consistent national catalogue of measures.

4. This approach often leads to the identification of measures with multiple benefits (for example natural water retention measures or nature-based solutions having the potential of improving flood protection, ecology, recreation and habitat diversity).

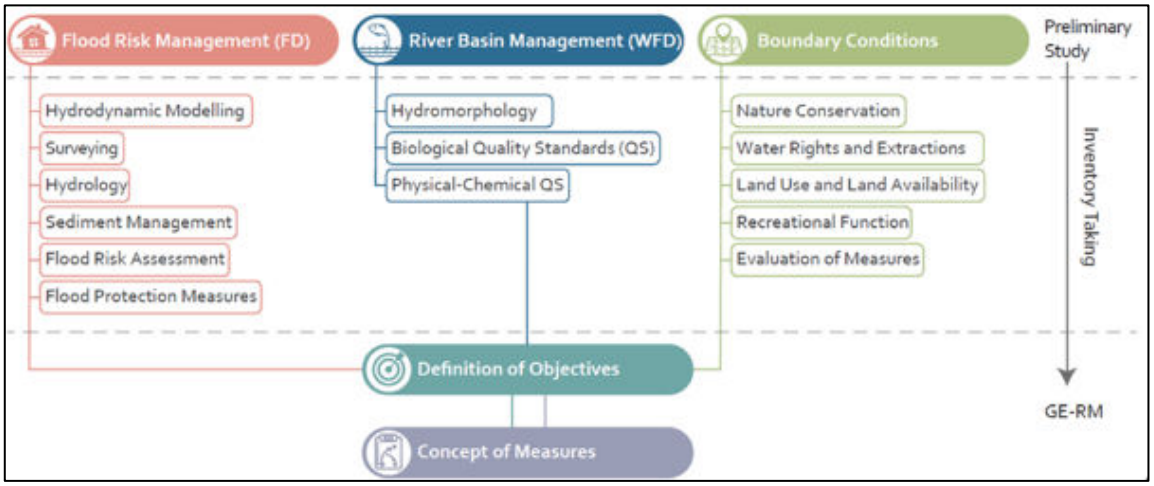

Figure 10-1 - Schematic overview of the GE-RM process

Applicability of Approach

A GE-RM is created primarily for water bodies and catchment areas with a need for action regarding FRM and river basin management. Other than flood hazard, ecological status, land use, zoning and third-party rights are also considered. Interdisciplinary objectives and measures are defined based on the preliminary studies and inventory. This approach could be applicable in many scenarios where multiple benefits are desired.

Benefits

The tool developed allows for catchment-based planning, independent of administrative borders and therefore support multi-level risk management.

The benefits of the process include sectors, such as agriculture, which were not included in project planning. Furthermore, there is a far closer (and institutionalised) inter-sectoral co-ordination and co-operation between flood risk managers, river basin managers, spatial planners, and emergency managers.

The preparation of the GE-RM includes obligatory stakeholder involvement and participatory processes in order to increase awareness of flood risk, ecological state, and further relevant water management needs.

Limitations

The tool currently does not include prioritisation, for example on the basis of cost effectiveness. The GE-RM instrument was introduced in 2019 and has been carried out fully for one catchment with eight pilot projects being developed. As such, there is limited guidance on more complex catchment issues.

- German – LAWA Joint Assessment Tool. (Section **Error! Reference source not found.**)

The Austrian River Development and Risk Management Concept (GE-RM) is also described in Section 7 Planning and implementation of measures

10.2.3. Austria – River Development and Risk Management Concept (GE-RM)

Context

The severe flood event along the Danube River and its tributaries in Europe 2002 initiated substantial revisions in flood protection and flood management in Austria. Lessons learnt from the event identified the need for an integrated risk management approach comprising a broad bundle of structural and non-structural measures. Integrated FRM is implemented in accordance with the FD, with a need for close coordination with the WFD.

While the Austrian government has not made the use of integrated approach mandatory, it is a pre-requisite for obtaining national funding. It requires creation of multiple outcomes for flood risk and the wider environment. A process has been set up requiring these to be developed through objectives through to development and delivery of measures.

Challenge

The main challenge is to coordinate between the objectives of both directives (FD and WFD) which might be significantly different or even contradictory.

The process of cross sectoral coordination at a national level in Austria is working well, as for both directives the competent authority is the same federal ministry. Major challenges arise when it comes to the implementation of distinct local measures. Flood protection measures have to be analysed at a catchment scale to identify potential conflicts as well as synergies with other sectors and policies including the WFD.

What is it?

GE-RM means River Development and River Management Concept. It is a planning instrument that Austria uses at a regional level for coordination of flood risk measures with other sectors (WFD/water quality but also all relevant others) to prevent conflicts and create win-win solutions.

Approach

The eligibility check for funding of flood protection measures in Austria has to be conducted based on the planning tool called 'River Development and Risk Management Concepts'. These concepts are coordinated with the objectives, measures and priorities of the National FRMP according to the FD as well as the goals of the National RBMP.

The integrated management approach which was used was a four-stage process. A schematic representation of this is shown in Figure 10-1 **Error! Reference source not found.**.

5. A preliminary study, reviewing existing data and determining who should be involved. Existing data was reviewed and tasks for the
6. subsequent revision were specified.

7. An inventory, collecting required data in relation to flood risk (FD), water quality (WFD) and 'boundary conditions', was created. This inventory identifies the need for action and supplies missing data necessary to determine deficits, objectives, and measures.

8. Working with all sectors to identify opportunities and challenges and identify a common target state in order to define objectives. Based on the inventory taking and cross linking to the goals of river basin management as well as the objectives of FRM potential deficits can be identified. By this approach an integrated reference is defined, serving as a common target state to be reached.

The river development and risk management concept is created, which describes the intended measures based on a consistent national catalogue of measures.

This approach often leads to the identification of measures with multiple benefits (for example natural water retention measures or nature-based solutions having the potential of improving flood protection, ecology, recreation and habitat diversity).

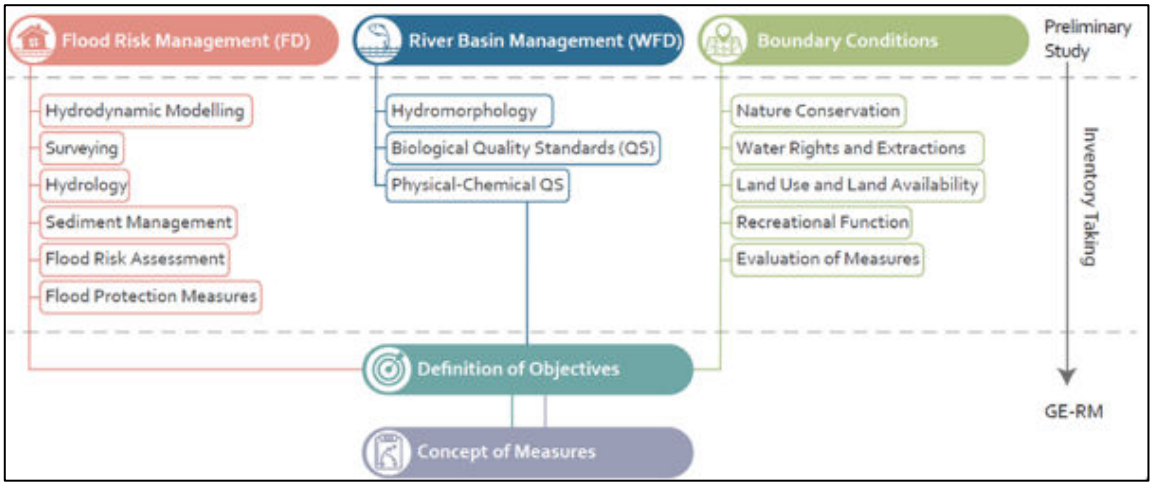

Figure 10-1 - Schematic overview of the GE-RM process

Applicability of Approach

A GE-RM is created primarily for water bodies and catchment areas with a need for action regarding FRM and river basin management. Other than flood hazard, ecological status, land use, zoning and third-party rights are also considered. Interdisciplinary objectives and measures are defined based on the preliminary studies and inventory. This approach could be applicable in many scenarios where multiple benefits are desired.

Benefits

The tool developed allows for catchment-based planning, independent of administrative borders and therefore support multi-level risk management.

The benefits of the process include sectors, such as agriculture, which were not included in project planning. Furthermore, there is a far closer (and institutionalised) inter-sectoral co-ordination and co-operation between flood risk managers, river basin managers, spatial planners, and emergency managers.

The preparation of the GE-RM includes obligatory stakeholder involvement and participatory processes in order to increase awareness of flood risk, ecological state, and further relevant water management needs.

Limitations

The tool currently does not include prioritisation, for example on the basis of cost effectiveness. The GE-RM instrument was introduced in 2019 and has been carried out fully for one catchment with eight pilot

projects being developed. As such, there is limited guidance on more complex catchment issues.

10.2.4. German – LAWA Joint Assessment Tool.

Context

The German federal states decided to harmonise objectives and to develop a joint 'assessment tool' which would build on the German catalogue of measures created in the 1st cycle of the FRMP and consider the realisation of these measures and their impact on risk reduction. An agreed set of objectives for flood risk reduction and a catalogue of measures was already developed as part of the 1st cycle.

The overall objective of the assessment tool was the reduction of flood risk, and to prevent and reduce damage to human health, the environment, cultural heritage, and economic activity. Within this overall objective, a system of four main objectives was created focusing on prevention of flood risks before a flood event and reduction of adverse consequences during and after a flood event.

Challenge

The current method to understand and report on the progress of the flood risk measures and their impact on reducing flood risk was complex and occurred as different processes. The need for a common approach was identified, however no methods were available in the individual federal states, nor was any readily identified in other European countries. An opportunity was identified to develop methods and tools to integrate and improve the efficiency of the assessment processes.

What is it?

A methodology and associated tool, developed by the German Working Group on Water Issues of the Federal States and the Federal Government (LAWA), to link measures and objectives and to assess the achievement of the objectives.

Approach

The objectives and catalogues of measures from the 1st cycle plans for a number of river basin catchments were evaluated. Criteria were identified for the individual objectives which could be used to measure progress towards the achievement of each objective. Suitable indicators (LAWA measures) were determined for each of these criteria.

Ranked valuation principles were applied to each indicator, creating categories of progress towards the achievement of objectives.

The overarching FRM objectives for Germany have been defined:

- Prevent new risks (before a flood) in the risk area;
- Reduce existing risks (before a flood) in the risk area;
- Reduce adverse consequences during a flood;
- Reduce adverse consequences after a flood.

These objectives are designed to minimise the adverse impacts of flooding on the issues listed in Art. 1 of the FD: human health, the environment, cultural heritage, and economic activity. Progress towards these objectives is measured through the specification of operational and measurable sub-objectives.

Once the sub-objectives were set, indicators which linked to these objectives were decided, which linked directly to measures taken from the standardised German Flood Risk Management Catalogue. The objectives and sub-objectives which were set are shown in Figure 10-2.

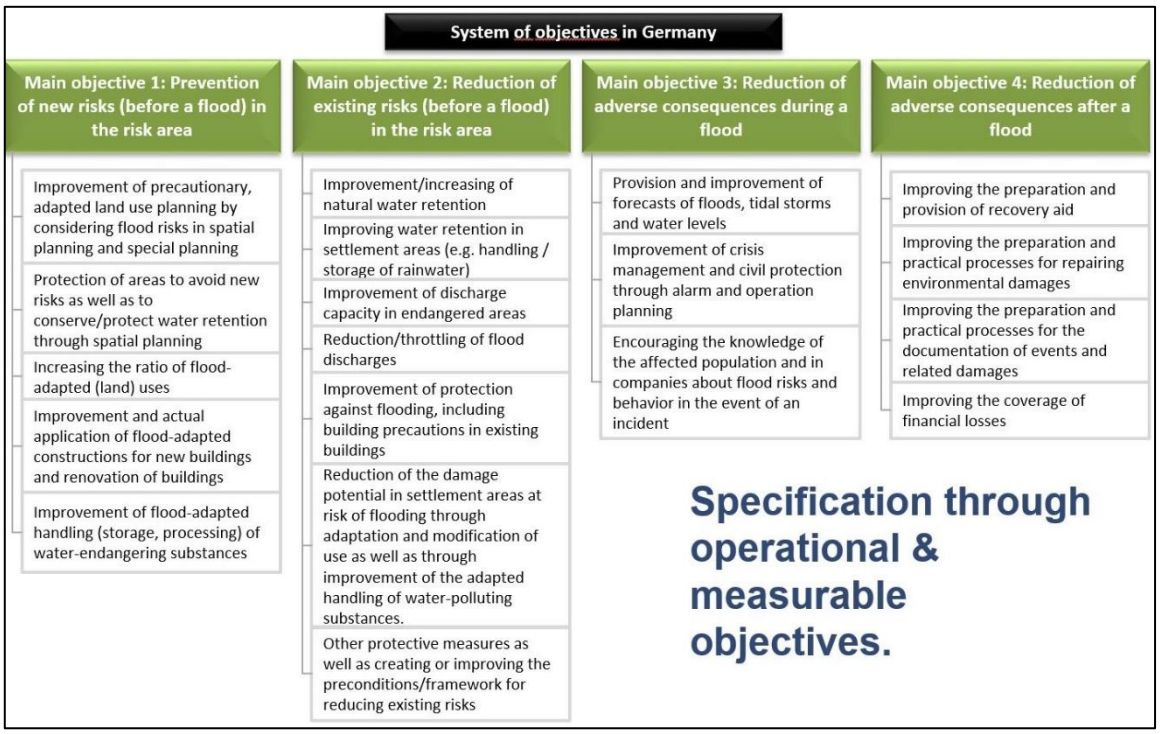

Figure 10-2 System of Objectives

Applicability of approach

This method is an effective way of ensuring a clear link between objectives and measures and their monitoring and impact of the

measures. It is widely applicable and it should be easy for other MS to adopt something similar as the data requirements for the method are based on the reporting data formats upon which the EC and the MS agreed. The only thing left to do for the other MS is to define their specific sub-objectives, indicators and processes. The tool being based on Excel makes it simple and easily transferable.

Benefits of the project

The simplicity of the approach means that objectives can be clearly defined, and measurable sub-objectives set, allowing progress to be easily measured. By setting impact criteria for each objective and linking these to measures (such as from the standardised German FRM catalogue), targets are clearly defined, allowing progress to be monitored effectively.

Limitations of the project

Use of the methodology and tool will require appropriate data, such as the German FRM catalogue. Without sufficient data about measures it may not be as effective.

10.3. Issues / Key Findings

The cases in this section show the measurement of progress for two different scales of FRM, essentially fulfilling two different purposes:

- Measuring progress against national objectives to create a national overview inventory. This requires nationally defined objectives and indicators, and is supported by a national catalogue of measures.
- Measuring progress against an integrated set of catchment-wide objectives, defined by a wide stakeholder group and relying on an interpretation of different national legislations and framework. This method is also supported by a national catalogue of measures.

Underlying both methods is a clear definition of the objectives that progress needs to be measured against, and by linking these to a national catalogue in both cases, targets are clearly defined, allowing progress to be monitored effectively.

11. NATURE-BASED SOLUTIONS

Definition and Context

11.1. Nature-Based Solutions (NBS) in the context of FRM are measures that work with natural processes to address FRM, while providing multiple benefits for both human well-being and biodiversity. However, there are also challenges: it is sometimes difficult to demonstrate their flood risk reduction capabilities, and the added complexity of multiple organisations and objectives can make it difficult to come to implementation.

A common example of NBS is reconnecting rivers with their floodplain, as is the case with the Arga River (Spain), Eddleston Water (UK) and the river restoration projects in Hungary and planting native species to slow the flow and stabilise river banks as seen in the Amarante region of Portugal and in the River Tweed catchment (Eddleston Water, UK). There are other examples which work with more complex natural processes such as the Zandmotor scheme in the Netherlands.

This chapter is closely linked with Chapter 7 which explores how FRM measures are planned and implemented, especially relevant is Section 7.2.10 which presents the example of the UK's Working with Natural Processes project which is supporting the application NBS across England.

11.2.

Cases

11.2.1. Overview

This section presents five cases of NBS for FRM, each in a different context. They are:

- River restoration projects – Hungary (Section **Error! R eference source not found.**)
- Zandmotor – The Netherlands (Section **Error! Reference s ource not found.**)
- Amarante Rivers for Everyone 3.0 – Portugal (Section 11.2.4)
- Arga River Restoration – Spain (Section 11.2.5)
- Eddleston Water Project – Scotland, United Kingdom (Section 11.2.6)

11.2.2. Hungary – River Restoration Projects (Using Nature-Based Solutions)

Context

In Hungary, the rivers are under special environmental and natural protection. This means that all flood protection interventions affect nature conservation priority areas, therefore, flood risk reduction measures need to be in accordance with the measures of the WFD. Two examples have been provided of river restoration projects which show good practice in the area of NBS, the Rehabilitation of the Mosoni-Danube River and the rehabilitation of Nagy-Pándzsa. Both projects aimed to reduce flood risk and improve ecology in order for the watercourses to achieve good ecological status under the WFD. In addition, the planned developments had to be sustainable in the long term, contribute to the development of water tourism, and fit into the landscape. The projects therefore have the following shared goals:

- General:
  - Improving the water quality and quantity of the water system and increasing its ecological potential;
  - Reconstructing of wetlands;
  - Maintaining flood and inland waterway safety.
- Social:
  - Improving the cityscape;
  - Boosting beach bathing;
  - Creating conditions for water and ecotourism in the inner sections;
  - Removal of aquatic vegetation and trees that have fallen into the water.
- Environmental / ecological:
  - Improving the quality of water bodies.
  - Creating optimal conditions of different types of aquatic habitats in all hydrological situations.
  - Ensuring the free migration of aquatic organisms, even in periods of low flow in the water courses.

Challenge

Rehabilitation of the Mosoni-Danube River

During low and medium flow, the river levels in the Mosoni-Danube have reduced creating a number of problems:

- The decreasing water levels combined with the suction effect of local waterworks lowers the groundwater level. Inland waterways are fed by groundwater. Water shortage is common, and a narrowing of the aquatic habitat can be observed;
- In the urban river sections at Győr, the bank protections were built in accordance with the previous typical water levels. The decreasing water levels therefore have an unfavourable effect on the cityscape, especially in the downtown area;
- The current hydrological and morphological conditions mean it is not necessary to open the sluices as frequently. Therefore, the Mosoni-Danube is losing connections with the associated tributaries and in-land waterways, resulting in deteriorating water quality.

Rehabilitation of Nagy-Pándzsa

In 2010 heavy rainfall led to several pluvial floods along the Nagy-Pándzsa and the Vezseny-ér. The muddy riverbeds created a significant flood risk to settlements along watercourses and had the potential to cause water quality problems.

What is it?

Rehabilitation of the Mosoni-Danube River

The rehabilitation of the Mosoni-Danube River project aimed to improve the water supply to cut-off meandering branches and wetlands and reduce flow risk and ice flow in the river sections of 16 settlements. This was achieved by rehabilitating 15 major river branches and wetlands along the 124 km length of the Mosoni-Danube. Silted, ingrown and significantly narrowed side branches were opened up and extended (dredged).

Rehabilitation of Nagy-Pándzsa

The main objective of the rehabilitation of the Nagy-Pándzsa was reducing flood risk, increasing the area of wetland habitat and achieving good ecological status. The Nagy-Pándzsa and Vezseny-ér riverbeds were laid, the Rabkerti Lake was dredged and the Holt-Marcal estuary was reconstructed. A flood reservoir in Mindszent was built to reduce the flood risk to the settlement of Pér, river retaining works in the area

of Écs and Ravazd, and a dam plus water abstraction lock in the Győr section of the Nagy-Pándzsa.

Approach

For both projects the preliminary feasibility studies assessed the nature conservation and environmental impacts of all solution variants. Special attention was paid to the sustainability of the project results whilst preserving the state of the environment. When selecting the technical solutions, the possibility of alien (and potentially invasive) flood vegetation was taken into account. An Environmental Impact Assessment was mandatory and helped in selecting the least harmful variant and therefore the achievement of the project goals was guaranteed in a sustainable way. In addition, representatives of nature conservation organisations were consulted during both planning and implementation phases. Climate change was taken into account in the design stages by following the national guidelines on Flood Design Water Levels; based on this study, flood levels and flood yields with different probabilities of occurrence could be modified.

Special attention was also paid to the involvement of stakeholders in the planning and implementation stages of projects. For each project, consultation, forums and press briefings took place several times. The Water Directorates also prepared summary documents on the technical content, objective and impacts of the projects and published these on project websites. The public forms were attended by the leaders, citizens, nature conservation representatives, planners and other co-authorities of the municipalities concerned. Stakeholders got the chance to share their views so that the designers could incorporate these suggestions and comments.

Applicability of Approach

The approaches presented in these examples can be applied to other similar rivers to suit the context and objectives for flood risk and wider benefits.

Benefits of Approach

The reduction in flood damage and reviews carried out during the year suggest that the projects have reached their goals on flood reduction. At the same time, a positive trend can already be observed in the ecological status of the waters. It should be noted, however, that further monitoring is necessary in order to prove the lasting positive effects of the projects. Tourism data provides evidence that the water tourism sector has benefited as a result of the projects. No official public opinion surveys have been undertaken after the implementation of the projects, however, a number of positive newspaper articles appeared during the

implementation stage, indicating the projects were well received by the public.

Rehabilitation of the Mosoni-Danube River

As a result of the project, the main riverbed channel and the tributaries take part in the flood flow process. Favourable conditions for tourism have been created. The preservation of natural values also made it possible to preserve the cultural values of the region (historic way of life, forms of farming).

Rehabilitation of Nagy-Pándzsa

The flood risk was reduced, with 2154 people protected against water damage as a result of the project. The RBMP that formed part of the project makes it easier for local government to carry our urban drainage tasks. The viability of flora and fauna has improved. Furthermore, the area of land that can be built on and cultivated has increased, which has contributed to the establishment of businesses and thus to economic growth and increased employment. In the case of Győr and Pannonhalma in particular, the project helped to boost tourism.

Limitations of Approach

There are no known identified limitations to record.

11.2.3. The Netherlands - Zandmotor (Building with Nature)

The main discussion of the Zandmotor case is provided in this section, but the case is also included to illustrate the aspect of Working in partnership, see Section 8.2.7.

Context

In the Netherlands, the national government is responsible for coastal flood and erosion risk management. The Dutch North Sea Coast is naturally eroding. The erosion problem also affects the risk of flooding of the low-lying hinterland, as the eroding dunes form the main flood defence along this stretch of coast. Therefore, in 1990 it was decided not to let the coast erode any further beyond that year's coastline – which thereafter was called the "Reference Coastline". Since then, the coast has been nourished annually at critical points (order of 1 million m^3 per location). This policy has been a success; it is expensive, but much cheaper than using hard defences and better from an environmental and socio-economic perspective.

Challenge

Around 2007, triggered by increased sea-level rise projections and the increasingly densely populated area in the provinces of North- and South-Holland (that benefit from the flood protection provided by the

dune system), a review of the implemented measures and policies was conducted, and it was concluded that these would still provide enough safety in the future. It was therefore deemed possible to try innovative ideas in the form of pilot projects, to be able to test them before critical situations happen.

What is it?

The Zandmotor pilot was initiated in 2005. Instead of repeating the nourishment annually, this mega nourishment (21.5M m^3) was to be placed in 2011 and then left for 20 years, for nature to distribute the sand along the coast to limit the erosion, which can be seen in Figure 11-1

Figure 11-1 An aerial image of the mega nourishment (source https://dezandmotor.nl/en/)

The project was designed with multiple objectives: not only to manage erosion and flood risk (maintain the Reference Coastline locally, and feed sediment to the neighbouring sections through the waves and tides), but also to improve nature and create recreation potential, while developing knowledge about the wider applicability of this innovative approach.

In 2012 a programme was started to extensively monitor morphology, ecology, nature and leisure, which ends in 2021.

Approach

In terms of coastal processes, the Zandmotor makes use of the natural coastal processes (tide, waves and wind) to maintain the Standard of Protection along the Dutch coast. The major intervention was local, leaving the rest of the coast undisturbed by works, but fed with sand from the Zandmotor through the natural processes. The aim of the pilot was to find out what happens with coastal habitats after reaching equilibrium, without being disrupted by the annual nourishments. The idea was that the Zandmotor approach would be more sustainable with respect to the environment.

The location of the Zandmotor was not chosen based on a local need for defence – the dune system had been reinforced two years prior. It was, however, the ideal location for incorporating a broad package of additional benefits. Locally, there was a need for more space for nature as well as recreation, with potential for a significant boost to the local economy. Furthermore, this stretch of the coast was characterised by calm morphodynamical behaviour, meaning that base conditions before implementation were easily assessable and predictable.

The scheme was funded by the Ministry of Environment and Water Management and cost in the order of €50M, justified primarily by the project's flood and erosion function. The monitoring programme was co-funded by the ministry and the Province of South-Holland and cost about €20M, and this was justified by the wider range of benefits. To execute the full envisioned monitoring programme, some extra funding from the EU was acquired. In the development of the Zandmotor, a large number of parties were involved (as discussed in Section 8.2.7).

Applicability of Approach

As part of the Zandmotor's experimental nature the project has been subject to various reviews (including a 10-year review to be published in 2021). One of the reviews specifically concerned the applicability of the concept elsewhere (Deltares, 2016). This concluded that there were three reasons why the initial idea was successfully implemented: a clear need for sand; a multifunctional design; and an appealing concept.

From the perspective of coastal flood and erosion risk, the Zandmotor concept is applicable on sandy and straight coasts (as applied on the sister project Bacton Sandscaping in the UK). The research findings do not apply to more complex curved coasts, for example at estuaries. From the perspective of nature and recreation the concept is mainly attractive in areas that currently have a uniform, low-diversity coast. There can also be other strong local drivers, for example to reduce salinity of low lying areas.

The lessons learned from the Zandmotor project in terms of flood and erosion management have been translated into policy via the Coastal Genesis project. The results of the monitoring of the effect of the Zandmotor project of the natural system have also been translated to the national nourishment practices. A range of other projects have implemented the lessons learned from the Zandmotor project:

- Hondsbossche Dune Area;
- Amelander Zeegat;
- Markerwadden; and
- Bacton Sandscaping (UK).

Benefits of Approach

The envisaged benefits of the Zandmotor approach, confirmed by the monitoring programme, are

- Improved efficiency as a result of economies of scale and the active role of natural processes helping to move the sand where it performs its roles
- Creation and improvement of habitats (although more slowly than predicted due to the interaction with the project's recreation and knowledge objectives)
- Space for recreation and emergence of new local businesses
- Development of knowledge about a wide range of aspects: coastal processes, ecology, recreation, governance (see Section 8.2.7).

It is important to note that the Zandmotor project was implemented as a pilot project. If the mega-nourishment had not acted as predicted, this wouldn't have been a reason to intervene. The sand would still be in the system and add to the robustness of the coastal system. As this was a 20-year pilot, even if the Zandmotor would not have behaved as expected, no re-nourishment would have been performed. The only consequence would have been a less efficient investment than planned. This means that although the uncertainty was recognised in the design, it was accepted as part of the pilot.

In practice, the Zandmotor behaved more favourably than predicted; the expected lifespan is now 40 years, compared to the initially predicted 20. This means transport of sediment didn't happen as fast as expected.

Another issue of uncertainty was potential pollution of the dune system and thus drinking water, due to remainders of the Atlantic Wall that could pose problems due to the mega-nourishment. This uncertainty was mitigated for in the design by installing sufficient drainage. Other

uncertainties that materialised after construction that were not taken into account in the design were addressed later in close collaboration with all relevant stakeholders; this included maintenance of the Zandmotor after construction, as well as swimmer safety.

Limitations of Approach

An experiment at the scale and level of ambition of Zandmotor is only possible for issues as critical as coastal flood and erosion risk in the Netherlands. Most other nations will normally have to work at a smaller scale or with less radically different approaches. They can however benefit from the lessons learned from the Zandmotor and its monitoring and research programme.

The evaluation of the monitoring programme identified the following lessons learned:

- Investment in T0 measurements was limited and consequently for some developments it is not clear whether this has been caused by the project, as the baseline measurement is not sufficient to determine this.
- Habitat monitoring was conducted annually, in hindsight, this could have been less frequent as changes are only observed over longer periods of time. Reducing the monitoring frequency could have saved a significant amount of money.
- The amount of morphological monitoring required was underestimated. It is now understood how important multiple measurements a year are, especially pre and post storm events.

11.2.4. Portugal – Amarante Rivers for Everyone 3.0

Context

The city of Amarante in northern Portugal has been regularly affected by floods with significant events occurring from 1982 onwards This is due to the geomorphological conditions and fluvial conditions of the Tamega Basin causing rapid increases in water levels. Historic floods have caused property and social damage.

Challenge

The most recent floods have occurred in 2010, 2016 (Figure 11-2) and 2019. The Tamega River runs through the main urban area of the Amarante county and as such, an overwhelming proportion of the damage occurs here. Less frequently, the nearby agricultural land has also been affected by flood events. The land is also prone to flood

induced erosion due to the loose ground. Heritage assets, accessibility and biodiversity are all at risk if another major flood event occurred.

Figure 11-2 2016 floods in Amarante City

What is it?

The 'Structural cleaning interventions, fluvial rehabilitation and flood control, in areas of frequent floods and high damage in Amarante - Rivers for Everyone 3.0' encompassed work on 24km of the Tamega River, on both banks. It consisted of an integration of both traditional and NFM measures. The NFM measures included removal of course woody debris from the watercourses, bank stabilisation using natural engineering techniques, floodplain restoration by creating detention basins, restoration of riparian buffer zones using native species, removal of invasive species and incorporation of swales and ponds. In addition, there has been an emphasis on (i) using permeable surfaces on car parking sites near the river and limiting its use, mainly during flood events, to ensure population safety and increase the infiltration area of the floodplain within urban zones and (ii) restoring and reinforcing some infrastructures, located on river corridor, to minimize damage and improve longitudinal connectivity of the watercourse. The scheme design can be seen in Figure 11-3.

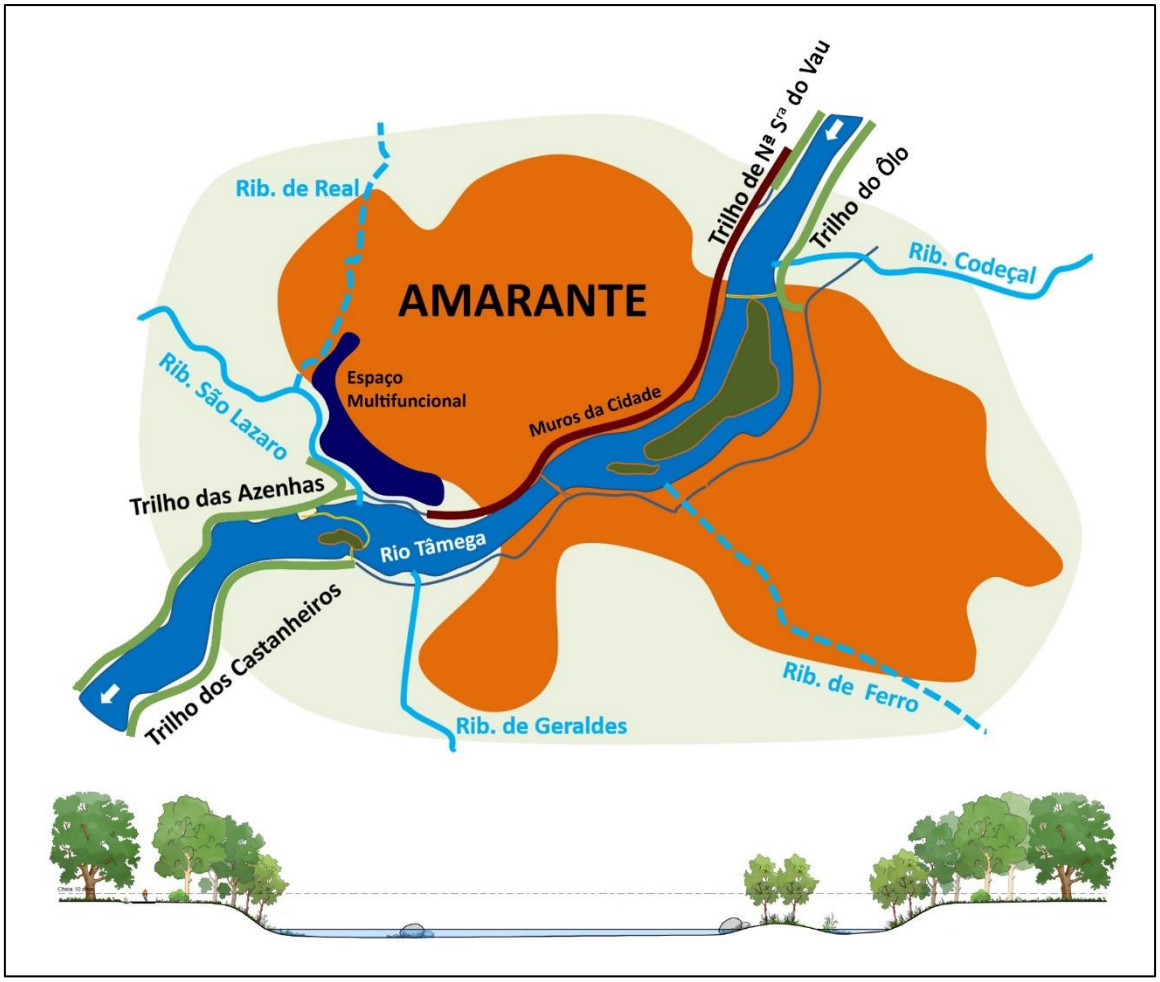

Figure 11-3 Amarante 'River for Everyone 3.0' design schematic

Approach

A private consultant, Engenho e Rio, worked with the Portuguese Environment Agency (APA) and local municipalities, at a national scale to identify and implement NFM measures to rehabilitate rivers and reduce flood risk. The Amarante project is one of approximately 150 across Portugal.

There were three primary goals of the project:

- To improve water quality, natural bank stabilisation and reduce flood risk;
- To improve habitat quality and hydro-ecological sustainability; and
- To improve local aesthetic and amenity value.

To achieve these goals, the project integrates the FD and the WFD with hydrological processes, ecological processes and socio-economic processes, at each local scale.

Decisions as to the potential NFM measures were based on hydraulic modelling (1D HEC-RAS model). There is insufficient data to model in 2D but the results of the 1D nevertheless provide a level of understanding as to the efficacy of the potential NFM measures. Altered Manning's n values are used to represent the different NFM measures. To test this approach prior to implementation in Amarante, modelling in other regions that have been historically affected by flood events was carried out. This large-scale modelling incorporated NFM measures and such measures were confidently shown to have a positive impact on flooding.

A particular point of interest during the development of this project is the relationship with other Areas of Potential Significant Flood Risk (APSFR) up and downstream of Amarante, as well as the management of the Spanish part of the river further upstream. The interventions in the Amarante are very important for the flood risk of the downstream APSFR, which had to be considered when designing the measures.

In order to engage with the local community, the municipality put out a press release to increase public awareness of NFM and the benefits of river rehabilitation, including along riverside landowner. Furthermore, workshops were held with construction companies in order to facilitate a change in their thinking with regard to NFM. The intent is to ensure the good execution of the projects and maintain its results over time, keep informing the public after the completion of the project to keeping them aware of the flood risk and its impacts on hydro-ecological and socio-economic processes. There are currently five ongoing construction projects on Tamega river, along Amarante county, but a key challenge is for the municipality to provide funding for NFM measures across all sites. An example of one of the NBS can be seen in Figure 11-4**Error! Reference source not found.**.

Figure 11-4 Natural bank stabilisation techniques created under Amarante project (Structural Interventions of obstruction removal, fluvial rehabilitation and flood control, in areas of frequent flood and high damage in Amarante - Rivers for Everyone 3.0)

Applicability of Approach

The expectation is that the example set by this project will lead to more projects on smaller rivers in the area. The techniques should be easily applicable to other rivers and MS to fit their contexts.

Benefits of Approach

The implementation of the measures is recent and therefore it is too soon to evaluate their effect.

Limitations of Approach

The availability of funding has limited the success of NFM in Portugal. At the start of the project, the Portuguese Environment Agency collated flood risk hazard information provided by the municipalities and then together with the Engenho e Rio, devised a list of priority regions that required flood alleviation measures. It was identified that other fluvial elements needed to be addressed, namely the hydro-ecology and social aspects. A compromise is required, balancing flood risk reduction goals

with social and ecological goals. A key challenge however is that funding is first and foremost allocated for flood alleviation, which can be acquired via national schemes. Any remaining funds that can be used to improve the ecology and aesthetics of the river need to come from municipalities and local communities. As a result, these additional aspects are seldom achieved.

The measures were scoped in using 1D modelling due to lack of data to allow 2D modelling. Had this data been available more targeted action would have been possible.

11.2.5. Spain – Arga River Restoration (Using Nature-Based Solutions)

The main discussion of the Arga River Restoration case is provided in this section, but the case is also included to illustrate the aspect of Working in partnership, see Section 8.2.8.

Context

The Arga River is in Navarra, Spain, and forms one of the upper sub-catchments of the Ebro river basin. Up until the 1960s, the Arga river was a naturally meandering river. As a result of urban and agricultural development this river was channelled by the construction of embankments, and the meanders and wetlands were cut off.

Challenge

The development along the Arga river led to an increased flood risk in the municipality of Funes, just upstream of the confluence with the Aragón river. In addition, the Arga is one of the first rivers in Spain to see the effects of climate change, with a significant increase in the frequency of occurrence of large floods. The local ecology had also been significantly degraded: human activity has led to the loss of riparian habitat considered essential for different fauna species, including the highly threatened European mink.

What is it?

The Arga River Restoration project consists of a range of measures to recover the natural dynamics of the river with the combined aims of reducing flood risk and restoring water quality and habitats (Figure 11-5).

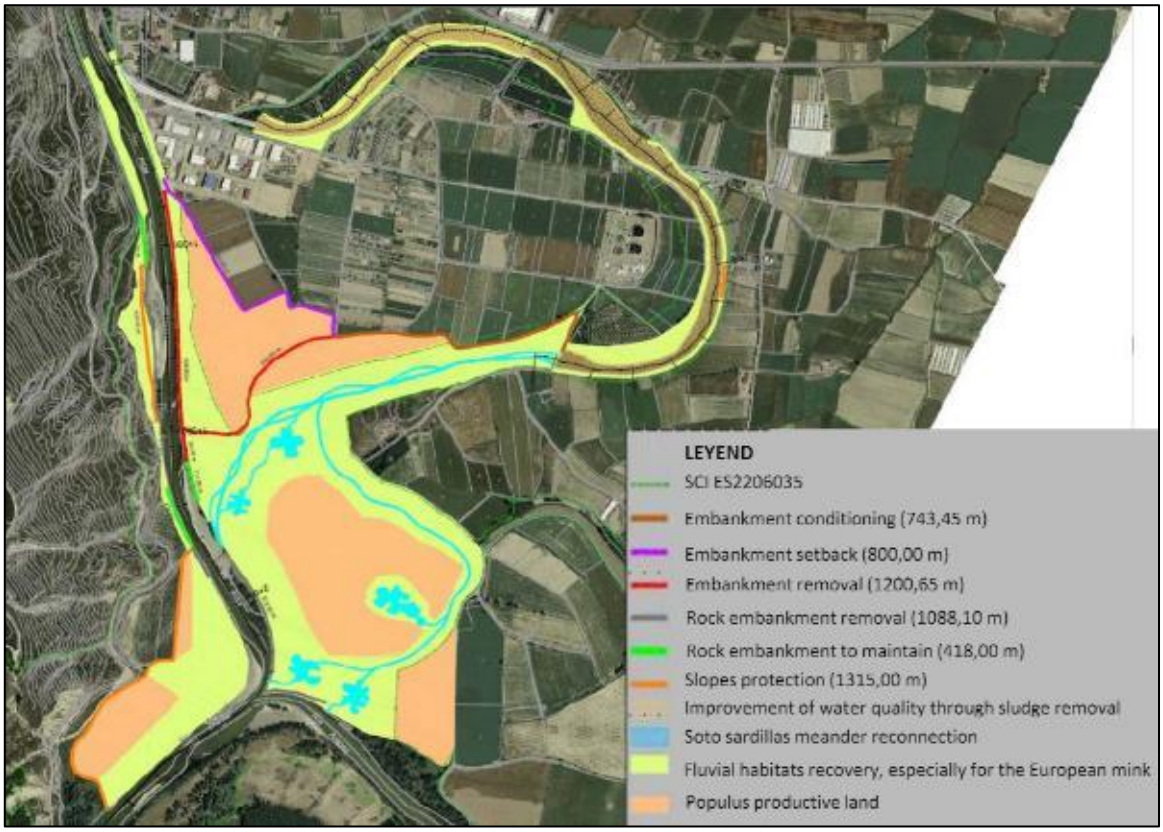

Figure 11-5 Planned fluvial restoration and green infrastructure on the Arga River (source Arga River Restoration Project Presentation)

Approach

The national government is working with regional and local partners (see Section 8.2.8) to achieve the project's multiple aims by reconnecting the Arga River to the ancient Soto Sardilla meander. In addition, the project aims to achieve good status for the water body (in line with the WFD) as well as the improvement of the habitat of the European mink (*Mustela lutreola*), which is at great risk of disappearance; in 2018 it was declared to be in a critical situation. This reconnection was one of the first proposals in the National Strategy for the Restoration of Rivers in 2007.

The project includes a range of fluvial restoration and green infrastructure measures:

- Re-establishing the hydraulic connection between the Arga river and the Soto Sardilla meander;
- Improving the meander's water quality through sludge removal;

- Managed realignment – setting back of embankments outside the river's space;
- Removal of the embankments at the confluence of the Arga and Aragón rivers;
- Increasing the permeability of existing obstacles;
- Flood plain recovery; and
- Improving the European mink habitat.

The downstream connection between river and old meander has been established, alongside most of the other measures. The project is however already having positive impacts: it has shown a consistent positive impact during the latest floods and has reduced flood damages in Funes (Figure 11-6). Furthermore, the wetland recovery is more successful than expected, with especially the water quality in the ponds exceeding expectations.

The next step is to also make the upstream connection so that the meander becomes fully part of the river system again. This brings additional complications due to the flood risk to the industries that are located at the reconnection point.

Figure 11-6: River Arga River Restoration – view upstream toward Funes

Applicability of Approach

The approach and solutions used on the Arga river are applicable to other projects: the specific challenges and opportunities are unique to each location, but similar to other places. The project is a frontrunner in Spain and its approaches are being applied across Spain on other restoration projects.

Benefits of Approach

The project is starting to show the envisaged combined benefits of reducing flood risk (demonstrated in actual floods) and improving water quality.

Limitations of Approach

There are no known identified limitations to record.

11.2.6. United Kingdom - Eddleston Water Project

Context

Eddleston Water is a tributary of the River Tweed. At the start of the 19th century Eddleston Water was severely straightened to enable the building of a toll road to Edinburgh which together with agricultural intensification, led to improved agricultural production. However, in combination with the subsequent building of a railway embankment and further changes in land use and forestry, flood risk increased downstream and habitats were lost/degraded.

Challenge

The SEPA risk assessment shows some 582 properties at risk of flooding in Eddleston and Pebbles under a 1:200 year scenario; the most recent floods being in 2015/16 (Figure 11-7). The river was also classified by SEPA as at 'bad' ecological status in 2009 (under the WFD criteria), largely due to physical changes to the channel and banksides.

Figure 11-7 Flooding at Lake Wood, December 2015

Figure 11-8 An aerial image of the meander created by the Eddleston Water Project

What is it?

The Eddleston Water project aims to reduce flood risk and improve river habitat through river catchment restoration, working closely with farmers and communities. It involved re-meandering three km of river channel, the planting of over 330,000 native trees, the installation of 116 low flow woody dams and the creation of 30 flood storage ponds. The new meander at Lake Wood can be seen in Figure 11-8.

The project is led by Tweed Forum (a well-established participative catchment charity), with public and academic partners. It represents a long-term study in support of the Flood Risk Management (Scotland) Act 2009. It looks to provide the scientific evidence in support of the Act's risk-based catchment approach that requires authorities to consider natural solutions to flood risk. The project began with a Scoping Study undertaken by Dundee University in 2010, with the aim of a detailed monitoring network in 2011 to gain baseline data before implementation of measures and monitoring since 2012. The project began its current 3-year phase funded by Scottish Government to 2024.

Approach

The project worked closely with landowners to implement a series of NFM measures that slow the flow, create storage and reconnect the river with its floodplain.

Participation by landowners is voluntary, so close engagement with land managers is central to the project's success. All stakeholder engagement is undertaken by Tweed Forum, who are trusted by farmers as a neutral non-government party. Crucially, they understand the farmers' business, and the type of land and options that can work both as NFM measures (reducing flood risk) and for the farmers (as least economically neutral). Tweed Forum has learned that it is essential to find the right trade-off: not always the ideal solution for flood risk, but solutions that are manageable within individual farm business plans, balancing effectiveness with the impact on farming. This includes obvious considerations of land productivity and access, but also impact on subsidies, and the recognition that farmers saw it as very important to retain long-term control of their land. The project found that farmers were more willing to become involved if they can see that a solution is working well in other places and for other farmers. The project has also made considerable effort to engage with the downstream communities and the wider public, through stakeholder meetings, organising project visits, conferences and wider publicity.

The project's research is coordinated by the University of Dundee. It uses both an empirical approach - based on a very detailed hydrological network and focussed ecological surveys - and combined catchment hydraulic and hydrological modelling. The catchment is also the location for detailed groundwater research. The choice and location of potential

NFM measures was informed by the initial scoping study. This also set out the Monitoring Strategy which covered the baseline period which included both a dry and wet year.

Project funding comes from Scottish Government, and in the recent phase from the EU's Interreg programme, along with support from SEPA, and from a range of other public, charitable and private funders, as well as the landowners themselves. These wider contributions could have only been bought in by Tweed Forum.

Applicability of Approach

The Eddleston Water project's approach is already working elsewhere, particularly in the Tweed Forum's area, but the approach to implementation can be applied in other places too. However, this is more difficult for the evidence gathering (monitoring and modelling) element, both for research and for local demonstration of performance. This requires significant public funding and could normally not be replicated elsewhere – but is now available to support implementation elsewhere. The Flood Risk Management (Scotland) Act 2009 provides an important supporting driver, because of its requirement to consider natural solutions. Flood scheme options appraisal and funding policies in Scotland however are not yet fully aligned. Whilst they allow inclusion of ecosystem benefits as an 'add-on' to justify investment, they do not yet require consideration of Nature-Based Solutions throughout the main scheme development process. The Eddleston Water project is being used as a case study for exploring how this could work.

The team highlights the following three aspects as requirements to apply a similar approach elsewhere:

- A legal framework such as the Flood Risk Act that requires consideration of NFM alongside other structural solutions;
- A funding mechanism that enables landowners to maintain the long-term profitability of their farm businesses alongside the introduction of NFM measures across the catchment landscape. This may involve public payment for the delivery of a range of public goods and wider benefits (flood risk reduction, carbon management, habitat improvement, water quality protection, etc.) as well as agricultural production; and
- A mechanism for true engagement with the landowners, via a trusted intermediary such as the Tweed Forum.

Benefits of Approach

Monitoring has already demonstrated that the NFM measures implemented are delaying and reducing flood peaks at the catchment scale. Ongoing modelling is helping to scale this up to show the impact at a larger scale and for more extreme events.

Working through an independent trusted intermediary such as Tweed Forum can provide important local knowledge, community buy-in, flexibility and pragmatism – longer term funding, upfront financing with gradual pay-back, working with minimal formal legal agreements (and associated costs) and landowner contributions.

Economic evaluation of the costs and benefits of implementing NFM has demonstrated a return on investment: the NFM work thus far has a net present value of £950,000 for flood damages avoided, on top of which a further £4.2 million of wider benefits have been delivered from these same measures. If other potential NFM measures were implemented, this could increase to £2.85 million flood damages avoided, with £17.7 million from other benefits on top. Although the main driver of the project is flood risk reduction, other benefits related to carbon capture, biodiversity, recreation and water quality improvements are extremely important, demonstrating the importance of an integrated catchment-wide approach.

Limitations of Approach

There are no known limitations to record.

Issues / key findings

11.3.

All of the examples presented above show that NBS not only reduce flood risk but also provide wider benefits such as improving the landscape, sequestering carbon and increasing tourism. However, the multisectoral nature of these solutions can sometimes act as a barrier to financing projects and funding is often provided for specific outcomes such as a reduction in flood risk and does not always take into account the secondary benefits in cost/benefit analyses. A key blocker experienced by NBS projects is demonstrating to non-technical stakeholders and the wider public the benefits of such measures. This is especially difficult in areas that have been affected by significant flood events in the recent past and therefore communities are keen for maximum protection. Chapters 8 and 9 explore how working with partners and the public can alleviate this issue.

12. URBAN FLOOD RISK MANAGEMENT

Definition and Context

12.1. Flood risk management in urban areas is typically complex because any measure will affect many functions. On the other hand, this can be positive when multiple benefits can be combined, leading to better projects that achieve win-wins. Urban flooding is often dominated by pluvial flooding, due to the extent of hard surfacing.

Cases

12.2.1. Overview

12.2. This section presents three cases of urban FRM, showing different perspectives in terms of city size and sources of flooding. They are:

- Ängelholm - Sweden (Section 12.2.2)
- Gothenburg – Sweden (12.2.3)
- Climate Ready Clyde, Glasgow Scotland – United Kingdom (Section 12.2.4)

There is a strong emphasis in each of these cases on working in partnership. There is a strong link therefore with Section 8 but these cases are not repeated there to avoid duplication.

12.2.2. Sweden – Ängelholm: Holistic (Flood) Risk Management

Context

The municipality of Ängelholm has 42,000 inhabitants and thus represents a more "normal" Swedish municipality relative to Gothenburg. It consists for a large part of rural areas and valuable nature areas. Ängelholm is assessed according to the FD at the national level, but despite not reaching the criterium to be appointed as an Area of Potentially Significant Flood Risk (APSFR), the municipality is under significant flood risk. The municipality stretches over two river deltas and is located at the coastline. Although the region is not overly exposed to wind waves and swell, the shape of the bay causes extreme water level set-up at the scale of hours during storms (+2m above normal).

Challenge

The coastline of Ängelholm is mainly protected by dunes, but since 2011 these have been severely affected by erosion caused during storms by extreme sea-level elevations in the bay. The height and width of the dunes varies, but their lowest point is only about 0.75m above the highest experienced storm water level. The buildings directly behind the

dunes are at risk of flooding and the dunes therefore need to be strengthened. Furthermore, the sandy beaches that characterise the coastline in this area are rare in Sweden and are therefore important to the local economy. Although extensive repair work was undertaken in the past after major events, the municipality is applying for permits to perform the additional work that is needed to strengthen the beach.

Flooding due to the rivers in the municipality is currently controlled by dikes. Although there is no recent history of flooding due to cloud bursts or acute pluvial flooding, risks were identified in 2019 and the situation is likely to worsen as climate change is altering the weather patterns.

What is it?

Ängelholm is taking a holistic view on risk, which goes further than flooding; erosion and landslides are taken into account in the risk assessments as well, creating a comprehensive overview of risk that can actively be counteracted.

Approach

The city of Ängelholm has developed an overarching working routine via a special working group on climate adaptation. This combines long-term strategic adaptation, crisis management, city planning, water/sanitation, environmental law enforcement, nature conservation, exploitation/city development and infrastructure, with a focus on overarching risk assessments and solutions for flooding, erosion and landslides and their combined risks. The municipality wants to create a comprehensive overview of which areas are under what risk and aims to counteract these risks actively. Part of these efforts is a flood risk model based on new elevation data and high-resolution river bathymetry through the town centre, which simulates sea level rise and cloud bursts. Underlying reports with analyses of climate scenarios and statistical extreme values that are relevant locally are available as well.

The city is currently working on a Structural Plan (see Section 12.2.3 on Gothenburg) that handles all water-related risks; currently there is only some guidance on addressing sea-level rise, but guidelines are lacking for other types of flooding and related risks. One such guideline that exists is the Planning and Building Act, which outlines where to build within the municipality, with varying vulnerability levels for types of development dictating the standard of protection required to resist flood water. Currently, strategic measures for handling FRM and for improving flood resilience strategically are outlined and prioritised in the action plan 'Storm', and several strategic measures have been implemented or are ongoing. In the past, measures and projects have always been approached individually and not as part of an overarching plan. The Sustaining Engineer is leading the effort to develop such a

plan; all other departments take part in the working group Climate Adaptation (monthly meetings whole group, specified subgroups), issue regular reports to the steering group (twice per year), and issue a whole-year-report and budget once per year to the city development board. These efforts are funded by public money. Cooperation between offices is promoted, for example to share risk assessments; the municipality tries to combine all this information into a map viewer.

When designing measures, combining functions is always a consideration; there are multiple examples of NBS. The funding for measures is provided by the municipality and allocated by the Sustaining Engineer.

In future development, city planning will be a high priority. Risk due to flood, erosion and landslides will be incorporated in detailed land-use planning where necessary. Ongoing education of city planners focusses on stormwater handling as well as cloud burst risks. Other risks are dealt with on a case by case basis, through learning-by-doing.

Applicability of Approach

The approach taken in Ängelholm is very specific to the issues that this city faces. It is a good example, however, of understanding those issues thoroughly and acting accordingly to tackle the combined risk, instead of continuing a scattered approach. Especially with regards to coastal flood risk, the city is moving from a reactionary approach of repairing the dunes and beach after storms, to an anticipatory approach. There is a strong link with land-use planning in the city which adds to the integral approach the city is taking to climate adaptation. It is this integral thinking that can be applied to other cities as well.

Benefits of Approach

The approach is a good example of understanding the different sources of risk thoroughly and acting accordingly to tackle the combined risk sources, instead of tackling these issues one by one.

The approach is driven by the Sustaining Engineer. Having a position within the municipality dedicated to climate adaptation, linked to a mandatory participation structure for other departments, means that issues can be progressed more effectively.

Limitations of Approach

The approach is centred around the position of the Sustaining Engineer, who is driving the partnership between the different departments of the local government, with key stakeholders and the general public. It is therefore very dependent on the person fulfilling this role how the

position, and thus collaboration, is given shape. It is also difficult to scale up efforts.

12.2.3. Sweden – Gothenburg: Strategic Plan (SP)

Context

The city of Gothenburg is one of the identified APSFR in Sweden. The city has been working with flood issues for many years and has to deal with multiple sources of flood risk including fluvial, pluvial and coastal. Actual floods have not occurred for some time now in Gothenburg, which allowed the city to develop a more strategic framework to deal with flood risk.

Challenge

Measures to address flood risk and prepare for climate change in a city require collaboration so that functions can be combined and conflicts avoided. The challenge is to prepare the city of Gothenburg for the long-term effects of flooding and climate change in a systematic and structured manner.

What is it?

The city of Gothenburg has developed a strategic framework, the Structural Plan, to deal with flood risk and reduce climate hazards. The Structural Plan looks at FRM at a system-scale.

Approach

The goal of the Structural Plan is to protect elements for which the city has a responsibility, for example the transport infrastructure. The Structural Plan indicates where the consequences of a certain flood scenario will be most severe, as well as what these consequences will be. Instead of searching for a local solution, the Structural Plan looks at system-level where measures can be implemented to relieve those consequences. This process is informed by flood models that include the whole catchment that influences the city, and that consider all aspects of the water balance (rivers, topography, sewers, infiltration capacity etc.). Climate change is taken into account using IPCC scenario 8.5, which is a precautionary approach. Based on these flood models, the Structural Plan takes into account the relevant water balances and specifies the volume of water that the identified measures should be designed for. Different limit states are applicable to different parts of the city, based on the required accessibility of the buildings in that area. These limit states determine what result needs to be achieved from the measures in the Structural Plan.

Multifunctionality of measures is considered a success factor. Financing of these multifunctional measures is challenging, because different public city bodies finance different parts of multifunctional projects; new regulations at a local level have been proposed to make this process easier.

Mitigation measures resulting from the Structural Plan are assessed using a scoring system. The next step is developing Measure Plans (see Figure 12-1). Where the Structural Plan only looks at the theoretical location of the measure and the design requirements, the Measure Plans will look at the elements that are important during the building phase, such as extreme rainfall data, and will work with building and planning acts to prepare the implementation of the measures.

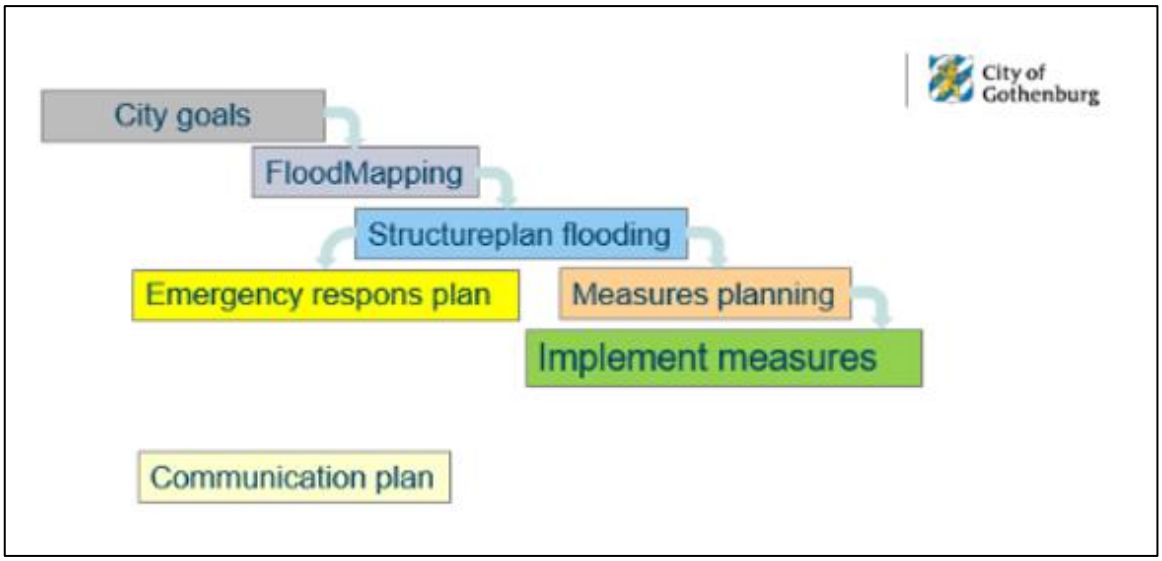

Figure 12-1 Workflow for the implementation of FRM measures in the city of Gothenburg.

The City also has a strategic document, a thematic flood risk annex to the Comprehensive Plan for Gothenburg which was decided upon by the City Council in 2019. Similar to the Structural Plan, the scenarios are based on IPCC 8.5 so that Climate Change is taken into account for all flood sources (fluvial, pluvial and coastal). It also takes into account vital societal functions, such as critical infrastructure. The strategic document is also taking direction decisions from middle to long term, up to 2070. A new comprehensive plan is prepared and now under public hearing and will be accepted in 2022.

Applicability of Approach

Based on the success of Gothenburg's approach, other cities in Sweden have started to follow a similar approach. Although Gothenburg is hindered by the legislation at national level (see Limitations), there is

potential for cities to work with other authorities in their catchment to take further control of their cities' water balance. For bigger catchments, this will become increasingly more complicated and might distract from the actual purpose of the Structural Plan, which is managing flood risk in the city.

Benefits of Approach

The Structural Plan looks at FRM at a system-scale, which leads to better and more cost-effective solutions than if considering it at a local scale.

Through the Structural Plan there is a large potential for collaboration between different authorities and stakeholders within the city, which will enable cities to tackle different water management objectives in a more structured manner.

Limitations of Approach

A catchment-wide approach to flood resilience, and the Structural Plan, would be preferable to the current municipality-wide approach. One of the reasons this has not happened yet is that legislation at a national level lacks the tools to facilitate catchment-level collaboration. In large catchments, other cities upstream can cause severe impact on a downstream city, and to solve these issues, a Structural Plan alone will not suffice.

Financing multifunctional solutions is difficult, as different public city bodies will have to come together (all through project development) to finance their respective elements.

The approach requires flood modelling for the whole catchment. This can become significantly expensive, especially for cities in large catchments.

12.2.4. United Kingdom – Glasgow: Climate Ready Clyde (CRC) and Strategic Drainage Partnership (MGSDP)

Context

1.8 million people live in the Glasgow City Region. A large number of organisations are based in the area as well. Flood risk is considered the most important climate adaptation challenge for the city.

The Climate Act drives Scottish Government to support place-based initiatives and requires Local Authorities to report progress on adaptation.

Challenge

The nature of drainage and management of rainfall and flooding is complex, with many agencies responsible for different aspects of drainage systems. In addition, there is a duty on all public bodies to work effectively, efficiently, in an integrated manner and in the spirit of collaboration, to deliver best value in sustainably draining the Glasgow city region.

The inhabitants and businesses in Glasgow will be increasingly impacted by the effects of climate change, especially due to increased flood risk (Figure 12-2). Therefore, a regional transformation is needed.

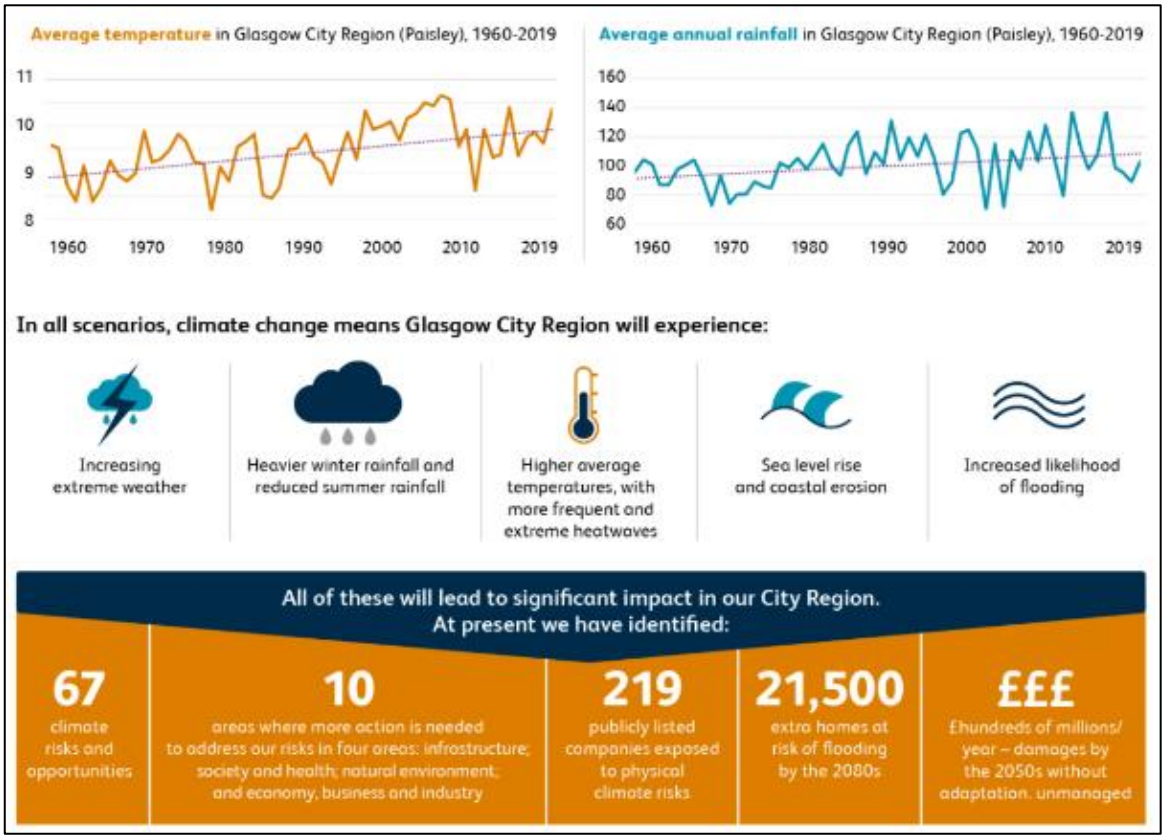

Figure 12-2: Overview of the challenges the Glasgow City Region faces. Adapted from: CRC Adaptation Strategy

What is it?

This case concerns two initiatives in Glasgow in which organisations work together to address urban flood risk in combination with other related challenges and opportunities: at a strategic level Climate Ready Clyde (CRC) and at an operational level Metropolitan Glasgow Strategic Drainage Partnership (MGSDP).

CRC is a cross-sector initiative of 15 public and private organisations set up to create a shared vision, strategy and action plan for adapting Glasgow City Region to climate change, supported by the Scottish Government. It consists of a Board with a small secretariat. The CRC project was the first place-based initiative emerging out of the Scottish Government's national Adaptation Scotland programme. Glasgow City Region was suitable as a first application because it contains the highest concentration of people, economic assets at risk in Scotland, and because of its geographical scale.

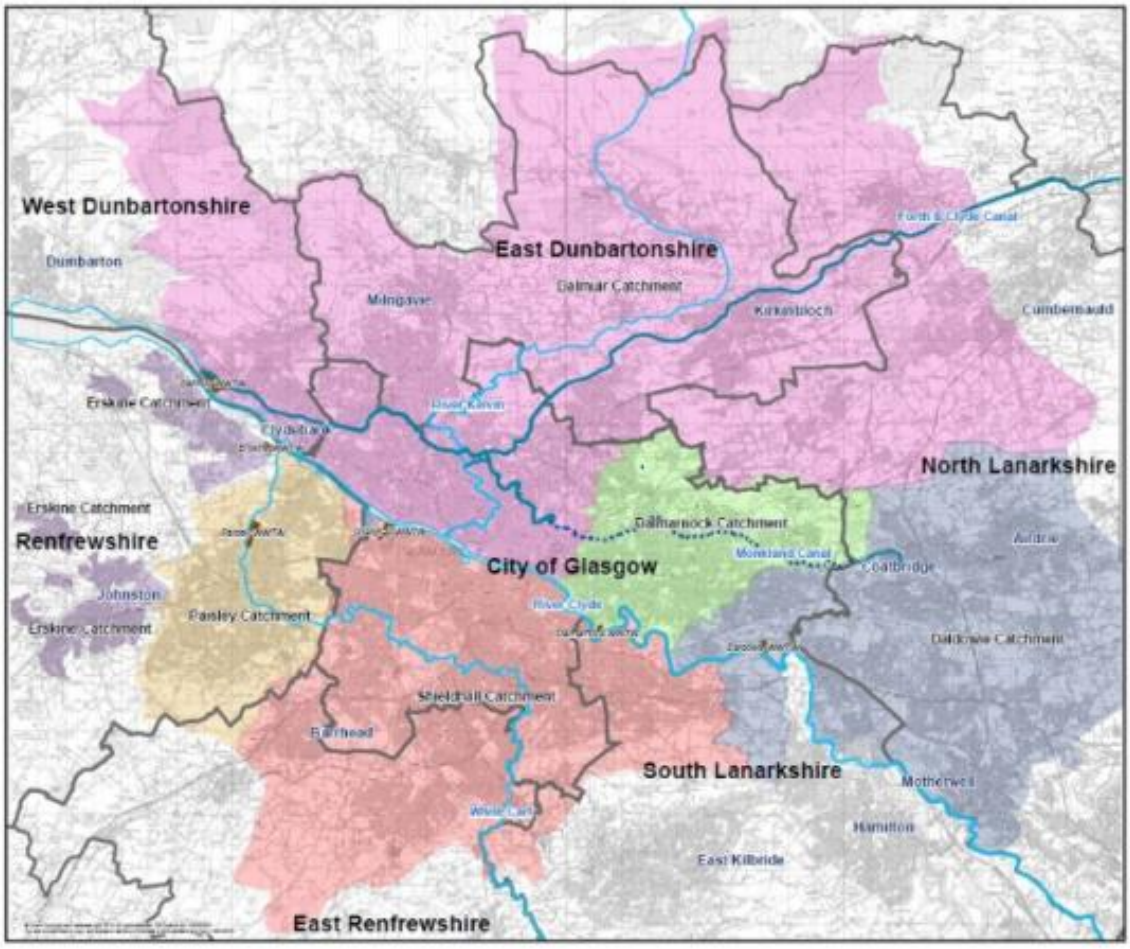

Figure 12-3: MGSDP area, taken as being the extent of the four main Glasgow wastewater treatment works (WwTWs), plus Paisley (Laighpark) WwTW and Erskine WwTW, as indicated by the shaded areas on the plan. From https://www.mgsdp.org/index.aspx?articleid=20289

MGSDP (area shown in Figure 12-3) is a non-statutory, collaborative partnership between the Local Authorities, governmental bodies and other water management organisations that was formed after a significant rainstorm and flood event in 2002. They work together with a range of key stakeholders, including Network Rail, Scottish National Heritage and several environmental organisations.

Approach

MGSDP works under the vision[8] *'to transform how the city region thinks about and manages rainfall to end uncontrolled flooding and improve water quality'*. They have defined the following objectives that the vision aims to deliver, to sustainably drain the Glasgow City Region:

Flood risk reduction

River water quality improvement

Enabling economic development

1. Habitat improvement
2. Integrated investment planning
3. **The collaborative working to deliver these objectives is guided**
4. **by their guiding principles (**
5.

Figure 12-4). A Surface Water Management Masterplan has been developed that outlines the challenges and identifies actions; it is recognised that much of the implementation work to date has been to bring the key parts of the current drainage system up to the standards required 'today' and the need remains to provide a level of resilience to the anticipated effects of future changes in climatic conditions. Examples of the actions are; to ensure collaborative working with upstream partners, and to consider all opportunities for NFM measures, to identify opportunities to increase awareness of a need to deliver a better balanced mix of blue, green and grey infrastructure, to consider whether existing costing and option selection processes give

[8] https://www.mgsdp.org/index.aspx?articleid=21054

appropriate weight to the added benefits of green and blue infrastructure and to quantify these benefits being delivered by current MGSDP interventions.

Ultimately, the partner authorities are responsible for actioning the Masterplan and to make the decisions. Developers also have a role to play. MGSDP's role is to stimulate and facilitate collaborative working. MGSDP recognises climate change as one of the main problems with respect to flooding, and this is where the collaboration with CRC comes into play.

Climate Ready Clyde has developed an agreed Vision ("Collaborating to flourish in our future climate", which is supported by a Theory of Change, setting out the conditions required for that change to occur; Figure 12-5) and has published a Climate Risk and Opportunity Assessment, plus literature review. This assessment has a 2200 horizon but also highlights where action is needed in the next five years.

Figure 12-4: Guiding principles to deliver the MGSDP Vision. From https://www.mgsdp.org/index.aspx?articleid=21054

Figure 12-5: Overview of CRC's "Theory of Change", which sets out the conditions which are needed to be able to implement the vision.

This formed the evidence base for the draft Adaptation Strategy and the Action Plan, which is due to be finalised in 2021, following public consultation. It sets out the framework, measures, processes, engagement and monitoring needed for achieving CRC's vision for 2050, while the Action Plan contains actions for the next five years. These are defined in the Strategy as 'interventions'; *"strategic packages of activities designed to achieve intermediate outcomes and to contribute to our long-term outcomes".* These interventions represent a suite of actions that start with incremental adaptation but move to transformation, as well as shifting from climate risk alone to wider sustainable development. The interventions are summarised in Figure 12-6 – there is a large overlap with the actions of MGSDP's Strategy. Together they form a suite of actions for managing future risk and taking advantage of opportunities.

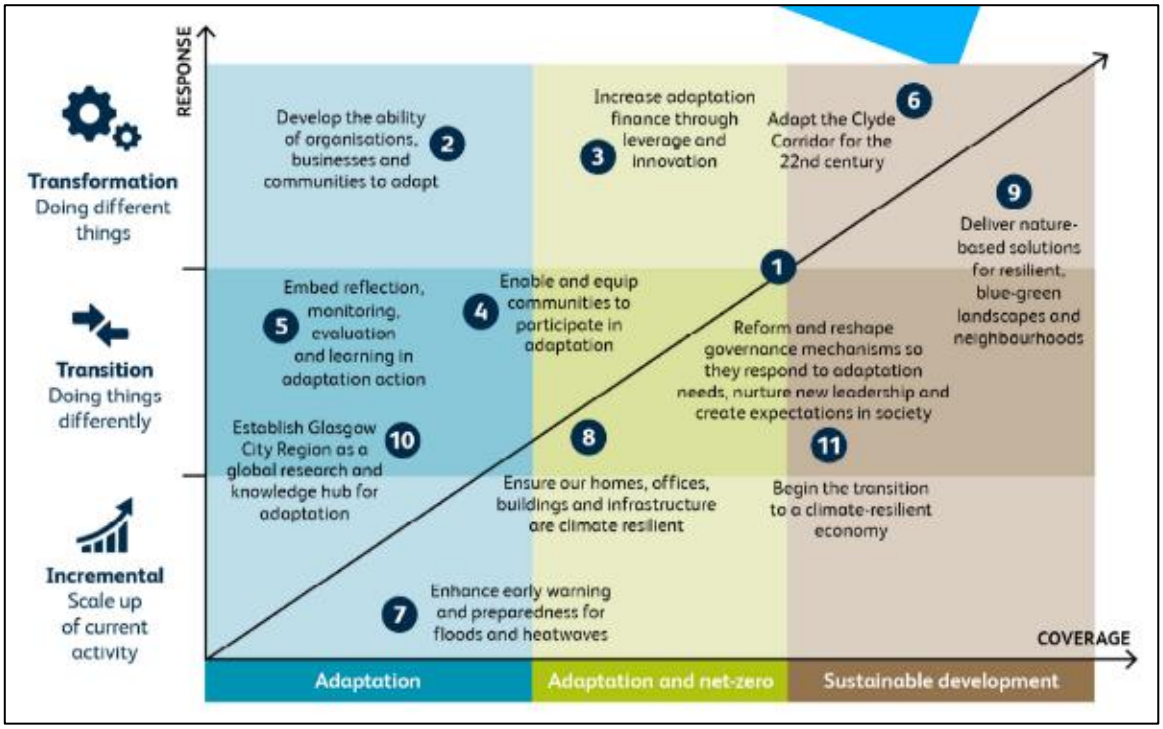

Figure 12-6: Overview of interventions in the Adaptation Strategy by coverage and response

The Strategy does not stipulate which organisation is responsible for each action, how to achieve it or how to fund it; this is the next step for the leaders of the partner organisations. Different regions and partnerships are taking action, but the Strategy calls for higher ambitions and pace. Furthermore, in an urban environment, effective flood management requires private action alongside public initiatives. CRC has also developed an adaptation financing strategy to support the implementation.

It is expected that CRC will feature heavily in the next 6-year plan, to be developed by MGSDP; this will guide the further implementation of the goals of CRC and adds a responsibility and methods to the Adaptation Strategy.

Applicability of Approach

Both the MGSDP and CRC were firsts of their kind in Scotland. However, similar initiatives are starting in other areas. A Strategic Drainage Partnership is now also being set up in Edinburgh, for example.

A Strategic Drainage Partnership can be applicable to any city or metropolitan region in which different organisations manage different parts of the city's catchment. Aligning goals and working towards those in collaboration, whilst also trying to involve key stakeholders, can make solutions better fitting and more cost-effective. It can also be an

effective way to create an incentive in the wider region to focus on more sustainable drainage and looking further into the future.

The structured way in which CRC's Adaptation Strategy is developed, makes it applicable to any city region that is looking to transition to a climate resilient future. The research that forms the basis of this approach, especially on financing, can be applied to other cities as well.

Benefits of Approach

In general, a strategic initiative like CRC is able to look even further into the future than an operational organisation like MGSDP can and is better suited to drive other sectors and city leaders to initiate change. An Adaptation Strategy can empower organisations like the MGSDP to be bolder and more ambitious in their own, shorter term, strategies. It is the combination of these two initiatives that makes this approach exceptionally strong.

CRC has spent a significant amount of time and resources into building an evidence base on which to build the Adaptation Strategy. Furthermore, the Vision for Glasgow is linked to the actual interventions via a Theory of Change. This provides a clear line on the horizon and a common development framework for other organisations, also outside of the FRM community.

CRC's process of developing the Adaptation Strategy includes public consultation; this sends a strong message to the city leadership that the final outcomes of the Strategy are supported by the constituents.

Limitations of Approach

It remains difficult to communicate the benefits of risk reduction. Measures do not fully resolve the hazard and often that reduction is difficult to quantify. Especially in regions where the risk has not materialised within the memory of most of the general public, it is difficult to convince people of the importance of adaptation measures.

12.3. CRC's Adaptation Strategy only provides a roadmap of what needs to happen, and not a method statement of how to do this, or which organisations are responsible to make it happen. This makes actually implementing the Strategy difficult; organisations are reluctant to commit future resources to efforts when the cost is unknown.

Issues / key findings

Although urban flooding is often dominated by pluvial flooding, due to the extent of hard surfacing, the examples in this chapter show that in many cases there are multiple sources of flooding and the associated risk with those sources should be considered holistically, not just

individually. Gothenburg combines multiple sources of flood risk in their Structural Plan, whilst Angelholm goes a step further than including only flood risk, as landslides are part in the city's risk assessment as well. Climate Ready Clyde (CRC) in Glasgow is a good example of how flood risk can be part of the challenge of making the whole of the city region climate proof, tackling a whole range of (future) risks at the same time.

Flood risk management in urban areas is typically complex because any measure will affect many functions. Efforts in Gothenburg are for example mainly driven by the need to protect certain infrastructure that the different municipalities are responsible for, like transport. In Angelholm, it concerns residential properties, business assets, but also infrastructure like the port and a tunnel. On the other hand, this can be positive when multiple benefits can be combined, leading to better projects that achieve win-wins. All examples show, that working in partnership is key to implementing a holistic set of measures. This means linking up different parts of the city in an overarching partnership, like the Metropolitan Glasgow Strategic Drainage Partnership (MGSDP), to define common goals to work towards. A similar approach is taken in Gothenburg in the formation of a Structural Plan that covers most municipalities in the city. It also means reaching out to other departments of local authorities like urban planning, as is done in Angelholm, to increase the range of measures that can be implemented, making the approach to flood risk reduction, mitigation and adaptation more robust. Although the problems that are being tackled are generally confined to the city's boundaries, both Angelholm and Gothenburg indicate that a catchment-wide approach is preferable. By looking over the city's boundary, some problems can be resolved in a more effective manner, or closer to the source. It can also open up additional streams of funding. Implementing this multifunctionality in projects and schemes is still a challenge, mainly in terms of financing. This can, for example, be because different organisations are required to fund different parts of such projects (Gothenburg), or because it is difficult to show the wider benefits of such solutions (Glasgow).

Because of the complexity and the reliance on public funding (in many cases from multiple public bodies, municipalities and government agencies), strong city leadership is needed to progress climate resilience and thus FRM issues. Angelholm has approached this by appointing a Sustaining Engineer; a position focussed on climate adaptation, that can drive all involved organisation to contribute and collaborate. In Glasgow, CRC provides a partnership framework in which a large number of stakeholders create a shared vision for the city region. As this process includes public consultation, it is a strong message to city leadership, and it provides a common strategy and a clear future goal that other organisations can leverage in their own multi-year plans and budgets.

APPENDIX A – FACT SHEETS

Member State	Project
AT	Flood Hazard Zone Plans (FHZP)
AT	HORA - The Austrian Platform for Natural Hazards
AT	River Development and Risk Management Concept (GE-RM)
BE	Information Plight for flood-prone properties
BE	Kerkebeek Valley River Contract
BE	Signal Areas
BE	Water Assessment
CZ	Flood Danger Maps (FHRM)
DE	The LAWA Joint Assessment Tool
ES	Climate Change Study (for APSFRs)
ES	Land use limitations in the Spanish Water Act
ES	Arga River Restoration (using Nature-Based Solutions)
FI	Flood Management Groups (for 2nd cycle of FRMPs)
HU	River Restoration Projects (using Nature-based Solutions)
IE	Calculation of Flood Damages using UK's Multi Coloured Manual
IE	Multi Criteria Analysis (MCA) in CFRAM
IE	Future Scenario Flood Maps
IT	Flash Floods in the Northern Apennines
IT	River Contract Middle Tiber
LV	Jelgava's Operative Information Centre (POIC)
NL	Flood Risk Mapping Portals
NL	Nijmegen – Lent: Room for the River Waal Project
NL	Zandmotor (Building with Nature)
PT	Amarante: River for Everyone 3.0
SE	Gothenburg: Strategic Plan (SP)
SE	Ängelholm: Holistic (Flood) Risk Management
SK	Flood Protection Act
UK (W)	Communities at Risk Register (CaRR)
UK (S)	Glasgow: Climate Ready Clyde (CRC) and Strategic Drainage Partnership (MGSDP)
UK (E)	Working with Natural Processes (WWNP)
UK (S)	SEPA Flooding Services Strategy
UK (S)	Eddleston Water Project
UK (NI)	Regional Community Resilience Group

Project	Flood Hazard Zone Plans
Country	Austria
What is it?	The Flood Hazard Zone Plans (FZHPs) are zoning plans that delineate in which areas it is safe or prohibited to settle, and in which settlement which adaptations to mitigate risks is possible. These FHZPs are included in the Water Act (2011), which obligates APSFRs to elaborate and use the zoning plans. They are also used for settlement developments.
Why was it developed?	Hazard zone planning was introduced in the 1970s in Austria, mainly driven by the risk of avalanches. These plans were initially made for catchments smaller than 10km^2, and in the 1990s extended to larger catchments as well. The Floods Directive triggered the inclusion of the FZHPs into the Water Act (2011).
How does it work?	Plans On the FHZPs, flood risk is specified per parcel. The extents, depths and velocities for a 100yr RP flooding event are determined using hydrodynamic simulations. A 100yr RP flood is also considered in the FHZPs, not including existing defences, to determine the residual risk. The input data consists of digital terrain models (Upper Austria: 0.5m x 0.5m resolution), river cross-sections, land use maps, data sets of buildings and measurements of river water levels. The maps are calibrated and validated against historical and gauge data. Climate change is not yet taken into account, as the current trends still fall within the natural variability. Zones Three zones have been defined, based on flood hazard intensities (flood depth x flood velocity) for the 100yr RP flooding event; a red zone, a yellow zone and a yellow-red shaded zone. The consequences of these zones for spatial planning are determined by the individual Federal Provinces. For example, the rules for development based on the zones in the FHZPs are strict in Upper Austria; under no circumstance is construction allowed in the red zones, even if precautions are taken with respect to flooding. It is mandatory for the municipalities to use the information of the maps, which are also available online and can be requested in print. Maps The maps are reviewed after approximately 10 years, or when a major development such as flood protection measures, settlement development is under consideration or if hydrologic boundary conditions change.
Who is Involved	Federal Ministry of Agriculture, Regions and Tourism – responsible for FHZP Provincial Governments and Consultants – modellers General Public -consulted for opinion Federal Government / Provincial Government / Municipalities – commissioners of FHZPs
Where can I access the information?	Federal Water Engineering Administration, 2021. https://www.bmlrt.gv.at/english/water/protection-against-floods/federal-water-engineering-administration.html Flood Risk Management in Austria, 2018 – Federal Ministry, Republic of Austria. https://documentcloud.adobe.com/link/track?uri=urn:aaid:scds:US:c1593cff-7311-473a-9bef-8fe07ab39e8c

Project	HORA – The Austrian Platform for Natural Hazards
Country	Austria
What is it?	The 'Flood Risk Zoning Austria' (HORA) Model aims to identify flood areas which provides information on a 30-year, 100-year and 200-year flood events relative to the river network. This approach does not provide the accuracy of detailed studies of local aspects. However, the model produced provides a first risk assessment tool, allowing information to be obtained quickly and easily.
Why was it developed?	Following flooding in 2002 and subsequent years, it was found that the Austrian Government should improve their communication on floods towards the public. The existing flood zone maps were complicated and only available for certain parts of the county. The need was recognised for a single platform across the whole county displaying information on floods in a simple manner. The overall goal was to achieve suitable accuracy for large-scale flood risk mapping and regionalisation techniques were used to determine flood peak discharge. (HQ_T).
How does it work?	The model uses a combination of hydrological and hydraulic calculations to provide: • Discharges for various return periods at each node of the river network • Vectorial presentation of the river network with scaled line widths and colours representing flood peak discharges (return period of 30, 100 and 200 year) • Vectorial presentation of flood plain boundaries for flood peak discharges with a return period of 30, 100 and 200 years covering Austria's whole river network (as a scale of 1:500 000) • Grid based topography of water depth covering Austria's whole river network (on a 1:500 000) for various return periods (30, 100 and 200 years). The result was a single model mapping Austria's entire river network which was able to the number of buildings in Austria at risk of flooding.
Who is Involved	The Federal Ministry for Agriculture, Regions and Tourism (BMLRT) and the Association of Austrian Insurance Companies (VVO).
Where can I access the information?	HORA portal – https://www.hora.gv.at/

Project	River Development and Risk Management Concept (GE-RM)
Country	Austria
What is it?	River Development (GE-RM) and Risk Management Concept is a planning instrument that Austria uses for coordination at a level of flood risk measures with other sectors to prevent conflicts and create win-win situations.
Why was it developed?	The planning instrument was developed for coordination at a regional level of flood risk measures with other sectors (such as water quality) to prevent conflicts and create win-win solutions. The goal of GE_RM is to develop an integrated package for sustainable catchment management.
How does it work?	The GE-RM is a four stage process which involves: 1. A preliminary study reviewing existing data and determining who should be involved in the project. This includes the key areas of Flood Risk Management, River Basin Management (WFD) and Boundary Conditions. 2. An inventory where data related to flood risk, water quality and 'boundary conditions' (related to other sectors such as nature, water use, land use and recreation) is collected. This includes a. Flood Risk Management (FD) includes topics such as surveying, hydrology, sediment management, hydraulic modelling, flood risk assessment and flood protection measures b. River Basin Management (WFD) considers hydromorphology as well as biological, chemical, and physical quality standards c. Boundary Conditions consider other affected areas such as nature conservation, water rights, land use and availability and recreational functions 3. The definition of objectives, working with all sectors to identify opportunities and challenges and identify a common target state, 4. The selection the intended measures from a national catalogue. The process is carried out at catchment level by a provincial authority. The resulting mapping form the basis for subsequent planning of detailed projects to implement the measures.
Who is Involved	The Federal Ministry of Agriculture, Regions and Tourism.
Where can I access the information?	Life IP Integrated River Solutions in Austria. https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=7006 Project Website. https://life-iris.at/

Project	Information Plight for flood-prone properties
Country	Belgium
What is it?	The Information Plight is a legal instrument used to make people aware of the flood risk and communicate the flood maps for a property. Flood chances have to be communicated to potential interested buyers, guaranteeing that people who buy a house in a flood prone area are aware of the risk and don't have to wait for the first flood.
Why was it developed?	There is a lack of understanding of flood risk when selling or renting real estate. Information on flooding for potential buyers of properties has been available since 2004, however this was usually only brought to their attention in the final stages of the purchase. Following the implementation of a law in 2013, information on flooding has to be available and clearly indicated to potential buyers immediately. The tool was developed to inform potential property buyers of the flood risk of those properties.
How does it work?	The Information Plight sets legal requirements to what information has to be disclosed when selling property. This particularly concerns the location of the property in a flood prone area, or other specially delineated zones with regards to flooding. Any measures against flooding that have been taken by homeowners will have been considered, with two levels of information available for properties (with and without flood measures). As many recently built properties have been adapted due to the risk of flooding, this is included in the Information Plight, with the intention that owners will adapt their house to flooding and thus increase the value of the property. The Information Plight is a supported by an online tool which allows potential property buyers to search for a property on existing flood maps. This will provide them with information on the flood risks to that property and thus inform decisions on purchasing properties.
Who is Involved	The Flemish Environment Agency has done the study work to implement, evaluate and improve the information plight.
Where can I access the information?	Informatieplicht overstromingsgevoelig vastgoed. https://www.integraalwaterbeleid.be/nl/beleidsinstrumenten/informatieplicht/informatieplicht-overstromingsgevoelig-vastgoed Flanders Website – www.integraalwaterbeleid.be

Project	Kerkebeek Valley River Contract
Country	Belgium
What is it?	A 'Contract' which forwards the common goals all stakeholders within the region to minimise flood risk and effect a bottom-up approach in which the needs and wishes of all participants are better included. The Kerkebeek is a small river with a catchment of approximately 80km^2, which flows through two municipalities which are at significant risk of flooding.
Why was it developed?	Due to the significant risk of flooding, a river contract was developed to implement measures to minimise flood risk and increase public participation and thus awareness of flood risk.
How does it work?	Stakeholders from across the Kerkebeek projects were invited to form a Steering Group, which was expanded to include members of the public. The first stage of the project was the ideation stage when local communities would hold a launch event. Inhabitants would receive information on the project and could share their opinions with the Steering Group and each other. After this stage, the Kerkebeek Forum was held to share ideas from the Ideation stage with stakeholders and the general public. From this, measures were drawn and summarised in a signed river contract with a duration of 5 years. The river contract is not a legally binding document. It has a duration of 5 years, with follow up meetings scheduled every six months to review progress. Most measures drawn up have been planned to be delivered within the 5 years. The contract is a live document, and as such it is possible to add and remove measures to/from the contract. Engagement of all parties has been maintained. At the moment, 70 measures are part of the contract and only 2 measures have been deleted since the signing of the contract.
Who is Involved	Flemish Environment Agency Kerekebeek Stakeholders and Steering group
Where can I access the information?	Kerkebeek – riviercontract.be (in Dutch) Stakeholder Engagement in Flanders, Flander Environment Agency. https://documentcloud.adobe.com/link/track?uri=urn:aaid:scds:US:d1a8fcf8-8e10-44c9-9c30-63f0c7c103e1 River Contract Kerkebeek – Through shared engagement to lower flood risks, 2019 – Vlaamse Milieaumaastschappij. https://waterresilientcities.co.uk/wp-content/uploads/2019/04/05_WRC_Sven_VERBEKE.pdf

Project	Signal Areas
Country	Belgium
What is it?	A Signal Area is defined as an area that floods more frequently than once every 100 years. The decision to designate an area as a Signal Area is based on both maps and local details, with different agencies involved at a national level, as well as the local communities. Once designated a Signal Area, no further development is allowed within the designated area, with the purpose of reducing flood risk and to prevent constriction of the river system.
Why was it developed?	In the past it was very difficult to stop new development in flood prone areas. By creating signal areas which are at high risk of flooding or would increase the flood risk in future if they were developed, it becomes easier to stop new developments in flood prone areas.
How does it work?	An evaluation of the indicated signal areas was carried out which detected areas which were not feasible for further development. A water assessment for a potential development when assessing this area would determine that future development is not possible in the given location.
Who is Involved	The Flemish Environment Agency and the Department for spatial planning.
Where can I access the information?	Signaalgebieden. integraalwaterbeleid.be Analysing and evaluating flood risk governance in Belgium – Dealing with flood risks in an urbanised and institutionally complex country, 2016 – StarFlood. https://documentcloud.adobe.com/link/track?uri=urn:aaid:scds:US:6add8ca0-762e-4899-8286-1300b10acba7

Project	Water Assessment
Country	Belgium
What is it?	The Water Assessment is a process whereby every permit has to be checked to confirm if there are any negative effects on water. Flooding is one part of this evaluation and this has primarily been focused on fluvial floods. Modelling of pluvial floods has allowed the water assessment to also focus on pluvial flooding. In the future, building permits will need to be checked for pluvial flooding and adaptations will be necessary to prevent damage.
Why was it developed?	Pluvial floods are a relatively new concept and were not addressed in the Water Assessment during the permitting system. New pluvial flooding modelling means it is possible for the effects of pluvial flooding to be considered as part of the water assessment. Future building permits will be required to be checked for the risk of pluvial flooding.
How does it work?	The Water Assessment works down at local spatial planning and permitting levels. In addition to using fluvial modelling to assess flooding as part of the water assessment, the pluvial flood model also allows the risk of flooding from pluvial sources to be checked. Based on the modelling done for the Water Assessment, maps are available indicating in which areas permit seekers should ask advice from the water board. Directions about the new models allow for communities to implement new information gained from the models into planning processes, permit systems and other planning infrastructure. This new approach means that it is possible to prevent inadequate drainage well in advance, rather than after the first flood.
Who is Involved	The Flemish Environment Agency did the modelling of these pluvial flood maps and was the leading actor for implementing the pluvial flood maps in the water assessment.
Where can I access the information?	Watertoets ('Water Test', Dutch). https://www.integraalwaterbeleid.be/nl/beleidsinstrumenten/watertoets/de-watertoets Link to flood risk and Water Assessment in Belgium https://documentcloud.adobe.com/link/track?uri=urn:aaid:scds:US:dc052fbd-1ef1-47b4-8fce-89b26fe5834c Integrated procedure for environmental, building and retail permits in Flanders, 2020 – Invest in Flanders. https://www.flandersinvestmentandtrade.com/invest/en/investing-in-flanders/setting-business/integrated-procedure-environmental-building-and-retail

Project	Flood Danger Maps
Country	Czech Republic
What is it?	The Flood Danger Maps divide flood areas into four categories based on level of danger and for each of them recommended rules for area development are specified. They are based on the method of risk matrix and express flood danger through colour scaling.
Why was it developed?	The previous standard practice implementing restriction in flood areas is based on determining flood plain areas and Active Zones. Within the Active Zone, strong restrictions (construction ban with several exceptions) on area development are in place in accordance with the Water Act. The Flood Danger Maps are based on Flood Hazard and Flood Risk Maps and introduce additional recommendations for area development and lad-use rules for the urban planning to be applied to the whole flood area.
How does it work?	The flood extent map indicates the maximum flood extents with the different return periods. This map is supplemented by flood depth maps, which indicate the worst case flood depths for the return periods considered, and velocity maps, indicating the maximum velocity of water flow. The Flood Danger Map uses the method of risk matrix to determine the category of danger, a semi-quantitative method. which classifies areas as being in 'high', 'medium', 'low', or 'residual' danger based on the flood depths and velocity provided in the maximum flood extent map. These four categories then dictate the type of development which is permitted within the area. The method of risk matrix is based on outputs from hydraulic modelling calculations - flood depth and velocity and their return period (RP). This is a sign of the destructive ability of a flood. The flood hazard is expressed by the flood intensity IP that is combination of flood depth and velocity. For each scenario, the flood danger per grid cell is then calculated based on the flood intensity and the RP of the flood scenario. Based on the maximum danger level for each of the grid cells, the grid cells are categorised in one of the four Danger Levels R; High (red), Medium (blue), Low (orange) and Residual (yellow). The final Flood Danger Map consists of the grid cells coloured according to their Danger Level. For each Danger Level recommendations for area development and land-use rules for the urban planning are specified. The Flood Danger Maps were primarily created in the APSFRs during the application of the Flood Directive. However, since 2018, Flood Danger Maps have been also set as a key input in the process of determination of the Active Zones. Flood Plain Areas and their Active Zones still have stronger legal status for decision-making than Flood Danger Maps based on The Water Act. Nowadays the process of harmonisation of the two above mentioned instruments used in sphere of flood protection is about to be initiated.
Who is Involved	Ministry of the Environment of the Czech Republic River Boards Authorities City Council of Prague T. G. Masaryk Water Research Institute, p. r. i

Where can I access the information?	All maps are published online for public viewing. (https://cds.mzp.cz/).

Project	The LAWA Joint Assessment Tool
Country	Germany
What is it?	The tool is used to collect and report the status of flood measures of all federal states in line with the requirements of the Flood Directive, and was developed by the subgroup of LAWA 'Flood Risk Management Plans'. The aim was to develop a methodology for assessing the achievement of objectives. In Germany, four overarching Flood Risk Management Objectives have been defined which consider how to prevent and reduce risk before a flood, and how to reduce adverse consequences during and after a flood. The overarching objectives are designed to minimise the adverse impacts of flooding on all four protected assets (human health, the environment, cultural heritage and economic activity.
Why was it developed?	Annex B of the European Commission Flood Risk Management requires Member States to assess and document the progress of risk management towards achieving objectives as part of a cyclical review and update.
How does it work?	The developed methodology involved: • Identifying the system of objectives based on the catalogue of measures from the 1st cycle plans for the Elbe, Oder and Weser RBC's. • Identifying the objectives of the 2013 LAWA recommendations on the establishment of Flood Risk Management plans • Identifying criteria for the individual objectives which could be used to measure progress towards the achievement of each objective • Determining suitable indicators (LAWA measures) to correspond with the identified criteria for the objectives. • Applying ranked valuation principles to each indicator, creating categories of progress towards the achievement of objectives • Documenting progress using text modules At the moment the tool is only used to meet the reporting requirements for the FD, not for other purposes like prioritisation or funding of measures. Individual states, however, can use it to track their progress towards meeting the flood related objectives and can also see what the impact of certain measures will be on the overall progress towards those objectives. The workflow was translated in an easy-to-use tool based on Microsoft Excel
Who is Involved	Ministry of Agriculture, Environment and Climate Protection of the Federal State of Brandenburg. Free and Hanseatic City of Hamburg, Agency for Environment and Energy
Where can I access the information?	LAWA methodology for assessing progress towards the achievement of objectives, 2019 – LAWA-AH. https://documentcloud.adobe.com/link/track?uri=urn:aaid:scds:US:7950f23d-fa5d-4b34-9969-6351c686167c

Project	Climate Change Study (for APSFRs)
Country	Spain
What is it?	Study of the influence of climate change in pluvial/fluvial floods, and in floods cause by the sea. It is focused on the analysis of maximum daily rainfall by combining global and regional climate models. It also considers the importance of other factors such as physical, biological and human parameters.
Why was it developed?	To assess the impacts of climate change in pluvial, fluvial and coastal flooding, in order to identify the areas where climate change may have the greatest impact. This is then used to determine the Areas with Potential Significant Flood Risk (APSFR) and to design adaptation and mitigation measures in those areas.
How does it work?	The study shows the areas with positive changes in maximum daily rainfall, changes in maximum accumulated rainfall and section of the water network with positive changes in maximum accumulated precipitation for different climate change scenario. The study identified that: • Small changes in precipitation rates could significantly increase the water flows • It is important to consider the characteristics of each APSFR in a River Basin District, taking into account the uncertainties associated with these two scenarios. • The relationship between precipitation and flow increases is not linear, but is generally exponential • Spatial planning is one the most important tool to minimise the flood risk, especially in a climate change scenario.
Who is Involved	River Basin Authorities Ministry for the Ecological Transition
Where can I access the information?	Website of the Ministry for the Ecological Transition final document of the methodology and the studies developed. https://www.miteco.gob.es/es/agua/temas/gestion-de-los-riesgos-de-inundacion/planes-gestion-riesgos-inundacion/Cambio-climatico-e-inundaciones.aspx

Project	Land use limitations in the Spanish Water Act
Country	Spain
What is it?	This modification to the Spanish Water Act was adopted to fulfil the absence of a common law in Spain and to comply with the EU Directive. Particular areas of improvement were: • land use planning through limitations of land use types in flood prone areas • criteria to consider land as "non-urban land" • construction criteria for those buildings located in flood prone areas. In effect, modification to Hydraulic Public Domain Royal Decree – affecting flood risk management, identifying uses and activities that may be vulnerable in case of flooding and establishing land use limitations in flood-prone areas. The modification establishes land-use limitations at a national level according to the hazard of the area and the characteristics of the land.
Why was it developed?	The first priority of this legislation is to prevent the increase of flood risk in the future. Previously, the definition and authorisation of vulnerable land uses was with the individual River Basin Districts – it was therefore necessary to coordinate both planning instruments with a common basic regulatory framework, applicable to the whole country, to achieve better transparency and legal certainty. Previous regulation established that any vulnerable use could not be authorized in the preferential floodway but does not specify which uses are considered vulnerable and does not distinguish between different hazards or type of land either.
How does it work?	The Spanish Water Act and the Hydraulic Public Domain Rule define the different river areas. Based on these areas, there are different restrictions to land-use. These areas are determined through the elaboration of Flood Hazard Maps. The elaboration of the hazard and risk mapping is the responsibility of the RBA in the area of the demarcation, in compliance with the Floods Directive. Definitions of legally-defined areas and limitations of their use are detailed below: • The Hydraulic Public Domain (riverbed): the land covered by water under normal flow conditions. • Easement Use Area: 5m-wide strip of land on both sides of the riverbed. Uses are limited to protect river ecosystems and ensure public passage. • Preferential Floodway: area where the flood flow is concentrated (for 100-year return period) and where the flood hazard is high (high velocity and depth for 100-year RP). Only non-vulnerable activities and activities that do not reduce the outflow capacity are allowed. • Flood-prone Area: area covered by flood events with 500-year return period. Limitations to most vulnerable activities and less restrictive conditions. • Police Area: 100m-wide strip on both sides of the riverbed. This can be wider in some cases to include the preferential floodway. Any activity must be authorised by the River Basin Authority Modification of the law identifies the specific uses that are considered vulnerable and cannot be located in the preferential floodway stabilising lowest limitation in the rest of the flood-prone area.
Who is Involved	River Basin Authorities Ministry for the Ecological Transition
Where can I access the information?	Land-use planning in flood-prone areas in Spain: Flood Directive and Spanish Water Act, https://documentcloud.adobe.com/link/track?uri=urn:aaid:scds:US:c450c64e-79e4-4d34-b088-8a79d2b1e5ea

	National Mapping System for Flood Prone Areas: https://sig.mapama.gob.es/snczi/

Project	Arga River Restoration (using Nature-Based Solutions)
Country	Spain
What is it?	River restoration
Why was it developed?	Due to urban/agricultural development the Arga River was channelled through cuts and embankments, causing bank vegetation destruction, leading to flooding, geomorphological imbalance and ecological degradation of the river's habitat. To recover the natural dynamics of the river and its hydromorphological conditions in a way that improves its behaviour against flood by reconnecting the Arga River and the ancient meander, a River Restoration project was undertaken.
How does it work?	Which measures were undertaken? i. Hydraulic reconnection between the Arga River and Soto Sardilla Meander ii. Improvement of the meander's water quality through accumulated sludge removal iii. Setback of embankment outside the river's space iv. Embankments removal in the confluence of the Arga and Aragon Rivers v. Permeability of existing obstacles vi. Floodplain recovery vii. Naturalise the zones through the reforestation and creating three wetlands and fluvial islands generated from irregular diggings viii. Naturalisation of intervene area and improvement on the European Mink populations The river restoration project reduced flood risk in Funes, a town upstream of the location of the project.
Who is Involved	Ministry for the Ecological Transition Ebro River Basin Authority
Where can I access the information?	Video: https://www.youtube.com/watch?v=JmPUzqbjdbY (Spanish only) Hydrological connection and improvement of habitats in the meanders of the lower stretch of the Arga River: Phase 1, 2020 – Ministry for Ecological Transition and Demographic Challenge. https://www.miteco.gob.es/es/agua/temas/delimitacion-y-restauracion-del-dominio-publico-hidraulico/estrategia-nacional-restauracion-rios/Plan-PIMA-Adapta-Rio-Arga-Fase-1.aspx Hydrological connection and improvement of habitats in the meanders of the lower stretch of the Arga River: Phase 1, 2020 – Ministry for Ecological Transition and Demographic Challenge. https://www.miteco.gob.es/es/agua/temas/delimitacion-y-restauracion-del-dominio-publico-hidraulico/estrategia-nacional-restauracion-rios/Plan-PIMA-ADAPTA-Rio-Arga-Fase-2.aspx Arga River Restoration Brochure. https://documentcloud.adobe.com/link/track?uri=urn:aaid:scds:US:cf4c95ec-cc6e-4d60-bc6e-2afd8670e2ff

Project	Flood Management Groups (for 2nd cycle FRMPs)
Country	Finland
What is it?	Under the Finnish Flood Risk Management Act, Flood Management Groups are established at the start of each Floods Directive Cycle (6 years) which is comprised of representatives from regional ELY Centres (Centre for Economic Development, Transport and Environment), Regional Councils, regional Rescue services, municipalities and optionally other important stakeholders. The work of these 'flood groups' is to integrate the views of all stakeholders in plans.
Why was it developed?	Finland is prone to flooding, particularly spring/snowmelt floods and ice jam floods. Flood management groups were initially developed for cooperation between the authorities necessary for preparing the flood risk management plan. The flood management group processes the studies and documentation prepared for the flood risk management plan and sets the objectives for flood risk management. In the 2nd cycle, the group also follows up implementation of the plan. An important role for flood group is stakeholder cooperation and strengthening participatory collaboration in the area.
How does it work?	To improve stakeholder engagement for the second cycle of FRM planning, the Flood Management Group of Kotka and Hamina APSFR organised workshops for key stakeholders with the aim of establishing objectives and measures for FRM. Flood group members can promote flood risk management and flood awareness regionally and participate in the implementation of measures in their own organisations. This is particularly important in the Hamina-Kotka region as one of the goals is to integrate flood risk management into general preparedness planning and industry plans. For stakeholder engagement, organising a large flood emergency exercise (in the first cycle of FRM) proved effective and beneficial as it created better relations between the participants.
Who is Involved	Centre for Economic Development, Transport and Environment (ELY) Flood Risk Management Groups
Where can I access the information?	Flood Risk Management Plans – Member State: Finland, 2019 – European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52019SC0070&from=FR https://www.ymparisto.fi/en-us/Waters/Floods/Flood_risk_management/Flood_risk_management_planning/Flood_risk_management_plans

Project	River Restoration Projects (using Nature-based Solutions)
Country	Hungary
What is it?	A number of river rehabilitation projects to reduce flood risk. The river rehabilitation projects have been carried out since the implementation of the Water Frame Directive (WFD) and Floods Directive (FD).
Why was it developed?	To reduce the flood risk to affected communities and to achieve a good ecological status in the water courses.
How does it work?	Flood risk reduction measures need to be in accordance with measures of the Water Frame Directive and thus all projects are planned in line with these principles. In the preparation phase of the preliminary feasibility studies for the rehabilitation projects, the nature conservation and environmental impacts of all solution variants were assessed. Special attention was paid to the sustainability of the project results whilst preserving the state of the environment. When selecting the technical solution, the possibility of invasion of alien flood vegetation was considered, with a mandatory Environmental Impact Assessment helping to select the least harmful option and guarantee achievement of the project goals in a sustainable way. Three projects were included: 1) Rehabilitation of Mosoni-Duna and Laiti River: improving the water supply in cut-off meandering branches and wetlands. 2) Rehabilitation of the Nagy-Pándzsa river basin: reducing direct flood risk, increase the area of rehabilitated wetland habitats and achieve good ecological status 3) Community significance protection of habitat in Floodplain area at Béda-Karapancsa: complex water habit rehabilitation
Who is Involved	Projects are initiated by the local water management directorates that are responsible for them. Stakeholders were involved in the planning and implementation stages of projects
Where can I access the information?	Mosoni-Danube rehabilitation project, 2009. https://documentcloud.adobe.com/link/track?uri=urn:aaid:scds:US:d09f446e-55bd-4be5-848b-9767a59a866c

Project	Calculation of Flood Damages using the UK's Multi Coloured Manual
Country	Ireland
What is it?	The Multi Coloured Manual (MCM) is a method used to calculate economic risk/potential damages of floods and thus the benefits of FRM measures when developing business cases for government funding. The MCM was initially developed in 2005 in the UK by the Flood Hazard Research Centre at Middlesex University, in collaboration with Defra and the Environment Agency. This case is looking at the adaptation of the MCM to the Irish situation, rather than developing a specific Irish method.
Why was it developed?	There is a lack of damage data in Ireland and therefore the UK method is used, along with the damage data from the UK. This method is converted to Irish prices using the OECD Purchasing Price Parity and corrected for the Irish inflation
How does it work?	The economic risk (potential damages) in each of the Areas with Potential Significant Flood Risk (APSFR) was calculated for current and future climate scenario, based on flood extents, levels and property types affected for up to eight flood events. The event damage for each probability is then integrated against probability to determine an Annual Average Damage and then discounted to provide a Net Present Value (damages) and a potential Net Present Value (benefits). The latter is compared to the NPV costs to derive a benefit-cost ratio (BCR) In some respects, the Irish method has evolved from the standard UK MCM and has been adapted for application in Ireland. The calculation of intangibles has been simplified; the allowance for intangibles is taken equal to the direct damages; this is intended to provide for a range of indirect and intangible damages, as well as just mental health and stress. Furthermore, the costs for emergency response are different in Ireland and these differences have been accounted for in the Irish method. Additionally, no agricultural damages are currently included and, as Ireland has no deprivation index, the factor derived from the deprivation index is excluded from calculations as well. There were no major costs involved with adapting the UK method to the Irish situation.
Who is Involved	Office of Public Works
Where can I access the information?	Flood and Coastal Erosion Risk Management – a manual for economic appraisal, 2013 – Multi Coloured Manual. https://www.mcm-online.co.uk/manual/ The Multi-coloured handbook: https://www.mcm-online.co.uk/handbook/

Project	Multi Criteria Analysis (MCA) in CFRAM
Country	Republic of Ireland
What is it?	Multi-Criteria Analysis (MCA) framework used on the Catchment-based Flood Risk Assessment and Management (CFRAM) Programme. It is a decision-making tool designed to consider a holistic approach to prioritise schemes which considers the three pillars of sustainability.
Why was it developed?	The aim of the MCA framework was to broaden the criteria for the assessment of measures from a simple cost-benefit analysis and environmental impact assessment, to adopt a more holistic approach which set nation-wide objectives that schemes should aim to achieve.
How does it work?	There is a framework which: 1. Is used to define objectives, weighting each to reflect societal values and including associated quantitative indicators 2. Includes a decision support system for selecting preferred measures for a given location that reflects the contribution of a measure to the achievement of the objectives using defined indicators 3. Includes a potential basis for prioritisation of measures reflecting overall benefit across sectors relative to cost 4. Monitoring progress on the basis of the objectives.
Who is Involved	Office of Public Works
Where can I access the informatio n?	Weighting the perceived importance of minimising economic, social and environmental/cultural risks in flood risk management, 2015 – University College Dublin. https://documentcloud.adobe.com/link/track?uri=urn:aaid:scds:US:701b793b-93a3-4e85-8a8a-43ba17d70671 Technical Methodology Note – option Appraisal and the Multi-Criteria Analysis (MCA) Framework – Office for public Works. https://documentcloud.adobe.com/link/track?uri=urn:aaid:scds:US:56792665-1b56-4696-87a1-61662acffdc0 The document at the link below provides an explanation of the framework, a table of the objectives and weightings (Appendix A) and a description of the indicators and application of scoring / local weighting for each objective (Appendix B): https://www.opw.ie/en/media/TMN%20for%20Option%20Appraisal%20and%20MCA%20-%20Rev%20B%20-%20Sept%202018.pdf Examples of the application of the process with regards to the propose measures in the FRMPs can be found in Appendices G at the following link: https://www.floodinfo.ie/publications/?t=22

Project	Future Scenario Flood Maps
Country	Republic of Ireland
What is it?	The Future Scenario Flood Maps are part of the CFRAM framework whose origins predated the Floods Directive and was meant as a comprehensive suite for Ireland as a whole.
Why was it developed?	The Flood Maps were developed to provide a comprehensive flood model for Ireland as a whole and inform Ireland's Flood Zones.
How does it work?	Modelling The flood maps are based on very extensive 1D-2D modelling, encompassing all Areas of Future Assessment (AFAs) in Ireland. Detailed bathymetric and topographic datasets were used to inform these hydraulic models.. Hydrological models, as well as gauge data for river flow and tidal levels, were also used to inform the hydraulic modelling with design flood flows and coastal levels . The AFAs within the same river reaches are connected via 1D fluvial modelling to be able to assess the catchment-wide effects of flooding. The large extent of hydrological modelling has meant that the same level of detail is now available for most of the country. Flood Zones Both current and future scenarios have been modelled, considering both present day conditions and the effect of climate changes, namely increases in rainfall, river flows and sea levels in the mid-range and high end scenarios. The current scenarios are used to inform Ireland's flood zones. Via these flood zones, local authorities stipulate which activities are permitted in certain areas, which is strictly adhered to by planners. Future scenario flood maps are available online, although they are not widely used by local authorities, as the local authorities define the flood and land use zones. Purpose The purpose of the Future Scenario Flood Maps is to inform a 'Scheme Climate Change Adaptation Plan' (SCCAP), which has to be created when a scheme is being developed. This SCCAP indicate the risks in the cases of mid-range and high-end scenarios and state measures which can be taken to avert or mitigate those risks.
Who is Involved	Office of Public Works
Where can I access the information?	The flood maps can be accessed here: About Flood Maps – Office of Public Works https://www.floodinfo.ie/about_floodmaps/

Project	Flash Floods in the Northern Apennines
Country	Italy
What is it?	A methodology has been developed to map, at basin scale, the probability of occurrence of flash flood caused by heavy and concentrated rainfalls, this is because The Northern Apennines River Basin District's territory is prone to flash floods due to its orographic characteristics. The methodology also provides a tool to analyse the impacts of climate change in terms of hydraulic hazard.
Why was it developed?	To estimate the effects of climate change in the Northern Apennines River Basin District. Flash floods caused by intense and concentrated rainfall are becoming more and more frequent and intense as a direct effect of climate change. The approach developed provides a flash flood mapping methodology that can be used at catchment and sub-catchment scale.
How does it work?	1. Integrated catchment is divided into sub-basins using GIS hydrologic analysis functions applied to Digital Terrain Models 2. Assessment of the catchment Lag time which represents the delay time of the flood wave compared to the rainfall centre 3. Assessment of the spatial distribution of return time with regard to critical rainfall (minimum precipitation that can cause flash flood) on the basis of rainfall intensity-duration-frequency curves 4. Calculation of the distributed cumulated frequency of the considered parameters 5. Parameters are ranked on the basis of classification, assigning a higher number to lower parameters scores. The resulting Flash Floods Index (FFI) is calculated by summing up single parameters' scores. 6. Flash flood prone sub-basins are identified and classed by estimated the cumulated frequency of the FFI.
Who is Involved	Northern Apennines River Basin District Authority Ministry of the Environment, Land and Sea – General Direction for Soil and Water Protection ISPRA
Where can I access the information?	http://www.appenninosettentrionale.it/itc/?page_id=6141 https://www.researchgate.net/publication/328601700_L'alluvione_lampo_di_San_Polo_in_Chianti_FI_del_8_maggio_2018_un_esempio_di_evento_meteo_intenso_difficile_da_catturare https://www.isprambiente.gov.it/files/pubblicazioni/atti/10117_ATTI_WS_Cagliari_2010.pdf

Project	River Contract Middle Tiber
Country	Italy
What is it?	The River Contract is a tool that aides in combining environmental policy with social-economic development; it is described as an act of shared commitment by public and private parties for sharing working methods aimed at environmental and socio-economic regeneration of river systems. The World Water Forum (March 2000) introduces River Contracts in Europe as tools that allow 'to adopt a system of rules in which the criteria of public unity, economic performance, social value, environmental sustainability, act equally in the search for effective solutions for the development of a river basin'
Why was it developed?	The River contract was developed for sharing working methods aimed at environmental requalification and socio-economic regeneration of the river system. The goal of the River Contract in practice is to bring people together to create a shared vision on the management of the river – this shared vision is translated into a shared Action Plan. These actions are to be taken away and progressed by the individual parties. The River Contract can act as a means to attract funding for measures as well. Flood risk is a particularly important in the Valley because it is prone to flooding and contains major highway and rail infrastructure, as well as significant nature and historic conservation areas. It's also important to underline that this area should be kept free from further settlements to guarantee, using the water storage capacity of those floodplains, the safety of Rome, which stands immediately downstream
How does it work?	The River Contract is a voluntary strategic and negotiated programming tool that purse the protect and correct management of water resources and the enhancement of river territories. It also includes the protection from hydraulic risk, contributing to local development. The action program for the Middle Tiber Valley is aimed at the following objectives: • Improve the quality of water and the river ecosystem • Identify shared measures to reduce flood damage • Increase security and usability • Develop economic and tourist activities in respect of the river basin and the enhancement of heritage • Initiate care and self-maintenance practices: farmers who are custodians of the territory. • European Territorial Quality Mark: territorial recognition and promotion
Who is Involved	Ministry of Environment: national observatory on River Contracts Lazio Region – presidency of the Lazio Region, purpose office "small municipalities and river contracts" District Authority (Central Appennino) Municipalities of the Middle Tiber Valley
Where can I access the information?	Website: https://contrattodifiumemediavalledeltevere.net/

Project	Jelgava's Operative Information Centre (POIC)
Country	Latvia
What is it?	The Operative Information Centre (POIC) brings together stakeholders from civil protection services to effectively work with disaster risk reduction and climate change adaptation.
Why was it developed?	Developed to enable and enhance cooperation between the different civil protection services, as well as the different municipalities that they serve. This was based on the agreement that crisis response would be faster and more effective through one institution.
How does it work?	The POIC co-ordinates information for everyday business as well as crisis situations. It is furthermore involved in the monitoring of critical assets and works with other Baltic states on cross-border projects. The data that is used for the monitoring of the POIC is available via online mapping. Based on this data, an Early Warning System has been created which sends out a warning for various hazards via SMS and email. For flood mapping, POIC uses a LiDAR dataset to determine the terrain levels and yearly field surveys (such as the number of residents in potential flood areas), which is subsequently mapped by GIS specialists and combined with flood extents. Data from water level gauges and surveillance cameras are also used, particularly for predicting the extent of flooding due to ice dams.
Who is Involved	Jelgava's Operative Information Centre Experts from Ministry of Environmental Protection and Regional Development
Where can I access the information?	Pašvaldības operatīvās informācijas centrs : Institūcijas : Jelgava (Latvian). https://www.jelgava.lv/lv/iestades/jpoic/ Interactive Flood Maps found here: https://karte.jelgava.lv/interactive-maps/flood-map?lng=en

Project	Flood Risk Mapping Portals
Country	Netherlands
What is it?	The Netherlands use three online portals to collate and share flood risk mapping: **Risicokaart** (Risk Map) provides a comprehensive overview of different sources of risk (industrial safety and flood risk included). **LIWO** (Flood Risk Mapping) was developed in 2015 to focus mainly on flood risk. **Klimaat Effect Atlas** (Climate Effect Mapping Collection) is a portal developed with spatial planning in mind and contains information on flooding and the effects of heavy rainfall and the consequences of heat and drought, focussed on the situation in 2050
Why was it developed?	**Risicokaart** was developed after the firework disaster in Enschede in 2000 to focus on industrial safety, with flooding added at a later stage to comply mainly with the mapping requirements of the Floods Directive and communication for the general public. **LIWO** was developed in 2015 by Rijkswaterstaat (Directorate-General for Public Works and Water Management) initially as the data storage for the development of the new Dutch flood protection standards, which now extends to available local and regional information, for the general public, water professionals and emergency services to better understand flood risk. **Klimaat Effect Atlas** was developed with the aim of measuring and addressing and measuring climate change by 2050.
How does it work?	All 3 portals are interconnected; A central database with flood risk scenarios (LDO) feeds into both the Risicokaart and LIWO. The Klimaat Effect Atlas shows information from both LIWO and Risicokaart. Risicokaart and LIWO Rijkswaterstaat only develops flood scenarios for limited areas (undefended floodzone and along major canals), so almost all the updates to the flood scenarios for the **Risicokaart** come from the Provinces or the Water Boards, which will then be implemented into **LIWO.** LIWO shows more information than the minimum amount that is displayed on the **Risicokaart**. **LIWO** does not include elaborate explanations with the maps, and prior knowledge of flood risk management is required to use this portal effectively. Emergency services use **LIWO** as well for their emergency plans, and the portal is available 24/7 to them – in case of emergency it is closed off to the public to guarantee access. General Public – **LIWO** has a website / app (Overstroomik.nl) focussed on the general public that shows a map of the maximum flood depth to inform the public whether their houses are safe, and if not what their evacuation options are ('horizontal' or 'vertical'). Options are being explored to make **LIWO** and the **LDO (which feeds in to Risicokaart)** as integrated as possible, though no decision-making has been taken yet. **Klimaat Effect Atlas** contains multiple 'Story Maps' that provide background information on the maps in the portal. In contrast to the other two portals, **Klimaat Effect Atlas** shows differences between shallow and deep floods, and the typical consequences and mitigation measures, which can be checked for individual neighbourhoods
Who is Involved?	Dutch provinces – responsible for producing the flood scenarios for national use Rijkswaterstaat – developer of the LIWO Regional Water authorities – providing scenarios for national use Emergency Services, General Public, Water Professionals – end users of LIWO
Where can I access the	**Risicokaart:** http://www.risicokaart.nl **LIWO:** https://basisinformatie-overstromingen.nl/liwo/#/ **LIWO** Information factsheet, 2020. **Klimaat Effect Atlas:** https://www.klimaateffectatlas.nl/en/

information ?	Overstroomik.nl

Project	Nijmegen – Lent: Room for the River Waal Project
Country	Netherlands
What is it?	The widening of the River Waal in Nijmegen as part of the 'Room for the River' programme. The project started in 2001 at the stage of option implementation and was completed in 2016.
Why was it developed?	Historically, the city formed a bottleneck in the river (350m width in the city versus 1500m width elsewhere, in combination with a sharp 90 degrees bend), which often lead to very high water level, causing over 200, 000 people to be evacuated in 1993 and 1995. The river widening was therefore designed to reduce the risk of high water in the Waal in the future.
How does it work?	Hydraulic improvements: In 2012, the city began adapting the river and its shores moving the main existing dike (in front of Lent, a village part of Nijmegen municipality located on the norther shore of the Waal River) 350 m inland, and digging an extensive new river channel parallel to the original. By its completion in 2016, the project succeeded in achieving a 35 cm river water height reduction (exceeding the initial target of 27 cm). During high river flows, one-third of the total amount of water is discharged through the new ancillary channel. Wider Benefits: As part of widening the river in the city, as the project meant that 50 people would have to leave their homes. The municipality of Nijmegen therefore negotiated that the project should contribute to the spatial quality of the city, including Green Solutions and Spaces. These improvements to the local socio-environmental elements of the local landscape therefore became known as the 'Park for the People', the finances from which were integrated within the flood safety budget such was the keenness of the local public to see community benefits. The implemented measures also created an island that is now used as a unique urban river park in the heart of Nijmegen with room for living, recreational activities, culture, water and nature.
Who is Involved?	As the project took place in the middle of the city, a large number of people were involved, with stakeholders from a variety of backgrounds, including: - The Municipality of Nijmegen - The Local Community - The Contractors - EIA and SEI consultants All stakeholders were engaged with information meetings and interactive workshops, which strongly helped to address the stakeholders' doubts and opposition.
Where can I access the information?	Climate Adapt, 2020. https://climate-adapt.eea.europa.eu/metadata/case-studies/room-for-the-river-waal-2013-protecting-the-city-of-nijmegen

Project	Zandmotor (Building with Nature)
Country	Netherlands
What is it?	Zandmotor is a mega-nourishment project involving 21.5M m^3 of sand which was placed in 2011 and then left for 20 years, for nature to distribute the sand along the coast to limit the erosion. This project involves extensively monitoring morphology, ecology, nature and leisure, which ends in 2022 following 10 years of surveillance.
Why was it developed?	Due to long-standing natural erosion of the Dutch coast's natural Dune defences, in 1990 it was decided to nourish the coastline annually at critical points (order of 1M m3 per location) to prevent any further retreat from this 'reference point'. It was deemed possible to try innovative ideas in the form of pilot projects such as the '**Zandmotor'**, to be able to test them before critical situations imposed by SLR impact ever-growing populations. One of the main aims of the pilot was to find out what happens with coastal habitats after reaching actual equilibrium, without being disrupted by the annual nourishments – The Zandmotor approach would be more sustainable with respect to the environment.
How does it work?	Concept The Zandmotor works with different parts of the Building with Nature and EcoShape concepts - it makes use of the natural coastal processes to maintain the Standard of Protection along the Dutch coast. The mega-nourishment intervention is done locally, whilst the remainder of the coast remains undisturbed – *nature* does the work instead. Application and Results The sand was placed on the coast of Ter Heijde / Monster, which is characterised by calm morphodynamical behaviour, meaning that base conditions before implementation were easily assessable and predictable. In practice, the Zandmotor behaved more favourably than predicted; the expected lifespan is now 40 years, compared to the initially predicted 20 – i.e. the transport of sediment along the coastline didn't happen as fast as expected. The lessons learnt from the Zandmotor in terms of FRM are now translated into policy via the Coastal Genesis project, which has initiated many more projects such as Hondsbossche Dune Area, Amelander Zeegat, Markwadden and Bacton Sandscaping, all of which embrace the natural nourishment practices undertaken in Zandmotor.
Who is Involved?	Funded by Ministry of Environment and Water Management for €50M Monitoring Programme co-funded by The Ministry and South-Holland Province for $20M Included many stakeholders: - Ministry of Environment and Water Management, Rijkswaterstaat, Province of South-Holland, Ecoshape (private-public-academic partnership aiming to promote Building with Nature), Delft University of Technology (NatureCoast; 12 PhDs), Water Boards, Municipalities (mainly Den Haag and Monster), Water Company (water supply installations present in the dunes), Local communities, Swimmer safety organisations.
Where can I access the information?	Homepage of Zandmotor. dezandmotor.nl Climate Adapt, 2020. https://climate-adapt.eea.europa.eu/metadata/case-studies/sand-motor-2013-building-with-nature-solution-to-improve-coastal-protection-along-delfland-coast-the-netherlands

Project	Amarante: Rivers for Everyone 3.0
Country	Portugal
What is it?	The project aims to identify and implement natural flood management (NFM) measures to rehabilitate the rivers and reduce flood risk. There are 3 primary goals of the project: 1) Improve water quality, natural bank stabilisation and reduce flood risk 2) Improve habitat quality and hydro-ecological sustainability 3) Improve local aesthetics and amenity value The project aims to achieve these 3 main goals by integrating the Floods Directive and Water Framework Directive with hydrological and hydraulic processes, ecological processes and socio-economic processes, at each local scale.
Why was it developed?	The city of Amarante in northern Portugal has been regularly affected by floods with significant events occurring from 1982 onwards because the geomorphological and fluvial conditions of the Tamega basin cause rapid increases in water level. The Tamega river runs through the main urban area of the region and as such, an overwhelming proportion of the historic property and social damage occurs here. On fewer occasions however, the nearby agricultural land has been affected by these flood events. This land is also prone to flood induced erosion due to the loose ground.
How does it work?	<u>Approach</u> The project encompasses works on 24km of the Tamega river, on both banks. It consists of an integration of both traditional and NFM measures, the latter of which includes removal of coarse woody debris from the watercourses, bank stabilisation using natural engineering techniques, floodplain restoration by creating detention basins, restoration of riparian buffer zones using native species, removal of invasive species and incorporation of swales and ponds. <u>Stakeholder Engagement</u> Engenho e Rio (EeR) work closely with the APA (Portuguese Environment Agency) to identify NFM elements needed to be addressed, namely the hydro-ecology and social aspects – all of which is informed by one-dimensional hydraulic modelling. This large-scale modelling incorporated NFM measures and EeR were confidently able to show that such measures had a positive impact on flooding. EeR have put on workshops with the intent to ensure the good execution of the projects and maintain its results over time, keep informing the public after the completion of the project to keeping them aware of the flood risk and its impacts on hydro-ecological and socio-economic processes. As part of the project, there has also been emphasis on using permeable surfaces on car parking sites near the river and limiting its use, mainly during flood events, to ensure population safety and increase the infiltration area of the floodplain within urban zones.
Who is Involved?	Engenho e Rio (EeR) – private consultancy identifying NFM measures Local municipalities – notify the APA of flood risk concerns in the region Portuguese Environment Agency (APA) – collate flood hazard information and works with EeR to designate priority regions with flood alleviation measures
Where can I access the information?	Contact the Portuguese Environment Agency.

Project	Gothenburg: Strategic Plan (SP)
Country	Sweden
What is it?	The City of Gothenburg has developed a Structural Plan (SP) for the planning of flood measures.
Why was it developed?	The goal of the SP is to protect elements for which the city has a responsibility i.e. transport infrastructure. There is an awareness and acceptance within these different departments of the city council that resilience is needed and needs to be planned for.
How does it work?	Hydraulic Modelling The SP uses MIKE DHI modelling, which includes the whole catchment that influences the city of Gothenburg. The modelling schematisation considers all aspects of the water balance (e.g. rivers, topography, sewers, infiltration capacity, etc). The SP looks at Flood Risk Management at system-scale, which is a more cost-effective approach than considering it at a local scale. Climate change is taken into account using IPCC scenario 8.5, which is a precautionary approach. Different flood levels are used for different areas and different limit states, based on the required accessibility of the buildings in that area, to determine what result needs to be achieved from measures in the SP Strategic Plan Outputs The SP indicates where the effects of a certain flood scenario will be the most severe, as well as what these consequences will be. Instead of searching for a local solution, the SP looks at a system-level where measures can be implemented to relieve those consequences. Based on flood models, it takes into account the relevant water balances and specifies the volumes of water that the identified measures should be designed for. Mitigation measures resulting from the SP are assessed using a scoring system. One example these joint ventures resulting from the Strategic Plan is the pre-tapping of certain lakes in the upstream part of the catchment to provide additional storage to reduce downstream flooding. Future of the SP The next step is developing Measure Plans (MP). Where the SP only looks at the theoretical location of the measure and the design requirements, the MPs will look at the elements that are important during the building phase, such as extreme rainfall data and will work with building and planning acts to prepare the implementation of the measures.
Who is Involved?	The development of SP was funded by the City Council. Climate Adaptation Network – consists of mainly public bodies e.g. National Road Agency and rescue services) and works with local municipalities
Where can I access the information?	Gothenburg City Water Stories Factsheet, 2020 – International Water Association. https://documentcloud.adobe.com/link/track?uri=urn:aaid:scds:US:1cb06bf2-802c-4870-9971-ceb324accc34 Analysing and evaluating flood risk governance in Sweden – Adaptation to Climate Change, 2015 – StarFlood. https://www.diva-portal.org/smash/get/diva2:995169/FULLTEXT01.pdf

Project	Ängelholm: Holistic (Flood) Risk Management
Country	Sweden
What is it?	Adoption of a new approach to tackling flood and coastal risk in the municipality of Ängelholm through holistic, joint measures.
Why was it developed?	i. The municipality is under significant flood risk: there are two river deltas in the municipality, the catchment of which covers about 25% of the region and about 17% of the runoff passes through the centre of Ängelholm. It is also a coastal region. Although the region is not overly exposed to wind waves and swell, the shape of the bay causes extreme water level set-up at the scale of hours during storms (+2m above normal). ii. Important coastal protection dunes have been affected severely by erosion caused by the extreme sea-level elevations during storms since 2011 – protection is necessary as buildings are located behind the dunes and are at risk of flooding. iii. There is no recent experience of flooding due to cloud bursts or acute pluvial flooding, but risk areas were identified in 2019, and this will get worse as weather patterns change in the future. The influence of sea level rise will play a role as well: extreme high sea levels are noticeable in the river up to 6km inland, into the town centre. iv. The trigger for this approach and the appointment of a Sustaining Engineer, were the severe storm events between 2011-2016 and the associated dune erosion and flooding of infrastructure.
How does it work?	Concept Ängelholm is taking a holistic view on flooding issues; this means an overarching working routine via a special working group on climate adaptation (combining long-term strategic adaptation, crisis management, city planning, water/sanitation, environmental law enforcement, nature conservation, exploitation/city development, infrastructure), with a focus on overarching risk assessments and solutions for flooding, erosion and landslides and their combined risks. Implementation There is work in progress for a plan that handles all water-related risks. Currently, there is only some guidance on addressing sea-level rise in the comprehensive plan, but it lacks guidelines for other types of flooding and related risks. The Sustaining Engineer is leading this effort; all other departments take part in the working group Climate Adaptation (monthly meetings whole group, specified subgroups), issue regular reports to the leading group (twice per year), and issue a whole-year-report and budget once per year to the city development board. This means that in future risk due to flood, erosion and landslide will be incorporated in detailed planning where necessary.
Who is Involved?	Ängelholm Municipality Sustaining Engineer Community The Sustaining Engineer gives several presentations at different organisations and there is a Coast Dialogue Forum which communicates mainly by email.
Where can I access the information?	Climate Adaptation, Ängelholm Municipality. https://www.engelholm.se/klimatanpassning Making Cities Resilient in Sweden, 2015 – Swedish Civil Contingencies Agency. https://www.msb.se/siteassets/dokument/publikationer/english-publications/resilient-cities-in-sweden---six-inspiring-examples-on-drr-action.pdf

Project	Flood Protection Act
Country	Slovakia
What is it?	In 2010, the Flood Protection Act was put in place that advised municipalities to take the inundation maps into account in their spatial plans during the next review, which is overseen by the The Slovak Water Management Enterprise (SVP).
Why was it developed?	The Construction and Spatial Planning Act (implemented following the extensive floods in 1974) already stated that flooding should be considered in local planning – on a local level, this was often skipped. Therefore, a more targeted plan in the form of a new Act would aim to ensure that local flood risk protection measures were taken more seriously.
How does it work?	Method and Outputs The inundation maps are produced by the SVP based on fluvial hydrodynamic modelling, which lay out the extents of a Q100 flood. The Q100 extents indicate land that will be flooded to prohibit new developments, and also represents the Q100 standard of protection to be provided from current flood defences. The state is not liable for any flooding damages if the municipality decide not to implement the inundation maps in spatial planning – the Flood Protection Act gives no exceptions for developments to be built there. As a result of the inundation maps, natural retention areas are also determined, which are meant to provide the retention capacity and are thus meant to be flooded during Q100 events. The Q100 standard is necessary in cities to ensure access to European funding, which adds an incentive to comply with new regulations.
Who is Involved?	Slovak Water Management Enterprise (SVP) – national organisation with 4 branch offices that maintains all waterways in the country Local Municipalities – works closely with SVP on spatial planning in relation to flood risk.
Where can I access the information?	Water Management in the Slovak Republic, 2010 – Water Research Institute Bratislava. https://www.minzp.sk/files/sekcia-vod/modra-sprava-2010-anglicka-opravena.pdf Link to 2010 Act (Slovak): http://extwprlegs1.fao.org/docs/pdf/slo124718.pdf

Project	Communities at Risk Register (CaRR)
Country	Wales, United Kingdom
What is it?	The Communities at Risk Register (CARR) is an internal planning tool within Natural Resources Wales (NRW) to determine which areas in Wales need to be prioritised for resources for FRM, based on a flood risk approach rather than a reactive approach to historic floods.
Why was it developed?	The CaRR started 10 years ago to be able to prioritise and take forward FRM measures effectively. CARR is currently used for two purposes: not only by NRW for its original aim of prioritising its work plans, but also by Welsh Government as one of the factors for allocating funding.
How does it work?	<u>CaRR Method</u> CaRR uses outputs from flood models to consider the number of people at risk from Fluvial, Tidal and Pluvial water, the hazard they are exposed to over a range of probabilities, the speed of onset of flooding and their ability to respond in terms of social vulnerability to flooding. It also uses factors such as availability and standard of flood warnings and flood defences. This methodology is based on the Flood Risks to People study by Defra / Environment Agency. 'Danger' scores are then calculated at an individual receptor (property) level, annualised and aggregated to a Community level (as taken from the Ordnance Survey 250k towns definition). This results in a Maximum score (natural, undefended scenario) and a Minimum score (for a mitigated scenario based on the presence of defences and flood warning systems). Based on the scores, the communities are ranked in order of absolute danger. For the prioritisation of NRW's work plans, the danger scores from each community are ranked for each risk source (Fluvial, Tidal, Pluvial) and this forms the basis for developing work plans and consideration of initiating further local analysis which could lead to flood schemes being proposed. Through this approach the highest risk communities (50 for each of the three regions) are prioritised and plans are identified to reduce flood risk in each of these highest ranked communities. This process will also inform the measures to be included in the next update of the Welsh Flood Risk Management Plans. <u>CaRR Output</u> CaRR is now also used by the Welsh Government to allocate FCERM funds to NRW and the Local Authorities. To prioritise Outline Business Cases (OBCs) and Business Justification Case (Pre OBC; BJCs) to be undertaken, the Max rank of a community is used as a criterium to score proposed projects The main advantages of CaRR to NRW is that it highlights medium- and long-term investment needs in FCERM and it helps with developing a long-term investment strategy <u>CaRR Update</u> Flood outlines now come from the national FRAW database instead of from different local models, which improves the consistency of CaRR significantly. This dataset is generated by a 2D JFlow model for the whole of Wales. Furthermore, the number of scenarios included has been increased. Another important improvement is the inclusion of the National Receptor Dataset.
Who is Involved?	Natural Resources Wales and the Welsh Government
Where can I access the information?	I. Information available from the Wales geo-portal - http://lle.gov.wales/catalogue/item/CommunitiesAtRiskRegisterCarr/?lang=en II. Scoring methodology for prioritising FCERM Grant Funding 2020-21. Link.

Project	Glasgow: Climate Ready Clyde (CRC) and Strategic Drainage Partnership (MGSDP)
Country	Scotland
What is it?	CRC is a cross-sector initiative of 15 public and private organisations set up to create a shared vision, strategy and action plan for adapting Glasgow City Region to climate change. It consists of a Board with a small secretariat. This is an initiative in which organisations work together to address urban flood risk in combination with other related challenges and opportunities at a strategic level. CRC was the first place-based initiative emerging out of Scottish Government's national Adaptation Scotland programme.
Why was it developed?	1.8 million people in the Glasgow City Region and a large number of businesses and organisations will be increasingly impacted by the effects of climate change, in particular flood risk.
How does it work?	Vision for Climate Adaptation CRC has developed an agreed Vision and has published a Climate Risk Assessment. This formed the basis for a Draft Adaptation Strategy and Action Plan which are currently out for consultation and will start to be implemented from Spring 2021. It sets out the framework, measures, processes, engagement and monitoring needed for achieving CRC's vision for 2050, while the Action Plan contains actions for the next 5 years CRC has also developed its agreed Vision for 2050: Collaborating to flourish in our future climate, which is supported by a Theory of Change. The general public typically don't recognise the CRC Assessment's finding that flood risk is the most important climate adaptation challenge for the city, because the last flood was a long time ago – this presents a challenge to get the public on board by using a story-based approach within the climate adaptation strategy. Next Stage The Strategy does not say who leads each action, how to do it or how to fund it; this is the next step for the leaders of the partner organisations
Who is Involved?	CRC is funded by Scottish Government and by its 15 members, and it finds additional funding through other collaborations and research funds. The Community
Where can I access the information?	Climate Ready Clyde, 2020. http://climatereadyclyde.org.uk/ Surface Water Management Masterplan, 2016 – The Metropolitan Glasgow Strategic Partnership https://documentcloud.adobe.com/link/track?uri=urn:aaid:scds:US:5997dbbc-29b5-465d-ab70-2465d1b4ba69 Glasgow City Region Climate Adaptation Strategy 2020-2030, 2020 – Climate Ready Clyde. https://documentcloud.adobe.com/link/track?uri=urn:aaid:scds:US:fdf083c7-acde-4673-9cfe-c881f91257d7

Project	Working with Natural Processes (WWNP)
Country	England, United Kingdom
What is it?	The Working with Natural Processes (WWNP) to reduce flooding risk involves implementing measures that help to protect, restore and emulate the natural functions of catchments, floodplains, rivers and the coast – this can take many different forms and can be applied in urban and rural areas, and on rivers, estuaries and coasts. The WWNP consists of 3 projects: Evidence Directory, Mapping, a guide and a set of 65 case studies.
Why was it developed?	There has been a lot of research on the WWNP but it has never been collated in to one location – this meant that it was difficult for flood risk managers to access up-to-date information on WNP measures and to understand their potential benefits. The evidence base is being used as a reference and starting point for those considering Natural Flood Management. Overall, NFM fits well with the Environment Agency's objectives as it can often move floods from 'disaster' to 'nuisance' and can reduce carbon (less construction locally and downstream; more capture).
How does it work?	<u>WWNP</u> The WWNP evidence directory is a structured collation of available research on measures' effectiveness in reducing flooding at different scales, their costs and wider impacts, and their potential for multiple benefits. For example, the England-wide mapping shows broad-scale suitability for floodplain reconnection, run-off attenuation and woodland planting. Having used the Evidence Base as a reference point, it typically needs to be followed by more local and specific assessments. Regional EA teams are building on the existing maps to provide more locally specific information on NFM potential. <u>How will the WWNP Outcomes be used?</u> The outcomes of the WWNP projects can be used by those planning projects that include WWNP measures to help understand: their potential FCRM benefits; any gaps in knowledge; where it has been done before and lessons learnt; where in a catchment they might be most effective. The Environment Agency has written a guide to site alongside the Evidence Directory and the Maps which explains how to use them to help make the case for implementing WWNP when developing business cases, as well as for areas at risk of groundwater flooding. <u>Natural Flood Management Fund</u> In 2021/22 the evidence base will be updated based on evidence gathered from the projects funded by the NFM fund. Thus far, the NFM funding programme has provided £15m of funding to NFM projects – evidence shows that these are more successful if they balance the full range of potential benefits, rather than focus primarily on flood risk benefits. Although the NFM programme benefits flood risk in a sustainable manner, many in the local community would prefer hard defences. More needs to be done to address the perception of NFM so that NFM becomes part of the regular portfolio of options.
Who is Involved?	UK Government and local practitioners of NBS and NFM
Where can I access the information?	https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/working-with-natural-processes-to-reduce-flood-risk

Project	SEPA Flooding Services Strategy
Country	Scotland, United Kingdom
What is it?	The new, to be published, Flood Services Strategy from SEPA was started as a catalyst to transform SEPA to be able to meet future challenges.
Why was it developed?	To meet future challenges of climate change – it is recognised that future risk is more important than present day risk. The aim is to build resilience now, instead of adapting later. Therefore, climate adaptation has to be built into new schemes and interventions.
How does it work?	Strategy and stakeholders Within the new strategy, a key principle of FRM is partnership and going beyond the traditional 'suite' of partners. To get all actors and stakeholders around the table takes a lot of effort, but is going on in many major places in Scotland. SEPA is trying to mainstream this approach for the whole of Scotland. This is communicated in the form of guidance to local authorities – it covers how many and what climate change scenarios to consider when assessing schemes, whilst removing large SoP periods to ensure small communities are able to develop flood protection measures without the over-complications associated with scale. This has resulted in an increase in 'portfolio schemes', as well as schemes that combine flood risk management with community enhancements, which increases community buy-in into the projects. Flood Maps User friendly Flood Maps underpin the aims and goals in the Strategy. Through Public consultation, the strategy develops a different approach to mapping of flood risk that is steered more towards a preferred yes/no to a proposed question; in the new maps, the user is therefore first taken onto a text based journey, which accompanies the maps. This approach addresses the fact that flooding comes with uncertainty and probabilistic aspects, and it is a challenge to take the user along and not lose them along the way. Insurers SEPA is now working to understand how they can share flooding information with insurers. Ideally this would be part of an exchange system, so that SEPA can validate their assumptions on risk and impacts of flooding
Who is Involved?	SEPA Public Engagement Local Authorities Insurers
Where can I access the information?	SEPA Flooding Services Strategy Consultation Draft, SEPA – 2020. https://consultation.sepa.org.uk/evidence-and-flooding/69a9d33b/user_uploads/sepa-flooding-services-strategy-2020-consultation-draft.pdf

Project	Eddleston Water project
Country	Scotland, United Kingdom
What is it?	The Eddleston Water project aims to reduce flood risk and improve river habitat through river catchment restoration, working closely with farmers and communities, and is led by the Tweed Forum (a charity), with public and academic partners. It involved re-meandering 3km of river channel, the planting of over 330,000 native trees, the installation of 116 low flow woody dams and the creation of 30 flood storage ponds
Why was it developed?	It was developed as part of the project's scoping study in 2009/10 was carried out as a pilot for the new Flood Risk Management (Scotland) Act 2009, identifying a scientific knowledge base, and supporting the Act's risk-based catchment approach that requires authorities to consider natural solutions to flood risk.
How does it work?	The project includes the installation of a monitoring network (2011), followed by implementation and monitoring since 2012 – the project is continuing beyond its current March 2021 stage as part of the 3-year phase to 2024, funded by Scottish Government. <u>Landowner and Community Engagement</u> The project works closely with landowners to make subtle changes that slow the flow, create storage and reconnect the river with its floodplain. The measures include river re-meandering, planting of trees and creation of new wetlands. Participation by landowners is voluntary, so close engagement with land managers is central to the project's success. The close engagement with the landowners works well because it is carried out by the Tweed Forum, who are trusted by the farmers as a neutral non-government party – they understand the farmers' business, and the type of areas and options that can work both as NFM (reducing flood risk) and for the farmers (at least economically neutral). The project has also made considerable effort to engage with the downstream communities and the wider public, through stakeholder meetings, organising project visits, conferences and wider publicity. <u>Dundee University Research</u> The project uses both an empirical approach - based on a very detailed hydrological network and focussed ecological surveys - and combined catchment hydraulic and hydrological modelling. The catchment is also the location for detailed groundwater research. The choice and location of potential NFM measures was informed by the initial scoping study. This also set out the Monitoring Strategy which covered the baseline period which included both a dry and wet year. <u>Benefits</u> The project has demonstrated a return on investment: work thus far has a net present value of £4.2m on top of £950k flood damages avoided. If other planned measures are implemented, this could increase to £17.7m on top of £2.85m flood damages avoided. Although the driver of the project is flood risk reduction, in this case other benefits related to carbon capture, biodiversity, recreation and water quality improvements actually proved to be more important.
Who is Involved?	The project's research is led by UNESCO Centre for Water Law, Policy & Science at Dundee University Funding from SEPA, local council, private partners Tweed Forum (charity) Public and Academic Partners
Where can I access the information?	The Eddleston Water Project, 2020 – Tweed Forum. https://tweedforum.org/our-work/projects/the-eddleston-water-project/

	Spray, C. et al (2009) Bridging the water law, policy, science interface: flood risk management in Scotland. https://documentcloud.adobe.com/link/track?uri=urn:aaid:scds:US:72f67a0c-17e0-4066-bab2-af011d42ef7b

Project	Regional Community Resilience Group
Country	Northern Ireland
What is it?	The RCRG brings together over 15 partner organisations to develop a Community Resilience Delivery Programme across the region in order to better the preparedness of communities to flood risk. Formed in 2013 the RCRG, using a 4 stage process, helps deliver a "Flood Warning and Informing Strategy" with reliable a weather forecast and river level information used to inform and support communities at known flood risk so they can be prepared for flooding.
Why was it developed?	Following a significant rainfall event in June 2012, which impacted the Greater Belfast Area, a review of the response to the flooding made a number of recommendations – one of which was to consider how to deliver appropriate flood warning and informing for Northern Ireland. One of the main goals is to support communities at flood risk in developing their Community Plans.
How does it work?	Approach The RCRG delivers this strategy by developing a regional standardised approach, focussing on communities in a prioritised way, and helping them prepare for and respond to weather related emergencies. The group brings together over 15 partner organisations to develop a Community Resilience Delivery Programme across the region. Local Communities The multi-agency governance group works with over 30 local communities, many of which have been pre-identified as 'at-risk' based on a prioritisation matrix that takes into account a combination of flood history, number of properties affected, and other relevant factors. Other communities have also been approached by the RCRG based on their knowledge of past flood events, or others who have proactively contacted the RCRG seeking assistance. The template for the Community Plan allows each community to develop tailored plans to suit the individual needs of their community with annual refresher engagement to ensure key information remains relevant. In addition to helping local communities to develop Community Plans, the local resilience groups are advised of weather information, based on the forecasts developed by Met Office. These weather warnings are directly communicated to the local communities and in this way the information reaches the right people at the right time. Engagement tends to be easier in regions that have experienced more recent flooding impacts with this real life impact also helping to illustrate technical parameters such as return periods. Overarching role of the RCRG Ultimately, by explaining the flood risk faced and outlining the limitations of the response from government, communities are better informed and can determine if they need to put in place self-help measures, for example sand bags which have been provided in suitable storage facilities for access by the local community. The RCRG provide ADDITIONAL support to the community and is not intended to reduce the role of government departments and emergency services.
Who is Involved?	Regional Community Resilience Group – 15 partner organisations Local Community
Where can I access the information?	Community Emergency Planning, 2020 – NIDirect. https://www.nidirect.gov.uk/articles/be-ready-community Links to RCRG newsletters on being 'Weather Ready' – https://www.infrastructure-ni.gov.uk/publications/getting-weather-ready-regional-community-resilience-group-newsletter

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