Managing Adaptive REsponses to changing flood risk

MARE toolbox and guidance for climate-proofing of responses and potential adaptations in Flood Risk Management Plans

Overview report

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MARE toolbox overview FV 121204

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Glossary of terms

ATP	Adaptation Tipping Point
Adaptation Tipping Point	Points where the magnitude of climate change (or any driver) is such that the system can no longer meet its performance objectives (Kwadijk et al, in press)
Climate-proofing (broad definition)	To use hard infrastructure to reduce risks to a quantified level, accepted by the society or economy. This risk can be further combated by 'softer' measures, such as insurance schemes or, as a last resort, evacuation plans . Such climate proofing should be driven by opportunities for technological, institutional and societal innovations (Kabat et al, 2005)
Climate-proofing (narrow definition)	To take account of and act upon changes in climate (Jeuken et al, 2008)
CPT	Climate-proofing toolbox and guidance
Exceedance event	An event which exceeds the threshold (the protection level) of the flood system. The volume of water is larger than the drainage system (including e.g. exceedance pathways) can handle, resulting in water flowing where it was not intended or planned to flow
Flood	Temporary covering by water of land not normally covered by water (Flood Directive, 2007)
Flood impact	Economic, social or environmental damage that may result from a flood. May be expressed quantitatively (e.g. monetary value), by category (e.g. high, medium, low) or descriptively. (Samuels and Gouldby, 2009)
Flood intensity	The flood intensity is a measure of the magnitude of the flood, e.g. expressed as the rainfall duration or flood discharge
Flood protection (measure)	Measure to protect a certain area from inundation (Samuels and Gouldby, 2009)
Flood risk	The combination of the probability of a flood event and of the potential adverse consequences for human health, the environment, cultural heritage and economic activity associated with a flood event. (Flood Directive, 2007)
FRMP	Flood Risk Management Plan
Learning and Action Alliance	Platform of professional stakeholders to enable collaborative learning and to provide a base mechanism for action; the platform has a shared interest in innovation and the scaling-up of innovation
Net Present	The sum of the discounted benefits of an alternative less the sum of its discounted costs, all discounted to

Value	the same base date.
Non-structural measures	Designed policies and procedures; supporting institutional framework, including land use planning economic incentives and human capacity building (EC, 2009)
Impact	See Flood impact
Preparedness	Informing the population about flood risks and what to do in the event of a flood
Prevention	Preventing damage caused by floods by avoiding construction of houses and industries in present and future flood-prone areas; by adapting future developments to the risk of flooding; and by promoting appropriate land-use, agricultural and forestry practices
Protection	Taking measures, both structural and non-structural, to reduce the likelihood of floods and/or the impact of floods in a specific location
Protection level	Threshold level up to which a drainage system is designed to protect against flooding
Risk	See Flood risk
Reaction curve	Relationship between the change in impact of the system in relation to increasing flood intensity
Resilience	The ability of a system or subsystem to maintain its identity in the face of external pressures (Cumming et al, 2005)
Structural measures	Physical, structural interventions and construction measures to make buildings and infrastructure more robust (EC, 2009)
Uncertainty	A concept that reflects a lack of confidence about something. Decision-makers may have more or less certain knowledge of a risk.
Unpredictability	Uncertainty which cannot be removed through more scientific research
Vulnerability	Characteristic of a system that describes its potential to be harmed

Executive summary

Policy makers and flood risk managers usually deal with uncertainties about current climate by defining acceptable standards, either based on likelihood or based on a broader risk-based approach (i.e. taking account of the likelihood as well as consequences). However, climate change introduces additional uncertainty. This is no longer simply something to be reduced through more scientific research, although this can help. It is with this kind of uncertainty that policy makers and flood risk managers struggle the most.

Analytical methods to account for climate change uncertainty are being further developed and implemented in some countries, but the majority of these are not yet fully operational (Bates et al., 2008). The availability of these methods is, however, a main requirement in application of the concept of climate-proofing to flood risk management. A principal aim of the MARE project is therefore to develop a toolbox and guidance for climate-proofing of responses and potential adaptations within flood risk management plans (FRMPs). The toolbox and guidance addresses the question of if, how and when to adapt to climate change. In this regard, it is intended to support the implementation of the EU Floods Directive.

The toolbox and guidance is based on the method for the planning and design of flooding and urban drainage systems developed by Geldof (2007). Geldof (2007) and later, (Fratini et al, 2012) conclude that it is not wise to develop a plan that focuses attention only on defining protection standards and meeting these standards. That is a one-dimensional approach. Two other dimensions need to be considered. One is related to exceedance events (i.e. events beyond the standard of protection), where attention should be focussed on spatial planning and urban design. The other is related to the day-to-day values, where water may improve the social and economic state of the area. The toolbox is therefore dealt with in terms of the three different dimensions that are a part of flood risk management: (1) day-to-day values; (2) standardized events; and (3) exceedance events beyond the standard. The MARE project provides a set of nested instruments based on the three dimensions of flood risk management. These can be summarised as follows:

- MARE1 concerns the interactions and synergies between the flooding and urban drainage system and society. If there are measures taken, a lot of money has to be invested and space provided for river discharge and rainfall events happening perhaps only once in 100 years - therefore it is important to maximise any additional benefits and value for people and the environment from the space and investment utilised. The options identified (in MARE2 and MARE3) should where practicable, have a ‘day to day’ value as well as their value for FRM. Therefore it is important to identify multi-functional and multi-value possibilities to synergistically utilise water management measures to other social, ecological and economic issues. Often FRM measures provide a unique opportunity to realise significant transformations within existing cities and their surroundings. This opportunity should be used carefully, and with awareness of the complex technical but also social, spatial and ecological systems being managed together. Looking for synergies can be seen as a chance to develop and improve the local living environment at the same time. If there is the possibility of achieving benefits of synergetic effects, then this will also ease the process of obtaining

political and public support for the implementation of plans and designs.

- MARE2 primarily concerns the technical aspects of the flooding or urban drainage system. It focuses on the performance of the infrastructure provided to deal with sea level rise, river discharge and rainfall variability. This is expected to be adequate to comply with current policy objectives; delivering acceptable protection levels. The acceptable protection levels are established by either defining the likelihood of events or by taking a more risk-based approach (i.e. differentiating protection levels according to potential adverse consequences). Climate change and urban development increase the impacts on the flooding or urban drainage system, such that the system performance progressively deteriorates over time. This means that there is a constant need to adapt flood related infrastructure to comply with the protection standards imposed by society. Alternatively, where this is acceptable or too costly, the acceptable protection level may be allowed to reduce when external threats change the flood frequency and severity. Under the MARE2 framework, the protection level is expected to keep pace with the external change drivers and to be resilient to uncertain future scenarios.

- MARE3 focuses on the preparedness for exceedance events. An event which exceeds the threshold (the protection level) of the flood system is defined in the MARE project as an exceedance event. The volume of water is larger than the drainage system (including e.g. exceedance pathways) can handle, resulting in water flowing where it was not intended or planned to flow. A 100% flood protection cannot be guaranteed. There will always remain a probability of an exceedance event causing water to flow where it was not intended it should be. A FRMP should therefore not only consider responses to prevent floods from occurring, but should also include responses which reduce the impact of an exceedance event if a flood were to occur.

The application of the Climate-proofing toolbox and guidance is best carried out within and supported by a learning and action alliance (LAA) approach (MARE WP1, Ashley et al., 2011). This learning in partnerships is essential in order to develop effective and efficient responses to adapt to future change and it needs to be managed collectively across all stakeholders. A discussion of how to organise LAAs to support decision making for the planning and design of flooding and urban drainage systems is dealt with in the WP1 report from the MARE project.

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1 Introduction

Upcoming global climate change and increasing urbanisation in flood-endangered areas forces us to reconsider recent and future flood risk management (FRM) strategies in cities. In order to handle flood problems the EU Floods Directive (EC, 2007) sets a framework to create awareness and capacity building in the EU.

The MARE project is about the FRM planning process in cities in relation to climate change. The EU Floods Directive demands the development of Flood Risk Management Plans (FRMPs) on a regional level. Nevertheless, cities have also utilised this planning instrument as part of guidance to deal with flood risk. They try to find a way of working towards living with water, creating more sustainable water systems and to look for synergies while applying flood protection measures, like Water Sensitive Urban Design (WSUD) (Ashley et al, 2013). Within this process, it is important to consider the increasing influence of and consequences coming from climate change.

The project has developed a toolbox and guidance for climate-proofing of responses and potential adaptations identified in FRMPs.

1.1 Context: the need to do things differently

1.1.1 Changing drivers for FRM

Recent flooding has demonstrated the vulnerability of the North Sea Region (NSR) through huge economic losses (e.g. damage to buildings and infrastructure) and indirect losses (e.g. production losses caused by damaged roads or power interruptions) in or beyond the flooded areas. Flood risk may be defined as a combination of the probability and consequences of flooding, i.e. the odds on it happening and the losses it may cause. Due to climate change, flood risk is expected to increase even further. A recent scientific study on climate change and future flood risk (Feyen et al. 2009) indicates that under the various IPCC emission scenarios, flood risks are projected to rise across much of the NSR (Fig. 1.1).

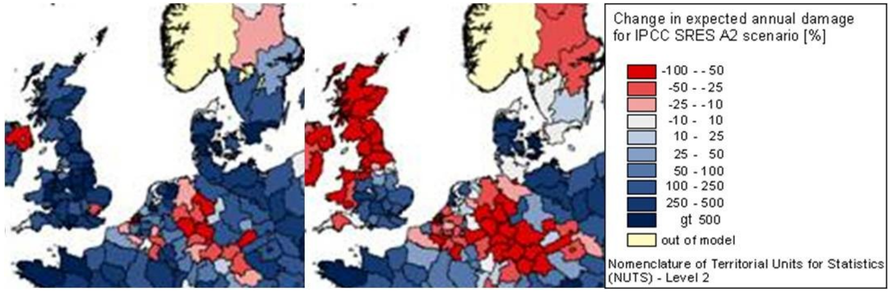

Figure 1.1. Change in flood risk between 2071-2100 and 1961-1990 for the IPCC emission scenario A2 (left) and B2 (right) (Feyen et al. 2009). Blue indicates an increase in risk, and red a decrease.

The magnitude, and in some cases even the direction, of the future changes in flood risk are still very uncertain, as can be seen from Figure 1.1. This uncertainty makes it necessary to modify the contemporary approach for flood and stormwater management. It is increasingly recognised that integrated, adaptable and flexible solutions are now needed to allow for climate change uncertainty as these are inherently better able to accommodate this uncertainty. This implies that non-structural measures (including measures that are reversible), such as urban planning, adapting new development and promoting flood risk awareness, will play a more important role than in the past and need to be used (alongside large structural measures), as these measures are easier to adapt once new information about the flood risks becomes available in the future (e.g. Pasche et al, 2008). This also includes planning for flood flows exceeding defences (i.e. exceedance events), with higher surface flows and urban area inundation being dealt with by urban planning and other non-structural measures. Moreover, these measures should (if possible) provide simultaneous short-term social and economic benefits, for example in terms of high amenity values of attractive waterscapes, and contribute to the objectives of the Water Framework Directive (WFD, 2000).

Four challenges are identified as particularly relevant to the need for new approaches to flood and stormwater management:

External threats affecting flood risk in cities

The two main factors affecting flood risk in cities are climate change and urban development. It is likely that climate change, even within medium-term horizons, will further increase flood probabilities (and hence, risks) across much of the NSR of Europe (see Fig. 1.1). Traditional urban development results in quicker build-ups in surface water runoff, and higher rates and volumes of runoff, because the capacity for local retention in green or porous areas is typically diminished. A dense urban layout can also prevent water from leaving the city, resulting in locally rapidly rising water levels. These drivers/pressures increase flood probabilities. Furthermore, increasing concentrations of people and property, particularly along coasts and rivers as these have always been attractive places for living and working, are likely to result in more severe flood impacts.

Climate change and urban development also introduce greater uncertainty in the understanding of the drivers of future risk, in particular for rainfall extremes. Although we are uncertain about the likely future rainfall, runoff and frequency of flooding, we still need to act now to start to provide the required protection for our communities (Stern, 2007), and this has to be affordable. This requires new approaches that seek to build-in adaptability to any systems or combinations of systems, introduced in this document. Ideally we need to find systems that are also robust so that they can be adapted whatever the future scenarios look like (Evans et al, 2004).

Societal needs and expectations

Key drivers for change in FRM include increasing environmental concerns and a steadily increasing demand for high quality social amenity in urban places. As a consequence thereof, the benefits from and expectations of flooding systems have broadened and have become more complex (Brown 2007). It is clear that contemporary approaches cannot dynamically (i.e. over a long period of time), and simultaneously, provide for flood protection, waterway health and other societal needs, like public health, recreation and amenity, micro-climate, energy reduction (Ashley and Brown 2009) without considerable investment and effort. Therefore it is important to identify multi-functional and multi-value possibilities to synergistically utilise water management measures to other social, ecological and economic issues wherever possible. Key to this is land use, both in planning terms and also in functional usage.

Policy developments

The new EU Directive on Flooding lays down a clear three-step approach for managing flood risk. It will require member states to reduce flood risk for those areas where the risk is deemed significant. For those zones

FRMPs must be prepared. These plans should include appropriate objectives that focus on either the reduction of the likelihood of flooding or on the reduction of potential adverse consequences, as well as measures for achieving the established objectives. With its requirement that FRMPs focus on prevention, protection and preparedness, the Floods Directive also gives non-structural measures a key role in mitigating flood impacts. In addition, it emphasises the need to assess and manage extreme event scenarios (i.e. floods with a low probability) as well as climate change scenarios.

A related policy document, the EU White Paper on climate change adaptation (EC, 2009), sets out a framework to improve the EU's resiliency to deal with the impact of climate change. The framework will complement national action and support international efforts to adapt to climate change. It adopts a phased approach: the intention is for phase 1 (2009-2012) to lay the ground work for preparing a comprehensive EU adaptation strategy to be implemented during phase 2 (2013 onwards). Actions to be taken in the first phase focus on the development of a knowledge base on adaptation, the integration of adaptation into EU policy areas, the development and implementation of policy instruments to ensure effective delivery of adaptation, and international cooperation. With regard to FRM, the implementation of the EU Floods Directive is expected to help increase resilience and facilitate adaptation efforts. It is therefore required that climate change is properly integrated into the implementation of this Directive. This emphasises the need to climate-proof responses and potential adaptations within the FRMPs, which are due under the Floods Directive.

1.1.2 Climate Proofing Toolbox and Guidance (CPT)

MARE stands for Managing Adaptive REsponses to changing flood risk in the North Sea region. The MARE project has developed a toolbox and guidance for climate-proofing of responses and potential adaptations within FRMPs. Using existing tools and guidance, the CPT helps users to take climate change predictions into account in the risk assessment and options planning processes. It helps to answer the questions of if, how and when to adapt to climate change. The CPT aims to help policy makers, flood risk managers and urban planners, to achieve timely and effective implementation of managed/adaptive responses. In this regard, it is intended to support the implementation of the EU Floods Directive. Through collaboration with other EU Interreg projects, this toolbox and guidance sits within the context of a larger framework for flood risk and water management.

1.2 Aims and objectives

Policy makers, flood risk managers and urban planners usually deal with uncertainties about current climate by defining acceptable standards, either based on likelihood or based on a broader risk-based approach (i.e. taking account of the likelihood as well as consequences). However, climate change introduces additional uncertainty. This is no longer simply something to be reduced through more scientific research, although this can help. It is with this kind of uncertainty that policy makers, flood risk managers and urban planners struggle the most. Basic questions for these actors are (Jeuken and Te Linde, 2011):

- *Is there a risk that policy objectives will not be achieved?*
- *Is there a risk that additional measures will be needed soon (extra money needed)?*

- *Is there a risk that too many measures are taken (too much money is spent)*
- *How large is this risk and when will this occur?*

Analytical methods to account for climate change uncertainty are being further developed and implemented in some countries, but the majority of these are not yet fully operational (Bates et al., 2008). The availability of these methods is, however, a main requirement in application of the concept of climate-proofing to FRM.

A principal aim of the MARE project is therefore to develop a toolbox and guidance for climate-proofing of responses and potential adaptations within FRMPs, due under the Floods Directive. In the current report, a toolbox is taken to comprise a set of instruments (e.g. a structured framework, a method, a technique, or a response option) that various actors involved in FRM can use to ensure that timely and effective adaptive responses are implemented.

The toolbox addresses specific challenges cities have to face when dealing with FRM: dealing with the uncertainty of climate change and the integration of FRM measures in the complex urban environment.

The toolbox and guidance address the question of if, how and when to adapt to climate change. In this regard, it is intended to support policy makers, flood risk managers and urban planners with the implementation of the EU Floods Directive. The toolbox and guidance are based on and aligned with the EU White Paper as well as a number of existing national policies and guidance (e.g. from UK and the Netherlands) on climate adaptation in the area of FRM. It deals with coastal, river and rainfall flooding.

As in cities it is extremely important to integrate various specific requirements of planning processes at the same time, FRMP measures must be coordinated with city planning in order to serve the overall aim to improve the city's spatial quality. To guarantee safety in terms of flooding is of course one important issue in spatial quality. Nevertheless, FRMP measures must coexistently be thought of in terms of their social, ecological, cultural, economic and aesthetic dimensions.

The toolbox and guidance may be applied both ex-ante, for developing a new climate-proof FRMP, and ex-post, for assessing the climate-proofness of an already developed FRMP.

The application of the Climate-proofing toolbox and guidance is best carried out within and supported by a learning and action alliance (LAA) approach (Ashley et al., 2011). This learning in partnerships is essential in order to develop effective and efficient responses to adapt to future change and it needs to be managed collectively across all stakeholders. A discussion of how to organise LAAs to support decision making for the planning and design of flooding and urban drainage system is dealt with in the WP1 report from the MARE project.

1.3 Guidance to the reader

This report provides an overview of the toolbox and guidance for climate-proofing of responses and potential adaptations within FRMPs, which has been developed for MARE. The report is structured as follows. After a general introduction of the context and CPT, Chapter 2 describes the method used to develop the CPT, which is the Three Points approach (Fratini et al, 2012). Chapter 3 introduces the urban (master) planning process and the FRM planning process. This sets the scene for the climate-proofing of the responses and potential adaptations within FRMPs. The proposed toolbox and guidance are discussed in Chapter 4, in the form of guidelines directed to the three dimensions of FRM. The first dimension deals with day-to-day values, and the process for this dimension is aimed at integrated planning and design to help achieve synergetic effects with water. The second dimension concerns standardized events, and it includes a process for attaining flood protection standards in the face of climate change. The third dimension then deals with the exceedance events (i.e. events beyond the standard of protection), and it includes a process for assessing the effects of climate change on the consequences of flooding. Chapter 5 provides guidance for positioning MARE 2 and 3 to the FRM process and the balancing process required to come to an acceptable strategy. Finally, key messages from the application of the CPT in the MARE cities and beyond are discussed and recommendations are presented (Chapter 6).

For each of the dimensions of the toolbox and guidance, a step-by-step procedure for implementation is provided in an accompanying technical report to the CPT:

- Richter, S. Zeller, S., Ashley, R., Walker, L., Gersonius, B. and Pathirana, A. (2013) **MARE1: Water management and urban planning - Methods to improve inter- and transdisciplinary planning processes.**
- Gersonius, B., Zevenbergen, C., Nasruddin, F., Pathirana, A., Ashley, R. and Blanksby, J. (2013) **MARE2: Methods to attain flood protection standards.**
- Stone, K., Gersonius, B. and Ashley, R. (2013) **MARE3: Preparing for extreme events incorporating changing climate conditions.**

Additional technical support to the development of FRMPs is provided in:

- Blanksby, J. (2013) **Developing a local flood risk management strategy.**

2 Method

2.1 Rationale

The basic idea of climate-proofing, as introduced by Kabat et al. (2005), is: *"to use hard infrastructure to reduce risks to a quantified level, accepted by the society or economy. This risk can be further combated by 'softer' measures, such as insurance schemes or, as a last resort, evacuation plans. Such climate proofing should be driven by opportunities for technological, institutional and societal innovations"*.

A specific definition of climate-proofing, based on Jeuken et al. (2009), is: *"to take account of and act upon changes in climate"*. In a specific sense, climate-proofing has not to do with dealing with the current variability in climate or sea level rise. This distinction is important because climate-proofing is often associated with FRM, where dealing with current climate variability is already an important problem. Climate-proofing is only needed when a 'design storm' (or sequence of storms) with a larger runoff peak and/or volume is predicted as a consequence of an estimated change in climate. The concept of a 'design storm' describes a simulated runoff peak and volume having a specific return frequency, such as once in 100 years.

In this document, the broader definition of climate-proofing, based on Kabat et al. (2005), as given above is adopted. This means that climate-proofing also needs to accommodate the variability in estimates of storm events and river discharges.

2.2 Work plan

The MARE CPT has been structured to contribute to the process for the development and implementation of a climate-proof FRMP, which is required under the Floods Directive. The FRM planning process has a number of phases, as described in Chapter 4 of this report. The outcome of this process will be the establishment and implementation of a FRMP for areas where the risk is deemed significant. This plan should include appropriate objectives that focus either on the reduction of the likelihood of flooding or on the reduction of potential adverse consequences, as well as measures for achieving the established objectives. It should address all phases of the FRM cycle, but focuses particularly on prevention, protection and preparedness. In this context, the MARE project provides a toolbox and guidance for climate-proofing of responses and potential adaptations within FRMPs.

The toolbox and guidance is based on the method for adapting to changing climate conditions developed by Geldof (2007). Subsequently Fratini et al, 2012, take this further to conclude that it is not wise to develop a plan that focuses attention only on defining protection standards and meeting these standards. That is a one-dimensional approach. Two other dimensions need to be considered. One is related to exceedance events beyond the standard of protection, where attention should be focussed on spatial planning, urban design and crisis management. The other is related to day-to-day values, where water may improve the social, environmental and economic state of the area. The toolbox is therefore dealt with in terms of the three different dimensions that are a part of FRM: (1) day-to-day values; (2) standardized events; and (3) exceedance events beyond the standard. This is depicted in Figure 2.1.

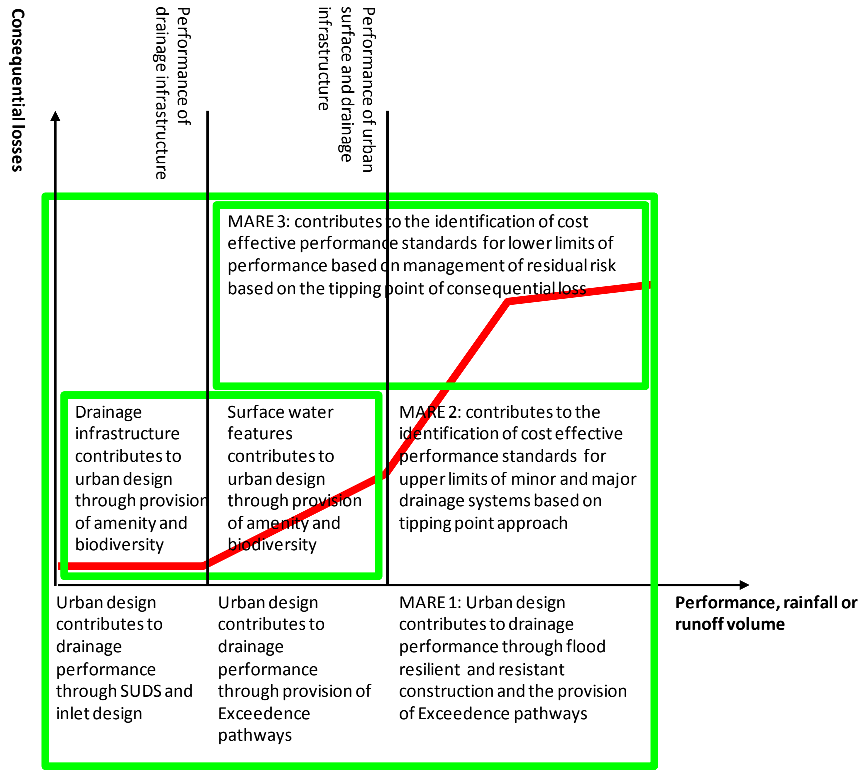

Figure 2.1. Three different dimensions that are a part of FRM.

The three dimensions of FRM (day-to-day values, standardized events and exceedance events) have different characteristics and require different approaches in/across different fields of expertise (Fratini et al, 2012). The first dimension requires engagement between urban planners, designers, community groups and other stakeholders concerning day to day values. The second dimension requires technical discussions with water professionals and infrastructure managers. The third requires interactions with urban planners and designers. Policy makers, decision makers and funders are involved in all the dimensions. The development of a climate-proof FRMP is complex as it covers all dimensions. In this sense, handling the different dimensions separately can help to untangle design and decision making processes, by focusing on one particular dimension of the overall problem at a time. The results for one dimension can then provide input for one of the other dimensions. As such, it is possible to develop a technically, socially and economically preferred solution in an iterative process: that is, through collective active learning in, for example, LAAs.

WP2 of the MARE project provides a set of nested instruments based on the three dimensions of FRM. These can be summarised as follows:

- MARE1 provides guidance for integrated planning and design
- MARE2 gives a method for attaining flood protection standards
- MARE3 gives a method to deal with exceedance events

In addition to these, WP1 of the MARE project provides guidance on establishing and running LAAs; refer to Dudley et al. (2012; 2012a) for details.

2.3 Tasks and activities

The CPT has been developed through the following steps:

- Definition of constituent parts and interrelations of the CPT in cooperation with LAAs.
- Execution of a requirements analysis for the CPT in cooperation with LAAs.

- Review of the theoretical and practical state-of-the-art (S-o-t-A) on climate proofing and integrated planning and design in cities.
- Development of a shared vision on climate proofing through learning from each other (based on needs & requirements of LAAs) and from existing knowledge.
- Development of a common understanding of the urban (master) planning process.
- Development of a common understanding of the FRM planning process.
- Development of a process and step-by-step procedure for addressing the three dimensions of FRM (day-to-day values, standardized events and exceedance events).
- Support for the implementation of the CPT in the MARE demonstration projects.
- Enhancement of the CPT and its constituent parts through experience and lessons learned from LAAs.

3 Urban planning and FRM planning

3.1 Description of FRM planning process

The following FRM planning process is consistent with recognised practice in the water sector, for example EN 752, (2008), is compatible with the management of other risks in the urban environment through ISO 31000 (2009) and is aligned with the steps of urban planning processes described in MARE 1. The process supports the development of organisational capacity for FRM and linking it to urban design and management.

As there is great uncertainty about the degree of change due to climate, urban demands and developments that will occur and, whatever the general change and the rate of change, there will be differences between different regions and cities; each City and County should develop their own unique and specific strategy for Flood Risk Management.

The aims of flood risk management are relatively simple and are to:

1. agree the approach by which flood risk will be managed including procedures and measures of flood risk
2. identify current and potential future risks, and who is responsible for the management of those risks
3. develop the most effective way of managing the risk, irrespective of whose responsibility it is, and
4. implement the necessary measures to manage the risk

The stakeholders will need to agree how to manage the work and communicate and also the measures by which flood risk will be assessed and prioritised. These could include the frequency and or consequences of flooding that will trigger action, and the targets that will be used to compare different options for flood risk reduction.

Hence, there are two aspects to the process. The first is about the identification of the context and the development of a strategy for FRM, including communication strategy. The second is about the process that leads to a FRMP. Figure 3.1 illustrates the two aspects of the process and how they may interact.

MARE 2 and MARE 3 are used in the Diagnostic study, to analyse and assess the level of flood risk associated with the current system (Phase 2 in Figure 3.1), and in the assessment of the performance of the risk management options, including urban design (Phase 3 in Figure 3.1).

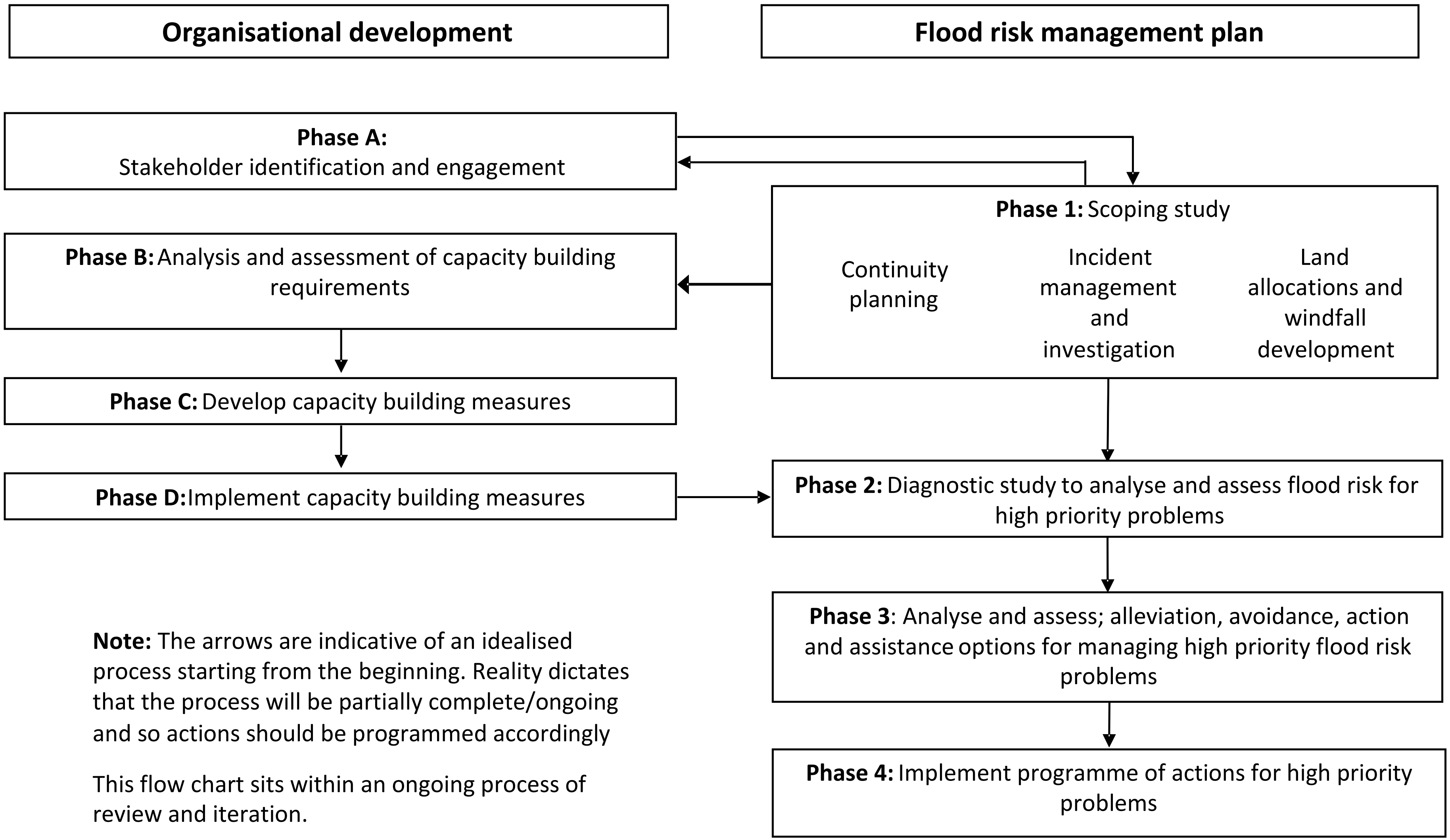

Figure 3.1. Process for developing strategies for FRM and strategies for managing flood risk

3.2 Relating FRM planning and urban planning

FRM planning is inseparable from city planning. Flood risks as well as measures to reduce flood risk have a significant effect on the spatial quality of a city. Yet, flood risk is just one of many risks that have to be managed by city authorities. The remainder of this section discusses how the urban planning process and the FRM planning process are related.

The aim of the urban planning process is to identify the preferred strategy for actual city development, not only in a technical way, but by balancing all social, ecological, aesthetic and/or spatial aspects in the complex urban environment. The overall aim is to enhance spatial quality.

Urban planning processes can be generally described by four phases comprising: 1. initial phase; 2. diagnostic studies; 3. design and assessment of options; and 4. decision making and implementation. These phases can be found in all types of urban planning processes.

Urban planning is not a linear but an iterative, complex process in which, in some cases, even the design idea (i.e. as part of phase 3) can be the starting point. But in the process all the phases have to be considered together.

The urban planning process generally, but not always, starts later than the FRM Planning Process when the risk and vulnerability maps have been created, the technical problems and opportunities are determined and a broad range of possible structural and non-structural responses are identified by the LAA The assessment of options will provide insight into effective options and strategies for reducing flood risk. This also enhances the understanding of the city transformations required to implement these options. Traditionally the urban planning process started after the diagnostic study of the FRM planning. This is not ideal and one of the reasons why in the past, planning and engineering have been considered separately is because of this flawed approach. Using a partnership approach in e.g. LAA, the diagnostics, formulation of innovative options and implementation should be done collectively.

When the necessity for a transformation in a specific area in the city is evident, then the urban planning process will start.

1. Initial phase

   In this phase the relevant stakeholders for the urban planning process are identified and engaged within the partnership (e.g. LAA). As part of this process, all stakeholders involved with FRM planning should be engaged from the beginning. They have to communicate and take (joint) responsibility for the FRM issues, while at the same time bringing in opportunities for synergies with other issues. Other stakeholders bring relevant information on the city or region, including social, ecological, economic, technical and even cultural issues. MARE 1 describes which aspects are important in the integration of the urban planning processes, when doing the stakeholder analyses.

2. Diagnostic studies for urban design

   This is the scoping and legitimisation via research and communication phase. The problems and opportunities of the water system, as well as the possible options and strategies identified (up to this point) in the FRM Planning process have to be communicated and agreed upon (legitimised) between all the stakeholders engaged in the urban planning and development process. Facts about the affected parts of the city, such as historical and cultural background or economic and ecological challenges and opportunities have to be investigated by the partnership and communicated between all the stakeholders involved, including the water experts. Furthermore overall aims in urban development and opportunities to link to existing projects and frameworks have to be summarized to get a full overview of the project's context. MARE 1 describes methods for: understanding the water system in the urban development site (step2); and detecting relevant issues for this site (step3)

3. Design and assessment of options

In this phase, the urban planners, water experts and other stakeholders within the partnership (e.g. LAA) start a collective creative design and innovation process. Together they look for synergetic options, which provide benefits to the city in as many ways as possible. At this point in the process, any creative idea is allowed - even a shift of the urban development site is possible, as FRM measures should not necessarily be implemented where flood problems occur. MARE 1 describes available methods to make this step as productive as possible: learning from best-practice examples of FRMP measures (step 4) and exploiting synergies through an interdisciplinary creative workshop (step5)

4. Decision making and implementation

The decision on the best option, or set of options, should be taken in an interdisciplinary forum. This decision making process may be supported by a range of tools, such as cost-effectiveness analysis or cost benefit analysis.

The urban planning process and the FRM planning process have some overlapping and some different ways of implementing measures. In this respect, effective coordination and alignment of the implementation phases is of key importance.

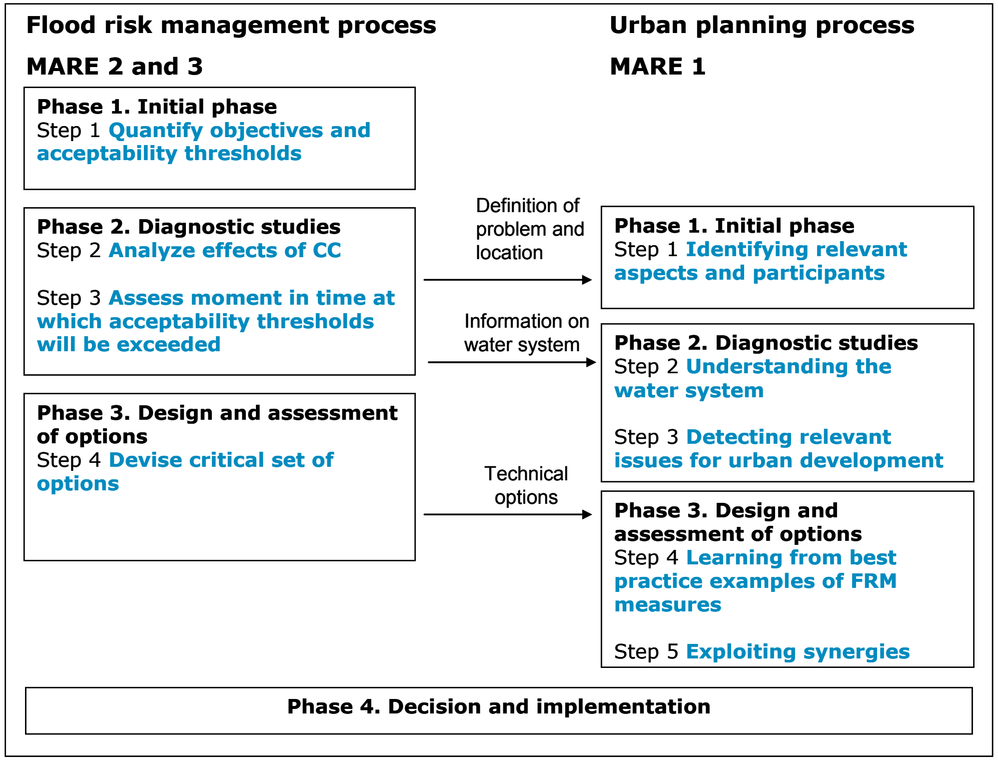

Figure 3.2. Relations between the FRM planning process and the urban planning process. Note that the phases of the FRM process are similar to the phases given in Fig. 3.1. Each phase includes one of more steps from the Climate-proofing toolbox and guidance, as explained in Chapter 4.

4 MARE Toolbox and guidance for climate-proofing

4.1 Overview of toolbox and guidance

The MARE project provides a toolbox and guidance for the development and implementation of climate-proof FRMPs, which aims to support the FRM planning process. Considering the effectiveness of FRM options and plans on a larger time frame and taking the possible effects of climate change into account will assist in developing a sound FRMP. The flooding issues are set as a first priority by the MARE toolbox and guidance, but policy aspects as well as the need to integrate plans into day-to-day benefits, are also taken into account through linking FRM planning and urban planning.

This chapter provides a theoretical background to and an overview of the proposed climate proofing process. In the accompanying technical reports, step-by-step guidelines are presented for implementation of this theoretical background. The guidelines thus provide a translation of the theory into practice.

4.2 MARE1: Methods to improve inter- and transdisciplinary planning processes

4.2.1 Water and urban development

Flood protection is one of many aspects of a city's development. The way in which the city is being developed has effects on the water system; on the other hand, interventions and alterations in existing water systems have influence on the urban system in either a positive or negative way. In recent years, approaches utilising the necessary changes for addressing water problems to provide wider benefits for the city, like WSUD, have been developed in different countries. These are dealing with different water problems, ranging from storm water drainage to flood protection along rivers or coastlines. MARE 1 aims to tie in with these experiences, not by making new technical guidelines or by demonstrating ideas on how to combine FRM with spatial quality, but by providing a way forward for the integration of these experiences (as well as existing knowledge) in the planning process of a city.

In this report this is called the "Integrated Design Approach". Water and FRM should contribute to improving the spatial quality, and hence the living quality, of the whole urban environment. Therefore, it is important to manage the specific functional needs with social, economic, ecological, cultural and aesthetic challenges in a synergistic way and include the interactions and relationships within the entire water cycle, like urban drainage, natural water bodies and flooding from rivers or coasts.

4.2.2 Interdisciplinary working process

The quality of integrated design primarily depends on the local stakeholders and organisations involved in the planning process. The task is interdisciplinary and complex – as is the planning process to manage this task. To realize this objective in practice requires an intensive interdisciplinary working process from an early stage of planning, innovative ideas, as well as assessment tools and methods to align and combine the various ideas in order to best achieve synergistic effects.

MARE 1 considers tools to improve the complex planning process, and in particular for ways to arrive at a well-structured and creative process. Here, various aspects influence the final result: Who participates in the project? Who is leading the process? Which information about the water system and the city is communicated and how? How can synergies be found?

4.2.3 MARE1 Step-by-Step

MARE 1 provides a method and techniques to come to an integrated planning approach, in which synergistic opportunities between measures to manage flood risk and benefits for daily life can be identified and creative solutions can be found. The following presents a step-by-step method, which provides the stages of a general planning process together with the possibilities to work effectively and creatively in this complex interdisciplinary process. The method is based on a guideline to organise planning processes around river basin management: 'Learning together to manage together'. The guideline was written to support the realisation of the EU-Water Framework Directive. Furthermore, it incorporates elements from a professionally organised, inventive and well-documented planning workshop: Rotterdam Waterstad 2035'.

MARE1 provides five steps to improve an integrated planning process:

Step 1: Identifying relevant aspects and participants

This is an iterative process which identifies the relevant issues and who is responsible for managing them. In addition, the process should identify how the project should be managed through differentiation and integration of tasks and how leadership should be addressed.

Step 2: Understanding the water system

Water management experts provide the interdisciplinary working group with detailed background information on the water system as well as water problems and possible solutions. It is important that information be presented in a way that the non-specialists achieve an appropriate level of understanding; for example by using visual presentations and explaining technical terms.

Step 3: Defining urban problems and potential

The next step is to understand how the city or region and the water system are linked together and which are the main issues and objectives of the specific urban development. Climate change is only one important driver regarding future changes. It is important to define the water issues alongside those associated with the social, ecological, cultural and economic aspects of a city and then to set the strategic aims and objectives for the development.

The technical knowledge about design standards and exceedance events from MARE2 and MARE3 will contribute to the enactment of steps 2 and 3.

Step 4: Learning from Best- Practice Examples

The inter- and transdisciplinary expert knowledge within the project team, supplemented by references and examples from the collective experience of the different disciplines will contribute to the development of an overview of the state-of-the-art solutions across different domains. These can be technical or design examples as well as guides for integrated approaches satisfying all the defined needs. Inputs may serve as a source of inspiration to initiate creative ideas or help to communicate ideas within the project team.

Step 5: Exploiting synergies (within the development of options)

Looking for synergies between FRMP and spatial quality of the city is a creative process. Therefore it is important to involve all actors like e.g. politicians, water experts, urban designers and citizens in this process.

MARE2 and MARE 3 also contribute to this step. Experts must help in decision-making by providing information to quantify the costs, benefits and any impacts of the different options.

4.3 MARE2: methods to attain flood protection standards

MARE2 primarily concerns the technical aspects of the flooding or urban drainage system; although non-structural measures may also be used where appropriate. It focuses on the performance of the hard and soft infrastructure provided to deal with sea level rise, river discharge and rainfall variability. This is expected to be adequate to comply with current policy objectives; performing to acceptable protection levels which will probably change over the life of any measures designed now.

Climate change and urban development increase the impacts on the flooding risk management system, such that the system performance progressively deteriorates over time. This means that there is a constant need to adapt flood related infrastructure to comply with the protection standards imposed by society. Alternatively, where this is acceptable or too costly, the acceptable protection level may be allowed to be lowered. Under the MARE2 framework, the protection level is expected to keep pace with the external change drivers and to be resilient to uncertain future scenarios.

4.3.1 Predict-then-act versus assess-risk-of-policy approach

There are two kinds of approaches that are suggested for assessing adaptation options to external change drivers; the Predict-then-act and Assess-risk-of-policy framework (Figure 4.1). These terms mainly emphasize the direction in which the cause and effect chain (e.g. from pressure to state to impact) is followed in the reasoning (Dessai and Van der Sluijs, 2007).

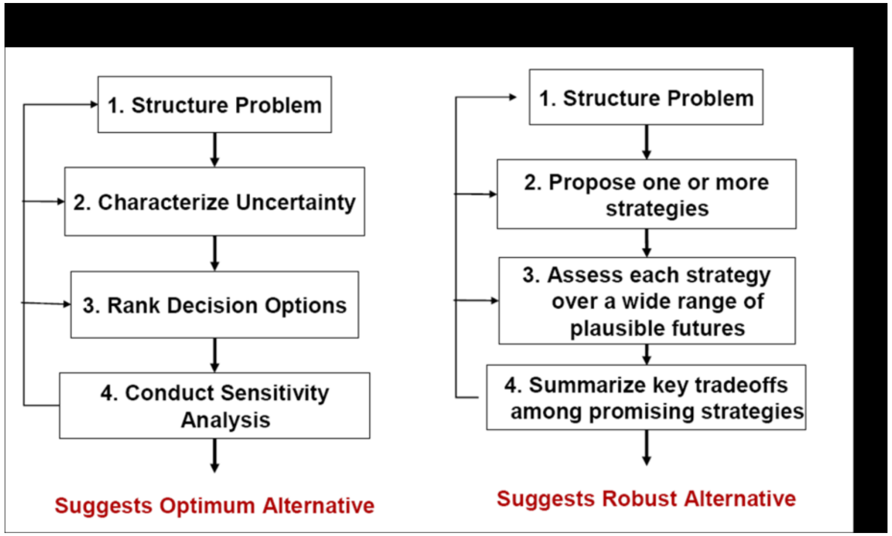

Figure 4.1. Alternative approaches for uncertainty management (Hulme, 2008) as given in European Commission (2009).

The predict-then-act approach is most widely used in practice. For instance, conventional Net Present Value analysis uses this approach to assess the likely impacts of climate change and to develop investment strategies based on the impacts. The main limitation of conventional Net Present Value analysis using the predict-then-act approach is the reliance on best estimate climate scenarios, which are expected to be precise forecasts of future climate change. However, such forecasts cannot likely be produced by climate modelling (Dessai et al., 2008).

Other approaches align with the bottom-up framework, and they can be carried out more independently of climate change scenarios. For example, Kwadijk et al. (2010) have recently developed an approach to assess whether, and for how long, the current flood risk management strategy or incremental, adaptive strategies will continue to be effective under different climate change conditions. This uses the concept of Adaptation Tipping Points (ATPs). An ATP is reached when the magnitude of climate change is such that current policy objectives can no longer be obtained (Kwadijk et al, 2010). The ATP approach does not rely on precise projections of future climate change to develop the adaptation strategy. Rather, it requires a range of plausible climate change scenarios that can be used to assess the durability of the current flood risk management strategy and incremental, adaptive strategies. Hence, this approach overcomes the main limitation of the predict-then-act approach, and this is the reason why the MARE2 method follows the ATP approach.

4.3.2 MARE2 step-by-step

Step 1: Quantify objectives and acceptability thresholds

Start by specifying which urban flood protection systems are subject to assessment and the climate change effects of interest for the assessment (e.g. increasing rainfall intensity or an expected increase in river water levels). This threshold can be defined according to current policy (e.g. set regulations by national law), decided by the stakeholders involved, or be based on an economic optimum of the costs and benefits involved.

Step 2: Analyze effects of increasing pressures

The next step is to identify the ATPs by increasing the design loading (e.g., the rainfall intensity) on the system, as a function of time, to assess the specific boundary conditions under which acceptable standards may be compromised. For this purpose, hydrological and hydraulic simulation can be used to determine the sensitivity of the performance of the current system to possible future design loadings. The results of the assessment are then represented in a bar chart, indicating the occurrence of ATPs.

Step 3: Assess moment in time at which acceptability thresholds will be exceeded

An estimate of when the boundary conditions are likely to be reached is then provided by using available climate change scenario information. The output from this step will indicate the earliest and latest times that the performance of the existing system is likely to no longer be sufficient. The outcome of the window in time could be revised in future as understanding of the climate change processes improve over time. An example of an assessment of the flood risk management system in the city of Dordrecht, The Netherlands, is shown in Figure 4.2.

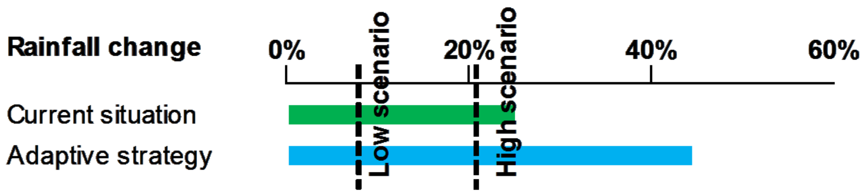

Figure 4.2. Assessment of the critical boundary conditions where the flood risk management strategy can no longer provide the required performance (Gersonius et al, 2012).

Step 4: Assess potential set of options

An alternative adaptive strategy is necessary when the ATP is reached in the short term or if the adaptation strategy requires a long time to implement. This strategy needs to be defined as early as possible and well before the critical ATP occurs. Implementing a strategy will alter the nature and timing of the critical ATPs.

Alternative strategies are then analysed by repeating step 3 and 4. This will result in the definition of a number of most effective adaptive strategies, some structural and some non-structural. Engagement with all stakeholders is required in this step to select an adaptive strategy that is both realistic and acceptable.

4.4 MARE3: preparing for extreme events incorporating changing climate conditions.

The MARE3 method is based on theories on resilience and flood management (De Bruijn, 2005). A central element of the method is the reaction curve which shows the change in impact of an urban area in relation to an increasing flood intensity. The flood intensity is a measure for the magnitude of the flood, e.g. expressed as the rainfall duration or flood discharge. The impact on the urban system is often expressed through damages, casualties or even social disruption. An example of a reaction curve is given in Figure 4.3.

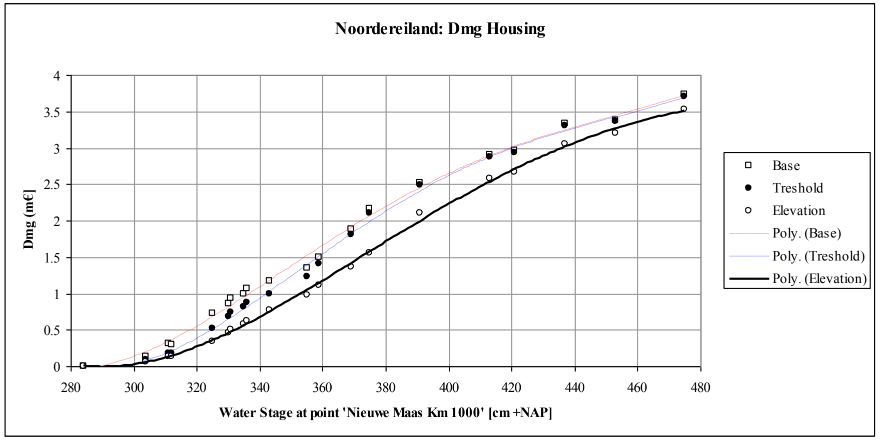

Figure 4.3. Expected damages to housing and interior for the neighbourhoods Noordereiland and Feijenoord in Rotterdam associated with the observed water stages in the Meuse River (Exercise executed within the context of the Knowledge for Climate project HSRR 3.1)

The MARE3 method is similar to the adaptation tipping point approach applied in MARE2, with the difference that there are often undefined objectives and threshold values for the impacts of a flood. Examples of such objectives could be a maximum accepted damage or number of casualties, a maximum overall flood risk or even a maximum acceptable social disruption. Setting objectives and thresholds is therefore included within the method.

4.4.1 Why consider other than flood protection measures?

From history it is seen that absolute protection against flooding is impossible. Even with a high standard of flood protection in place, there will always remain a residual flood risk. Therefore more attention is now being given to responses aimed at reducing flood impacts. These responses range from spatial zoning, through building regulations to responses such as event management and early warning and can be applied stand-alone or in combination with protection measures. Examples of possible situations where other than flood protection responses are applied are:

- A situation which does not allow for flood protection responses or where enhancing existing flood protection structures is not possible e.g. too costly, no space, technically not achievable;

- When significant risk reduction through responses other then protection against flooding can be achieved either instead of, or in addition to flood protection responses;
- A situation where preparations are made for a flood event if protection responses were to fail, following the principle that a 100% flood protection cannot be guaranteed.

4.4.2 MARE3 step-by-step

Step 1: Quantify objectives and acceptability thresholds

Comparable to the protection levels for the urban drainage infrastructure, it is recommended to set an attainable standard or threshold as an objective for exceedance events. The ultimate objective would be to reduce damages and casualties to nil under all circumstances. For most situations this will not be feasible e.g. because unexpected or very low probability floods could still occur and because the costs of implementing measures to reach these standards are too high.

Often standards are only defined for the drainage infrastructure while setting a standard for exceedance events will aid in setting goals and layout plans for an area. In addition this provides the possibility to assess the urban impacts for current as well as future climate conditions according to the standard. The process of developing a standard will result in discussion on acceptability of flooding impacts and choices of threshold values.

Step 2: Analyze effects of increasing pressures

Through impact analysis, such as the calculation of damages or casualties for different flood events, a reaction curve is developed. As a result of climate change the return period for a specific event is expected to shift. The reaction curve therefore gives insight into the consequence of this possible future shift.

Step 3: Assess moment in time at which the system acceptability thresholds will be exceeded.

With use of available climate scenario information, an estimate is made of when in time the threshold is likely to be reached. As for step 3 for MARE2, this results in an earliest and latest time where flood impact on the urban area is likely to exceed the objectives set for the area.

Alternative strategies are then developed and analysed by repeating step 3 and 4. This will result in the definition of a number of most effective adaptive strategies. An example of applying the tipping point method to exceedance events is illustrated in Figure 4.4.

Step 4: Assess potential set of options

The final step is to define alternative adaptive strategies to be able to cope with the changing climate conditions if the threshold is expected to soon be exceeded in time or if changing to an alternative adaptation strategy is foreseen to be a lengthy process.

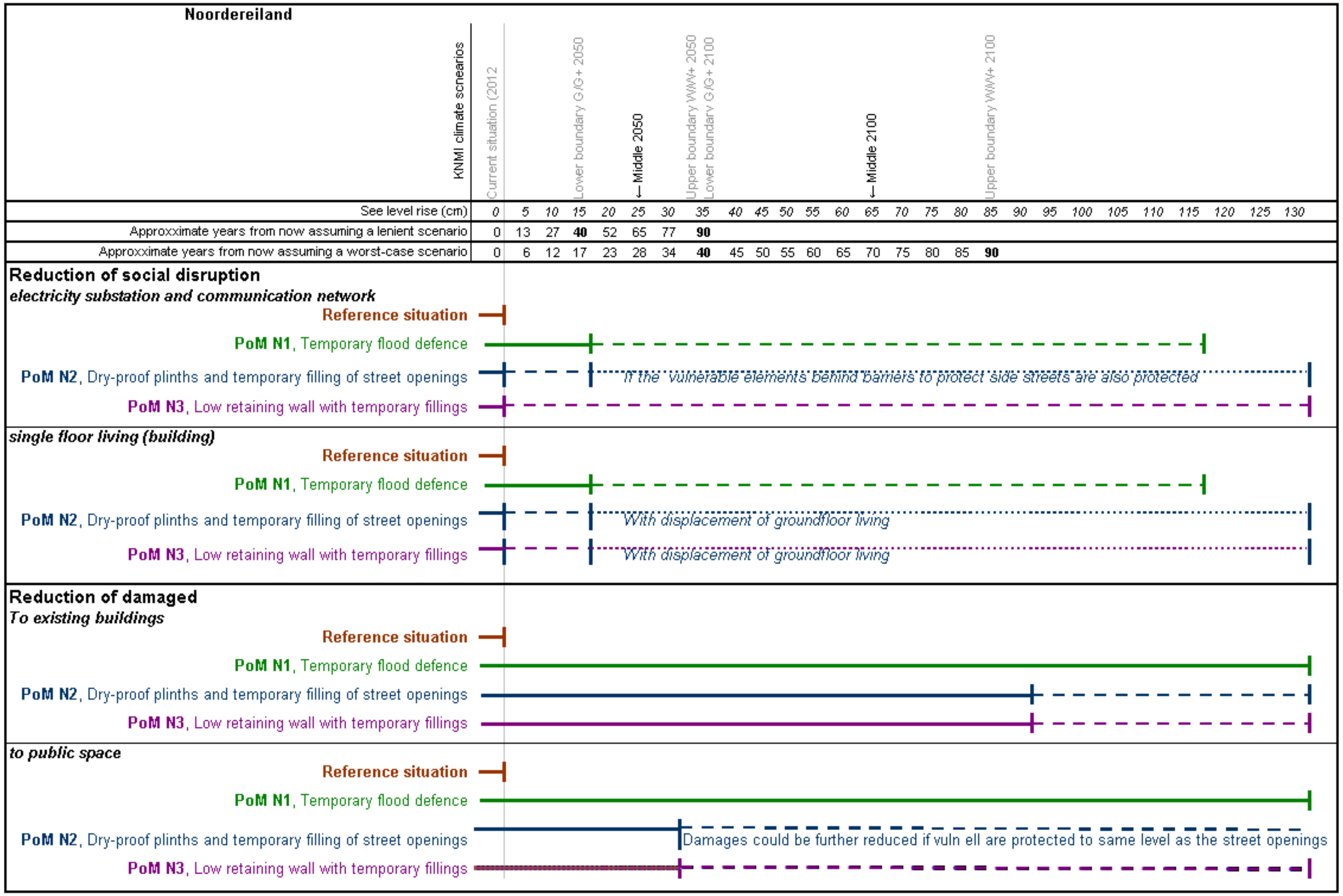

Figure 4.4. Overview of the effectiveness of the Portfolio of Measures (PoM's) for Noordereiland in regard to the objectives. The dashed lines illustrate the effectiveness of the PoM's if the maximum variant for the measures is implemented (Stone, 2012).

5 Linking MARE 2 and 3 together

5.1 Positioning MARE 2 and 3 in the FRM planning process

MARE 2 and MARE 3 have been designed to fill gaps relating to the analysis and assessment of climate change aspects in existing approaches to FRM as described in EN 752 and in the strategy for managing flood risk described in Figure 3.1. Consideration should be given to MARE 2 and MARE 3 during initial planning, diagnostic studies and the development and assessment of options. There is also a need for a feedback loop to enable the achievement of a balance between MARE 2 and MARE 3 in the development of options.

In the initial planning stage it will be necessary to achieve a consensus between all stakeholders involved in the partnership (e.g. about the objectives and acceptability thresholds for probabilities of flooding for both MARE 2 and MARE 3 so that the work may be properly scoped.

In diagnostic studies, additional simulations will be necessary to create a matrix within which the probabilities of future rainfall and flood events for different climate change scenarios will lie.

In the analysis and assessment of options, this matrix will be used to quantify the costs and benefits of providing flood protection or relying on the management of exceedance events. Here a feedback loop will permit the assessment of different objectives and acceptability standards and will involve further interactions with stakeholders to ensure that variations are not considered excessive.

The process is illustrated in Figure 5.1.

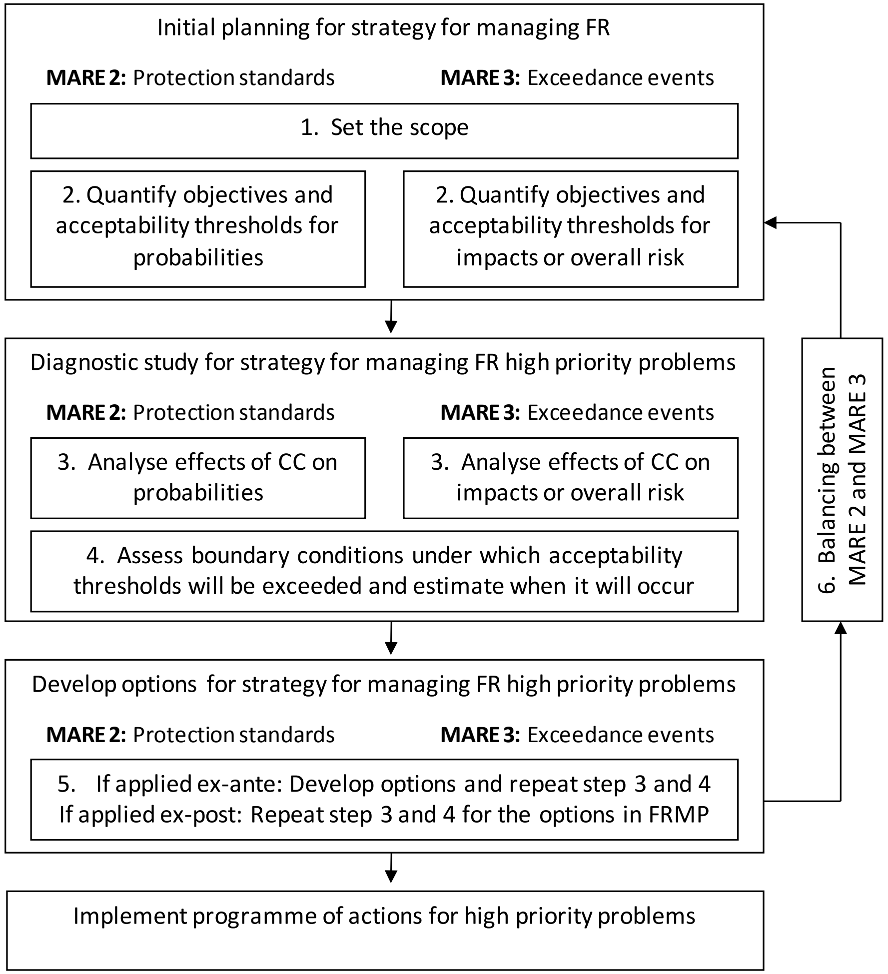

Figure 5.1. The position of MARE 2 and MARE 3 within the process for developing a strategy for managing flood risk

5.2 Balancing between MARE 2 and MARE 3

Flood risk depends on the performance of the drainage infrastructure, urban surface and preparedness measures. This is expected to be adequate to comply with current policy objectives; performing to acceptable standards. Figure 5.2 shows how the drainage infrastructure, urban surface and preparedness measures work together to provide an expected level of performance to manage flood risk. This shows the performance of the drainage infrastructure and urban surface is decreasing with time due to deterioration (among other factors). In addition, climate change and urban development will increase the probability and magnitude of flooding, leading to an increase in the performance that is required just as the actual performance deteriorates.

The solid lines in Fig. 5.2 are shown to decrease with time as lower acceptable standards are tolerated. In practice, however, the adaptation process will be iterative and the solid lines will exhibit a sawtooth pattern; with enhancements in performance periodically. This is the managed/adaptive approach recommended in Defra (Defra, 2006) and also in the accompanying technical report on "MARE2: Methods to attain flood protection standards".

In relation to the diagram in Fig. 5.2, the question can be posed whether to invest in the reduction of flood probability or instead in the reduction of flood impact? The answer to this question depends on the nature and impact of flooding, the local attitude and policy towards flood risk and the relationships between the stakeholders. This will require the identification of some 'optimal' (or: preferred) set of options. Here, optimal could mean 'for the lowest costs', 'with the highest risk reducing effects', 'best suited and fit for the local situation' etc. The following step is thus about optimising and about weighing between options and about finding synergetic benefits in correspondence with MARE 1, (step 5: exploiting synergies within the development of options) Here aspects given in MARE 1 should be taken into account as well as available budgets and local preferences.

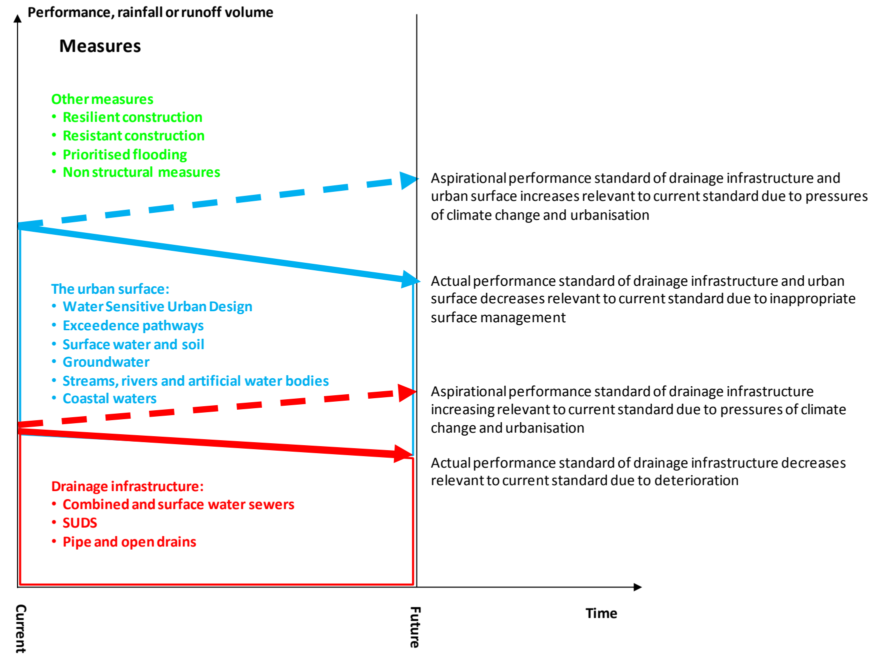

Figure 5.2. Performance of the drainage infrastructure, urban surface and preparedness measures – showing examples of approaches.

In addition to the steps for MARE 2 and 3, an additional step is therefore required to bring the potential options identified within MARE 2 and 3 together into an overall set of options which is then established within the FRMP.

The following methods can assist in identifying the 'optimal' (or: preferred) set of options:

- (Social) Cost Benefit Analysis: integrated weighing of all costs and benefits, preferably expressed monetary. Social costs and benefits, e.g. spatial quality, improved transportation modes, can also be taken into account

- Cost Effectiveness Analysis: tackling the problem from an angle of keeping the costs as low as possible while gaining the highest risk reduction, although in practice also non-financial effects are taken into account.

- Multi Criteria Analysis: often qualitative expert judgment on pre-defined criteria. Weighting of criteria can be incorporated into the method.

These methods are not described here; refer to WMO (2007) for details and see MARE 1 (technical report).

6 Conclusions and recommendations

6.1 Conclusions and key messages

It will be necessary to learn to live with flooding better than communities have done in the recent past. This also applies to engineers, planners, urban designers and other built environment professionals. It is no longer possible (affordable or sensible) to try to 'build our way out of trouble'.

The concept of adapting urban areas to cope with changing climate and other developments is relatively new and many professionals and others, including decision makers need assistance to understand and operationalize the concepts. The CPT can help all of those involved to understand the concept of, approach to be used, and opportunities from taking a managed adaptive approach to coping with changing flood risk in urban areas. The 3 points approach helps also to break down the analysis and composition of responses into manageable and easily explainable elements that can also be understood by communities. The easiest way to climate proof urban areas and communities is to identify measures that

It is no longer sensible, efficient or effective to separate 'engineering' solutions from planning or urban design measures that are routinely applied in urban areas. For the required approaches to be effective, a new paradigm of professional/community/policy/decision maker cooperation and shared visions is needed. Learning and Action Alliances are one way of ensuring frank, open and honest cooperation that can deliver innovative approaches that provide not only solutions to problems, but also new opportunities to enhance urban environments.

6.1.1 Key messages

The key messages from the application of the CPT in the MARE cities reflected within the LAA's are summarised below.

Engineering and engineers

- There is continuing trust in engineering solutions by both the public and many professionals (MARE2) – but what if exceedance does happen (MARE3)? Traditional practice focuses (only) on MARE2 using performance standards (e.g. 1 in 100 years, EN752 etc.), with very little attention to MARE3 considering what needs to be in place for when performance standards are exceeded. Emergency procedures, plans, warnings and measures need to be planned to respond if/when an event occurs (MARE3). MARE has highlighted the need for this to be done rationally and as part of a concerted 3 points approach.

- The advantage of ATP analysis (MARE2) is that it can be carried out using rough data/models and therefore there can be utilised even where more precise information/models may be later required for the final detailed analysis.

- The CPT helps deal with the fear of uncertainty and a reluctance by decision makers to decide what to do, making uncertainty less inhibiting by providing the means to take multi-value opportunities and no-regret measures (MARE1).

- There is no panacea or general solution that can be identified to deal with flood risk and changes therein due to climate, for every city or circumstance. Specific and individual responses/solutions must be found for every city if the unique opportunities in MARE1, 2 and 3 are to be realised in a multi-functional and multi-value way. Thus delivering best value for society and outcomes that support sustainable living.

- The acceptable flooding system performance standards for FRM (MARE2) are locally specific, despite being based on defined national and international standards and will change over time due to expectations and affordability. The local standards will have to be defined and refined continuously in decisions made by and with stakeholders.

- Assessing the effects of climate change on exceedance events (MARE3) and how best to deal with these requires that objectives on flood impacts are clearly defined (above) to be able to decide on how the flood impacts that will happen can best be handled.

Economics

- Missed opportunities for additional or alternative sources of funding to deal with climate change and FRM can in part be caused by a failure to include the potential for multi-benefit solutions outlined in MARE1 (i.e. beyond the single goal of managing flood risk, accruing additional benefits) but also possible in MARE2 and MARE3:

    - Without MARE1: benefits = Net Present Value of reducing flooding impacts

    - With MARE1: benefits = Net Present Value of {reducing flooding impacts + value of green infrastructure + value of ecosystem services + value of recreational use + value of…}

- Linking the FRM and urban design process at an early stage (MARE1), provides the means to take advantage of opportunities and add value.

- It is often difficult to decide when, where and whether it is best to invest in, or balance, between MARE2 or 3. However, investment in MARE1 is always a good idea and can often be done at no or limited cost, as no-regret measure or in conjunction with MARE2/3.

Institutions and integration

- FRMP in cities in times of climate change is very complex. 'Solutions' cannot be devised by one single discipline in isolation as when performance is exceeded (MARE2) the challenge moves from being a drainage engineering issue into the land use and urban design domain (MARE1 and MARE3). In all aspects, FRMP needs to be properly embedded in land use and urban planning and hence not seen only as an engineering issue. The cooperation of experts across various disciplines is therefore absolutely essential.

- Urban planners often know how to deal with exceedance flows using e.g. blue-green corridors, but rarely do they know that planning for such flows is essential as all designed flood risk management assets will fail at some time, nor that they are resourced to deal with it (when performance is exceeded, MARE3); as they do not believe that planners are responsible ('this is the engineer's job' MARE2) – this is a consequence of working in separate and poorly integrated divisions.

- The emphasis on sectoral goals within disparate institutional divisions leads to sub optimization (every member thinks they have the most important job in the organization). There is a need for common and aligned goals between the different departments, divisions and also institutions involved both within (intra) and between (inter) organisations (MARE1,2,3).

- A major challenge is to find the appropriate balance between developing the required transdisciplinary corporate vision within an organisation and in the arrangements for FRM and at the same time ensuring that FRMP arrangements are sufficiently flexible and adaptable to respond to an uncertain future (as it unfolds) – this requires flexible organisations.

- There is a need for common and aligned goals (shared visions) to be shared by those working within an organisation and ideally between organisations in relation to not only FRMP but also how water can and should be utilised within urban areas for multi-beneficial purposes (MARE1,2).

- There is a need for a 'common language' within an organisation (and beyond) and for communication systems that support integrated approaches to flood, water and urban system management (MARE1)

Capacity building

- As the approaches required to address the current and future challenges of FRMP are novel and innovatory, capacity needs to be built in all stakeholders to equip them to take an appropriate role and approach.

- Currently water system managers can only ask (need to be more seductive) for assistance from other professionals regarding FRM. There needs to be greater understanding of the need for all stakeholders to work better together within the built environment community; i.e. without the need to demand cross-disciplinary assistance (from other professionals) – MARE1,2,3.

- The current lack of functional transdisciplinarity which creates a problem of differentiation and lack of integration, requires a cultural shift which needs to begin with the way in which professionals see themselves (and how others also see them), are educated and resourced that creates a more collaborative and partnering culture – MARE1,2,3

- The increasing lack of certainty/stationarity means that the past is no longer a reliable predictor of the future (MARE2). Organisations with a 'stationarity' culture have problems with 'lock-in' to tried and tested, 'we have always done it this way and we know it works' attitude that is no longer affordable or reliable. This needs to be recognised and rectified.

- The practicality of developing and implementing flexible adaptable responses to a changing climate is often constrained at local level by a lack of capacity/experience – despite rhetoric at a Governmental level that recognises the problems and develops strategies and guidance to respond. There needs to be both a top-down and bottom-up convergence in approach, culture and understanding so that all share a common vision, understanding and collective way forward.

- There is a need to nurture integrated approaches (MARE1,2,3) to FRMP in organisations by developing a supportive management environment that removes barriers and disincentives between and to collaborative working.

- There is a pressing need for academics and experts to provide guidance to support practitioners to function in the new ways required for effective FRMP in a simple and understandable way

- There is an increasing need to engage, inform and involve the public and affected parties as stakeholders throughout every stage of FRMP.

- Cities learn from cities – there has been tremendous value from pilot projects and learning from each other in MARE across the LAAs and more such activities need to be encouraged and supported.

- Partners working together in Learning and Action Alliances (LAAs) appreciated the LAAs as a useful vehicle in order to deal with the complex planning tasks and create the innovation required for FRM under a changing climate.

6.1.2 Added value of applying CPT

The added value of applying the CPT can be summarised as follows:

- Draws attention to the need to bring the 3 dimensions of FRM together (MARE1/2/3).

- Supports what organisations already have to do as part of day-to-day tasks, and also builds on and helps to formalise common practice (not anything new) ==> bringing existing components together

- Helps to reduce the significance and inhibiting spectre of uncertainty for decision makers by bringing together multidisciplinary, multi-beneficial risk management measures, which build in system capacity at little extra cost:
  - Build in factors of safety at little extra cost (MARE1)
  - Build in amenity under normal operation (MARE1)
  - Understand the current and future boundaries between normal and exceedance operation (MARE2)
  - Build in capacity to deal with residual risk under exceedance operation (MARE 3)

- Higher benefits to costs accrue when MARE1, 2 and 3 are taken together compared with the traditional way of dealing with MARE2 in isolation.

  Although there is and always will be uncertainty, policy makers can still make decisions under uncertainty using the CPT, because it helps to provide insight into the robustness and adaptive potential (i.e. effectiveness of responses) of the systems being managed within cities. This will result in better/more informed and more timely decisions being made.

- By working together in a transdisciplinary way, professionals and decision makers can develop a ‘shared ownership’ of the planning, design and innovation process, i.e. the outcomes are more legitimate across a wider range of participants and for FRMP within and synergistically together with urban planning as a whole

- The new approaches both support collaborative working and vice versa, require collaborative working to be effective, efficient and affordable

- Working together better can also increase public support for plans/solutions and opportunities to be taken up.

6.1.3 Barriers to applying CPT

A number of barriers were uncovered that hinder the effective application of the CPT, and these can be summarised as follows:

- Key organisations an individuals are so hard-pressed in terms of time and other resources that they don't have the financial/time resources to change what they do or to innovate, resulting in utilisation of inefficient and no longer valid ‘we have always done it this way solutions that fail to maximise opportunities.

- Continuity of practice and the evolution of innovation cultures within organisations is very dependent on key personnel and when these leave, the entire process can be compromised.

- Organisational receptivity: CPT can be perceived to be too complex or organisations may lack expertise to understand its added value. This requires an appropriate environment (organisations, individuals, context) and capacity within an organisation.

- A degree of competence/expertise/capacity is needed within organisations and/or external consultants to apply the CPT. Where the work is contracted out, clients need to be intelligent enough to assess the validity of the work done on their behalf.

- Too often, national government or regulations prescribe which analysis methods to use, rather than the required outcomes. This constrains local thinking and beneficial opportunities as well as innovation.

- Organisational receptivity to the use of the CPT: particularly when an organisation has to undertake flood risk analysis for legal reasons or regulatory compliance, then they can utilise the CPT. Organisations need a reason to utilise it, such as when starting a modelling study.

- In many countries/jurisdictions there may be confused ownership of a FRMP problem and unclear responsibilities can hamper implementation especially of innovative approaches such as the CPT.

- Often the ‘owner’ of a FRM problem is not the beneficiary of any solutions nor of any multi-value benefits. Therefore allocating funding is difficult as there are unclear supporting benefit–cost ratios. Cross-stakeholder funding arrangements that recognise this are often not in place and therefore can inhibit schemes that may provide the greatest benefits.

- There is frequently a historical and misplaced trust in engineering infrastructural responses (MARE2): as a result, there may be no planning for exceedance and no/less use of MARE1 and a failure to use non-structural measures.

- If an organisation is not open to multi-value opportunities, then ATPs are not that relevant (because of a lack of interest in bringing interventions and intervention timings together). This suggests a need to start from the point of view that MARE1 (spatial planning) encompasses MARE2 and MARE3 and is therefore the starting point for the FRMP analysis.

6.2 Recommendations

- Need to address opportunities rather than problems. This should be aimed at maximising multi-values, multi-functional land use and multiple benefits.

- Need to plan for system failure: i.e. to understand consequences of choices for risk management measures and act on it

- Need to create a robust framework that outlines the objectives on flood risk management, balancing and bringing all three dimensions of FRM together, and defines a strategy with a set of measures that is adaptable over time.

- Need to try and do things differently (i.e. innovation). This is about being adaptable and, when there is uncertainty, doing a little now and a bit more later in an adaptive process, rather than doing a big step now. In this respect, it is crucially important that government arrangements and institutional structures support innovation

- Need for more demo projects in order to gain more experience with the CPT

- Need to build up multi-disciplinary teams, accompanied by capacity building within disciplines. This can be done by working together in LAAs or something equivalent. Also there is a need to provide further guidance on how to organise this.

- Need to start a dialogue with politicians on informing the objectives for climate proofing process. As an example, politicians will demand a 1 in X year flood protection, but do not specify whether that is for today, 2020, 2050 and 2100

- Need for guidance on the planning and implementation process (e.g. monitoring and updating of plans)

7 References

ASHLEY, R., BLANSKBY, J., NEWMAN, R., GERSONIUS, B., POOLE, A., LINDLEY, G., SMITH, S., OGDEN, S. & NOWELL, R. 2011. Learning and Action Alliances to build capacity for flood resilience. *Journal of Flood Risk Management*, 5, 14-22.

ASHLEY, R.M. & BROWN, R. (2009) Entrapped in common sense: why water management by current regimes is not sustainable and what we can do about it. Working Group 8: Water - 9th NESS: Knowledge, learning and action for sustainability, 10th-12th June 2009, London

ASHLEY R., GERSONIUS B., BLANKSBY B., STAM J-M, DONCASTER S. (2013). Water sensitive urban design for the flood resilient city. Movatech conference Lyon, June.

BATES, B. (2008) IPCC Technical Paper on Climate Change and Water. Cambridge, United Kingdom and New York: IPCC. Cambridge University Press.

BROWN, R. (2007) The importance of water infrastructure and the environment. Chapter 1 in: V. Novotny and P. Brown. Cities of the future: towards integrated sustainable water and landscape management. ISBN 1843391368, IWA Publishing, London, UK, p2-7.

BRUIJN, K.M. (2005) Resilience and flood risk management. A systems approach applied to lowland rivers; Delft University Press, ISBN 90-407-2599-3

DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS. (2006) Flood and Coastal Defence Appraisal Guidance FCDPAG3 Economic Appraisal. Supplementary Note to Operating Authorities - Climate Change Impacts.

DESSAI, S., HULME, M., LEMPERT, R. & PIELKE JR, R. (2008) Climate prediction: a limit to adaptation. Living with climate change: are there limits to adaptation, 49-57.

DESSAI, S. & VAN DER SLUIJS, J. (2007) Uncertainty and climate change adaptation: a scoping study. Report NWS-E, 1-95.

DUDLEY, E., ASHLEY, R. & BLANKSBY, J. (2012) MARE WP1 Final Report Establishing LAAs and managing individual needs.

DUDLEY, E., WALKER L., ASHLEY R.M. (2012a) Socio-psychological behavioural aspects of learning and action alliances for water management and adapting to flood risk Proc. 7th Int. Conf. on Water Sensitive Urban Design. Melbourne. 21-23 Feb 2012

EN 752 (2008) Drain and sewer systems outside buildings, European committee for standardisation, Brussels, Belgium

EUROPEAN COMMISSION (2007) Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks. Official Journal of the European Communities, L, 288, 2007.

EUROPEAN COMMISSION (2009) White Paper on Adapting to climate change: Towards a European framework for action.

EVANS, E. P., ASHLEY, R., HALL, J. W., PENNING-ROWSELL, E. C., SAUL, A., SAYERS, P. B., THORNE, C. R. & WATKINSON, A. (2004) Foresight Flood and Coastal Defence Project: Scientific Summary: Volume I, Future Risks and Their Drivers. *London: Office of Science and Technology*.

FEYEN, L., DANKERS, R., BÓDIS, K., SALAMON, P. & BARREDO, J.I. (2009) Climate warming and future flood risk in Europe, submitted to Climatic Change.

FRATINI C., GELDOF G., CLUCK J., MIKKELSEN P. (2012). Three points approach (3PA) for urban flood risk management: A tool to support climate change adaptation through transdisciplinarity and multifunctionality. Urban Water journal, Vol. 9 No. 5. 317-331

GELDOF, G. (2007) The Three Points Approach. South Pacific Stormwater Conference.

GEMEENTE ROTTERDAM, WATESCHAP HOLLANDSE DELTA, HOOGHEEMRAADSCHAP VAN SCHIELAND EN DE KRIMPENERWEAARD (2005): Rotterdam Waterstad 2035 - International Architectuur Biennale Rotterdam, Rotterdam, ISBN 9059730240

GERSONIUS, B., NASRUDDIN, F., ASHLEY, R., JEUKEN, A., PATHIRANA, A. & ZEVENBERGEN, C. (2012) Developing the evidence base for mainstreaming adaptation of stormwater systems to climate change. *Water Research*.

ISO 31000 (2009), Risk management – Principles and guidelines, International Standards Organisation, Geneva,Switzerland.

Jeuken, A., Mens, M., ter Maat, J. & Klijn, F. (2009) Klimaatbestendige inrichting van Nederland: Opgave voor de Rijksoverheid?

JEUKEN, A. & TE LINDE, A. (2011) Applying tipping points and adaptation pathways. Werken met knikpunten en adaptatiepaden. (In Dutch). Available at: kennisonline.deltares.nl

KABAT, P., VAN VIERSSEN, W., VERAART, J., VELLINGA, P. & AERTS, J. (2005) Climate proofing the Netherlands. Nature, 438, 283-284.

KWADIJK, J. C. J., HAASNOOT, M., MULDER, J. P. M., HOOGVLIET, M., JEUKEN, A., VAN DER KROGT, R. A. A., VAN OOSTROM, N. G. C., SCHELFHOUT, H. A., VAN VELZEN, E. H. & VAN WAVEREN, H. (2010) Using adaptation tipping points to prepare for climate change and sea level rise: a case study in the Netherlands. *Wiley Interdisciplinary Reviews: Climate Change,* 1**,** 729-740.

PASCHE E., ASHLEY R M., LAWSON N., SCHERTZER D. (2008). Effectiveness and Efficiency of Non-structural Flood Risk Management Measures. CRUE Research Report No I-4: Risk Assessment and Risk Management in Small Urban Catchments. CRUE Funding Initiative on Flood Risk Management Research. Contract number: ERAC-CT-2004-515742

STERN, N. (2007) *The economics of climate change: the Stern review*, Cambridge University Press.

STONE, K. (2012) Exploring adaptation pathways; Knowledge for Climate project KvK 3.1; KvK report.

UNIVERSITY OF OSNABRÜCK , INSTITUT OF ENVIRONMENTAL SYSTEM RESEARCH (Publisher) (2005): Harmonising collaborative planning: Learning together to manage together. - Improving participation in water management, Osnabrück. ISBN: 3-00-016970-9

WFD. (2000) EC Directive of the European Parliament and of the Council 2000/60/EC establishing a framework for community action in the field of water policy. *Official Journal C,* 513**,** 23.

WMO (2007) Economic Aspects of Integrated Flood Management. WMO-No.1010. Associated Programme on Flood Management, World Meteorological Organization, Geneva. Available at: http://www.apfm.info/pdf/ifm_economic_aspects.pdf