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Integrated flood risk management – progress from the FLOODsite project

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INTEGRATED FLOOD RISK MANAGEMENT – PROGRESS FROM THE FLOODSITE PROJECT

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Abstract

FLOODsite is the largest ever EC research project on flood risk management, with an EC grant to the budget of nearly €10 Million complemented by supporting national funds. The project, which started in 2004, is scheduled to complete in February 2009, and has involved over 200 researchers from 13 countries including many of Europe's leading institutes and universities. The project is interdisciplinary integrating expertise from across the physical, environmental and social sciences, as well as spatial planning and management. FLOODsite is an ambitious project and aims to maintain the world-leading position of Europe in knowledge and practice for flood risk management. The tools and techniques developed through FLOODsite have been drawn together through the use of pilot studies, enabling direct feedback to flood risk managers and river, estuary and coastal stakeholders. For example, within the UK, the Thames Estuary 2100 team has proved a valuable pilot site – supporting more targeted research and better practice. The use of the pilot sites and collaboration with executive agencies in several countries will help ensure that FLOODsite results are of real value, practicable and usable. This paper describes some of the outcomes of FLOODsite in terms of contribution to knowledge on sources, pathways and receptors of flood risk and support for integrated methods of flood risk management.

Introduction

A short paper at an earlier Defra conference (Samuels et al, 2004) described the objectives of the research and these will not be repeated here. The research within FLOODsite is structured in four Themes (Figure 1), with a fifth theme dedicated solely to dissemination.

Within each Theme the research is undertaken within a series of Tasks, with each task providing useful new insights into flood risk and how best to manage it. The FLOODsite research has remained close to the changing international policy setting, helping to inform the development of the European Directive on the assessment and management of flood risks and how it may be implemented (EU directives, 2000, 2007) as well as maintaining links to over 80 other projects and programmes, both national and international (a number of these links have lead to joint research with the Agency / Defra TAG Programmes for example).

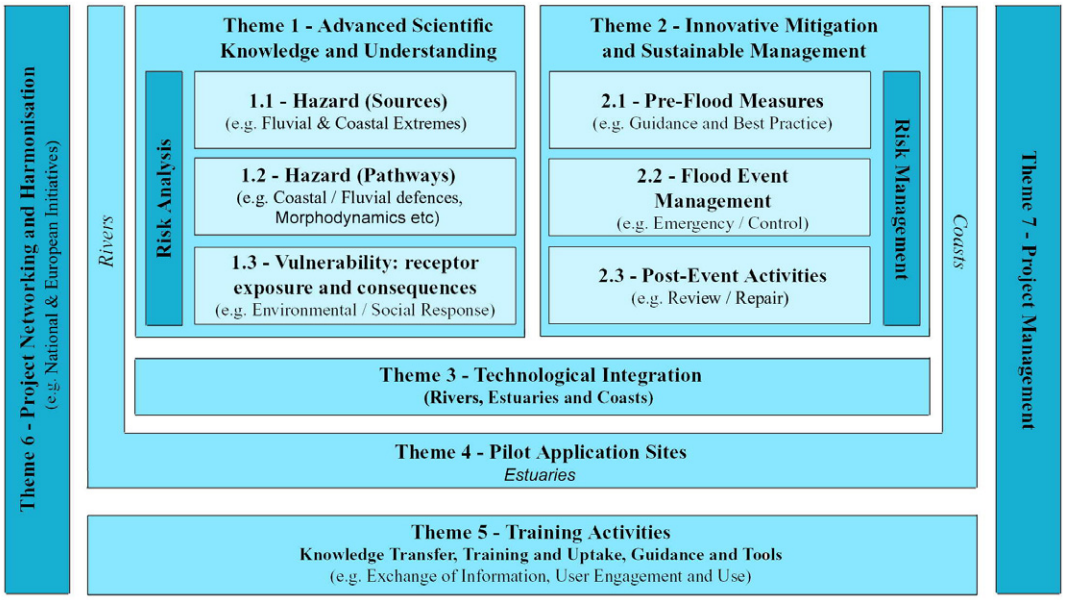


Figure 1 The inter-relation of the FLOODsite Themes

Selected advances from the FLOODsite Project

Sources

A significant number of tasks within FLOODsite are devoted to improving our ability to predict and understand extreme events. The number of observed extremes is of course limited because of their intrinsically rare character. This, together with the lack of stationarity in the observational period including seasonality or decadal/centennial trends, poses a serious challenge for a robust determination of the related probability of occurrence (hazard estimation). This will influence the bounds of uncertainty associated with risk assessment of current and future flooding. Within FLOODsite Task 2 for example, traditional approaches to extreme value analysis have been challenged and reviewed. In particular the way in which statistical model and statistical inference uncertainties are handled and reported. Clear recommendations are made regarding preferred methods and approaches including the use of a generalized Pareto distribution as a function encompassing most of the conventionally used extreme distributions. Re-sampling techniques, such as boot-strapping, were shown to offer a useful means of reducing the uncertainty in extreme values (particularly where record lengths were short). Bayesian methods where also found to be useful enabling available physical knowledge to be used to constrain input variables – resulting in improved estimates of the extreme values and an associated reduction in predicted variance. This work has already been reported within FLOODsite and will be more widely disseminated through a special edition of the Journal of Hydraulic Research (in press).

A separate strand of work considered the hydrometeorology of flash flood hazards in small basins, and methods to better predict extreme flows in these settings – a key question in many of the mountain areas of continental Europe as well as some areas in the UK.

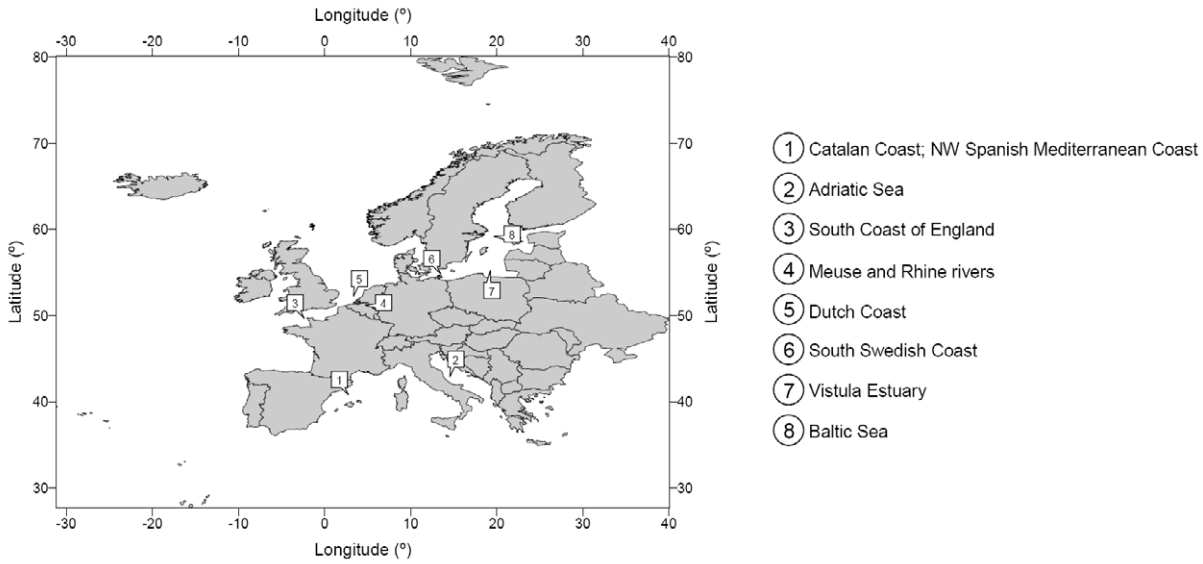


Figure 1 Task 2 used sites and datasets from across Europe to investigate improved approaches to the estimation of extreme values (work lead by Sanchez-Arcilla, UPC)

Pathways

Improved understanding of complex flood defence systems, their failure modes and their interaction with morphodynamic processes have all been considered within FLOODsite and the science has been advanced. Key outputs include:

Failure modes - A library of failure modes relating failure mode equations and parameters to different linear structures (Allsop, 2007). This provides a valuable and updateable reference for practitioners and researchers alike.

Reliability analysis (asset fragility) – A flexible method and tool has been developed in Task 7 by HR Wallingford and TU Delft to support the detailed analysis of asset fragility (van Gelder *et al*, 2008). The software allows the user to construct fault trees involving multiple failure modes (both dependent and independent) and link associated failure modes. This work has been undertaken jointly with the Flood Risk Management Research Consortium (www.frmrc.org) and provides a real example of collaborative working. Although further work will be required to bring this tool to industry, HR Wallingford are already applying this within the context of the TE2100 – working together with a range of consultants - to provide detailed fragility analyses.

Breach analysis – The initiating processes of a breach and associated dynamic growth remain an active research area of significant practical interest. Within FLOODsite further specific advances have been made relating to the erosion due to wave overtopping, breaching of homogeneous clay dikes by overflow as well as breaching initiated by wave impacting on the seaside of a sea dike, see for example D'Eliso (2007). These advances are allied with large scale physical model testing and the developed of practical software tools such as HR Breach.

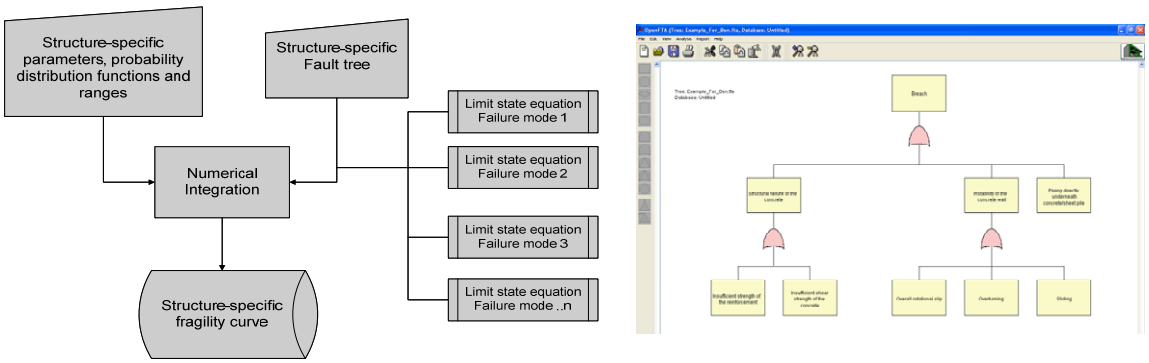


Figure 2 The workflow used within the reliability tool (left) and screen shot of the user constructed fault tree (right)

Receptors – Vulnerability and damage evaluation

A good understanding of what makes people more or less vulnerable to flooding and the methods of valuing flood damage is vital for rationale flood risk management – without such understanding any investment can easily be misdirected. FLOODsite covers both of these issues, highlighting through Task 11 (Steinführer, 2008) that although an individual's vulnerability is highly context specific a common set of issues influence the likely impact. These include pre, event and post event issues, namely:

- *Anticipation* (risk awareness, preparedness, inherent behaviours)
- *Resistance & coping* (ability to resist flood inundation – main defences or local defences – and to cope with damage and/or nuisance)
- *Recovery & reconstruction* (persistent physical and mental health issues, speed of return to "normality" – return to home, work etc)
- *Communication / participation* (knowing what to do, who to contact insurers, emergency agencies, clarity on when the flood will recede etc)

Through comparison of different approaches to the evaluation of flood damage, guidance has been provided to Member states (Messner *et al*, 2006), that caters for those countries where flood management is a mature process and those less experienced (see Figure 3).

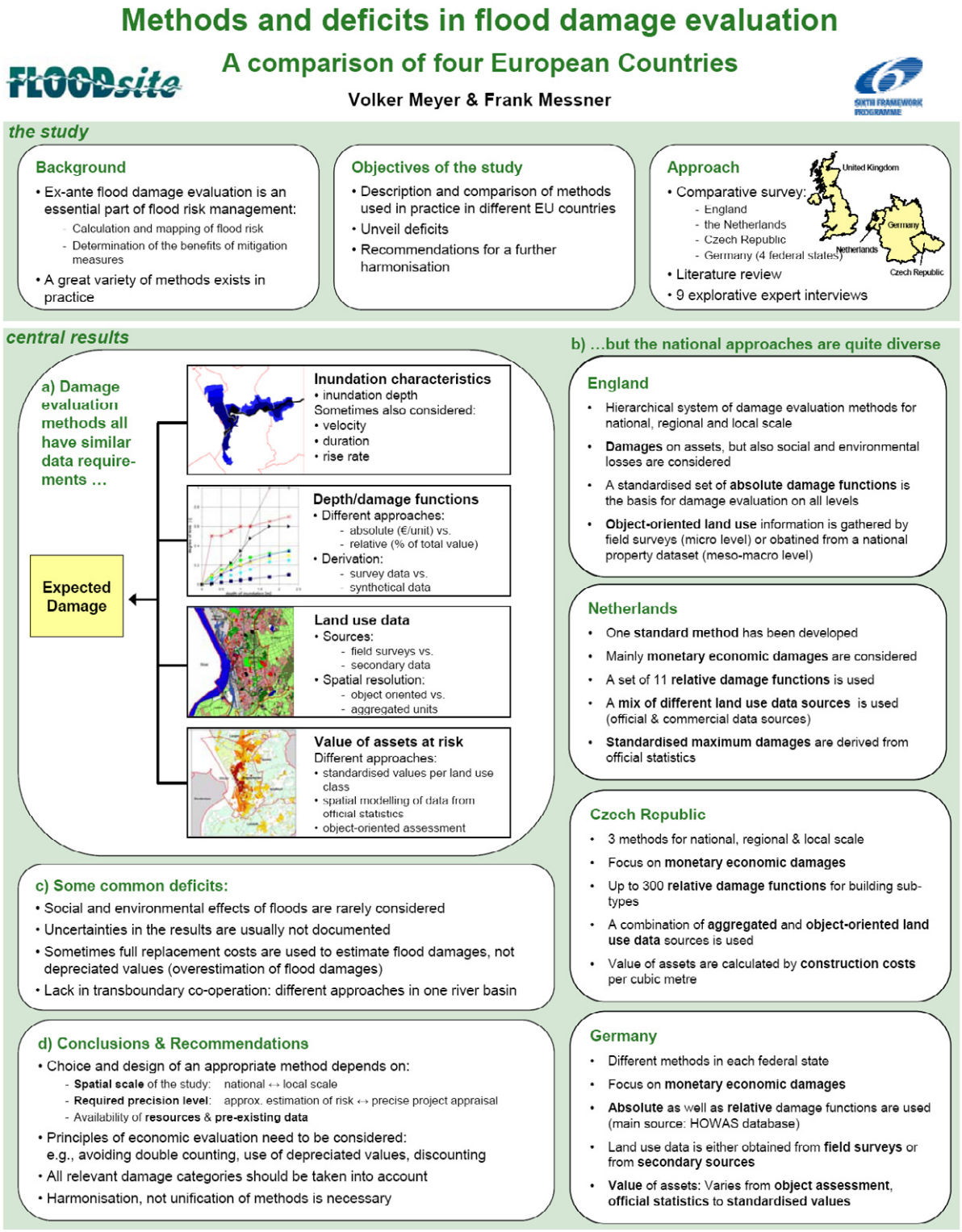
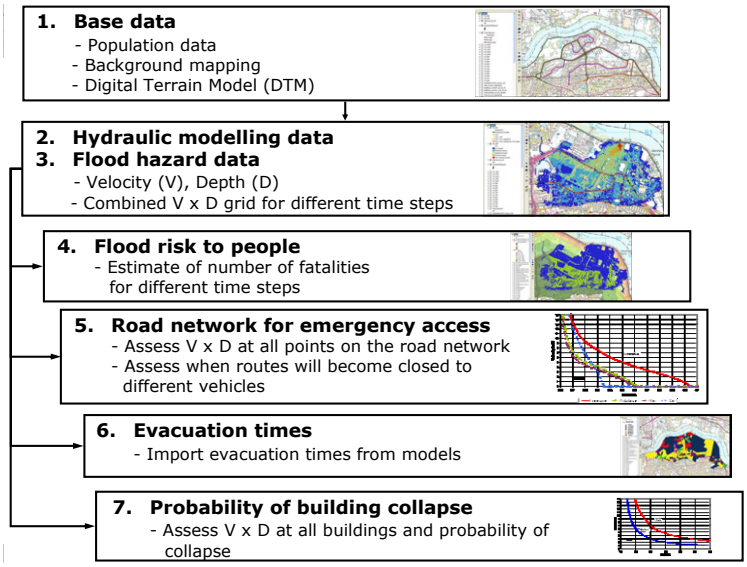


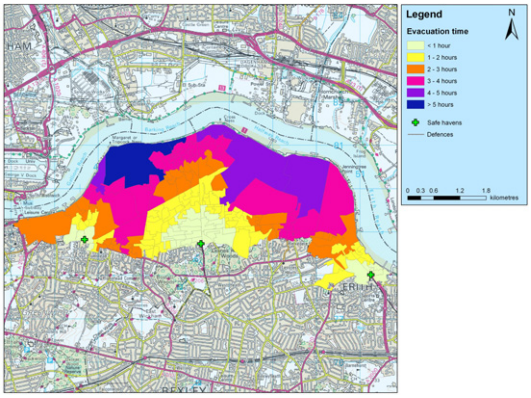
Figure 3 Methods and deficits in flood damage evaluation Messner et al (2007)

Integrated methods

Through Theme 3 FLOODsite provides a focus on the tools and techniques needed to support better decision making. It focuses on two decision types:

- ***Event management and evacuation planning*** In Task 17/19 Deltares, HR Wallingford, Sogreah and TU Delft are examining methods to assist with flood emergency management. During a flood event, the responsible authorities need to make decisions quickly – should a barrier be closed/opened, should a temporary defence be deployed, should a road be closed, should a house/community be evacuated (and if so by what route taking account of any road blockages or other safety issues). A new suite of frameworks have been developed, including a system that links the dynamic behaviour people with the dynamics of the flood forecast flood wave. This provides decisions makers with an ability to pre-plan the siting of strategic safe havens and excavation routes based on an ability to compare options in terms of evacuation times and lives lost. An example of the type of outputs from this tool is provided in Figure 4 from Lumbroso *et al* (2008).





Evacuation times (Lumbroso et al)

Figure 4 Overview of the process developed within FLOODsite (right). Example output for the time to evacuate taken from the Thames example (right)

- ***Long term planning*** - Flood risk management requires policy making for the long term. This means policy making for a relatively far and largely unknown future. This implies dealing with many uncertainties and many possible futures. Long-term planning is now widely accepted as fundamental to providing sustainable flood risk management strategies, for example:
  - Policy making in view of sustainability requires considering what 'world' we want to pass on to future generations.
  - 'Decisions taken today will have a profound impact on the size of flood risks that future generations will need to manage. They will also strongly influence the options available for managing those risks' (Evans, 2004a,b).
  - Some flood risk management measures and instruments, such as changing land use in floodplains and within cities, could take decades before they become effective.

In advancing from studies such as Foresight, FLOODsite describes both management policy and climate scenarios separately as follows:

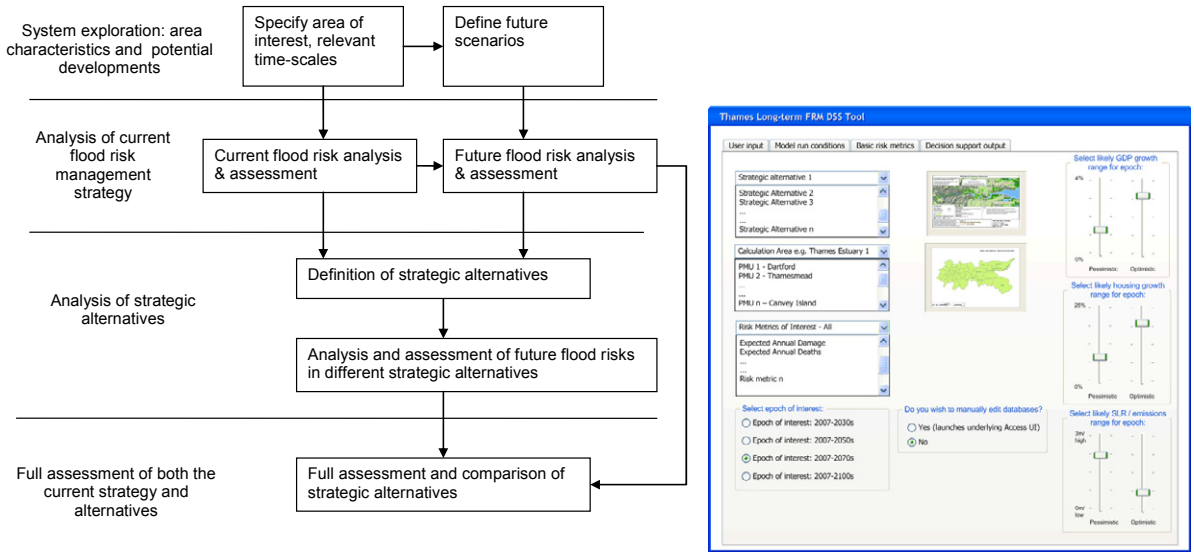


Figure 5 an overview of the process of long term planning defined in Floodsite (De Bruijn et al, 2008)) (left) and example of the supporting tools being developed (right – taken from McGahey et al, Task 18 Floodsite in press)

This enables preferred approaches to be developed based on consideration of their performance across all futures (through a formal robustness analysis – see McGahey et al, or Hall et al) and how flexible (or adaptable) they are should the need arise (Figure 6) (i.e. can the strategy be modified as the reality of the future becomes know).

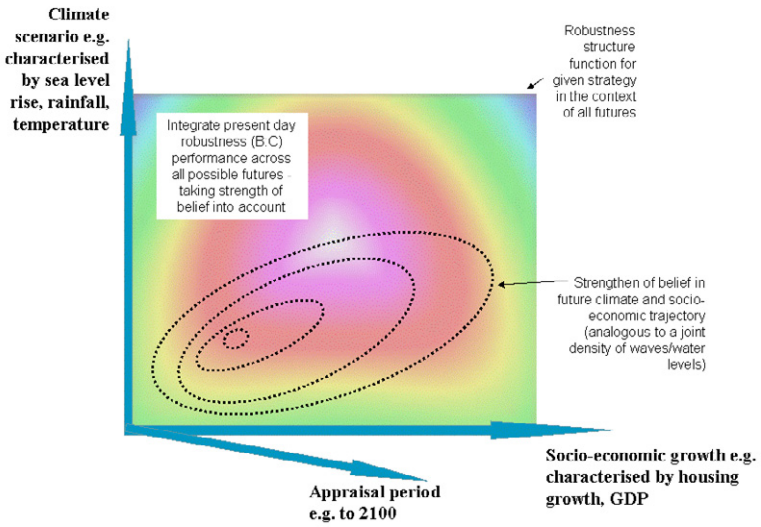


Figure 6 Evaluation of robustness evaluation of a strategy across all possible climatic and socio-economic futures (McGahey et al, Task 18 Floodsite)

Integrated thinking

Integrated flood risk management is progressively being viewed as a comprehensive and continuous process of analysis, assessment and action. It considers the external *pressures* placed upon the flood risk system by climate and societal change; the *state* of the flooding system (including all the *sources* of the flood hazard and the various *pathways* that link them to through to the *receptors);* as well as a full range of potential *impacts* and the *responses* to them. Most importantly however integrated flood risk management (IFRM) demands an integration of the flood risk management process with wider societal demands and aspirations. As such IFRM can be seen as a proactive approach and distinct from the more reactive approaches that have often characterised traditional flood defence based paradigms. It can also be seen as more inclusive than the often sectoral focus of current flood risk management approaches.

Throughout, FLOODsite has had the goal of promoting a consistent view of what constitutes integrated flood risk assessment and management procedures across Europe. In particular providing a common language as well as sharing underpinning theories and practical experience. As part of this a "language or risk" (Gouldby *et al*, 2005) was developed early in the project that built upon key texts from across Europe but principally the UK and the Netherlands. In addition to the language of risk, methodological integration has also been explored. This has included agreeing the concepts and principles that underpin integrated flood risk management; from the frameworks of source, pathway and receptor, through to the principles of hierarchical whole system analysis (Sayers *et al*, in press).

Dissemination and implementation of the results

The management of flood risks is a matter of ensuring public safety and provides benefits for the health and well-being of society. From the outset of the contract negotiations the FLOODsite Consortium was encouraged to put the results in the public domain through publication in the literature. Real public benefit from the expenditure on the research comes from others using the project results in their broadest form; however, the implementation and uptake of the research outcomes lie outside the scope of the EC project. Thus it is essential to take action on uptake and implementation beyond the conclusion of the research phase of the project. By openly publishing our results they become public knowledge and available to all to use; as a consequence the FLOODsite consortium is unlikely to produce commercially "exploitable" results for the benefit of the consortium members alone. Exploitation of the project results will follow primarily through the subsequent development and production of professional standard software to encapsulate the project results. One avenue for assisting in this process is via our formal Consortium Affiliates, which include Météo-France, Defra and the Environment Agency.

Project partners have been active in presenting and publishing project advances to scientific, technical and professional communities. The project website (www.floodsite.net) has approximately 150 documents available for public download. Conference and Journal papers are only made available via the website once they have been formally published or presented and are cleared of copyright restrictions. To date the FLOODsite partners have produced over 430 publications; a list of these is included in the project report T35-08- 11: "*FLOODsite plan for using and disseminating the knowledge*", which is available from the public pages of the FLOODsite website.

Conclusions

The findings from FLOODsite confirm the widely accepted notion that the management, mitigation and reduction of future flood risk will not come from a single technical solution or policy but from a portfolio of responses which are tuned to the specific circumstances at a local or regional scale, taking account of national governance structures and public attitudes towards flood risks.

The FLOODsite tools and techniques will help facilitate the implementation of the European Directive across Europe through flood risk assessments, risk mapping and the preparation of flood risk management plans. Although FLOODsite does not seek to provide a single integrated methodology for flood risk management it does provide a set of linked methodologies which support integrated flood risk management.

The diversity and range of the FLOODsite tools and techniques can not be easily reported in a single paper or report and the interested reader is referred to the project website (www.floodsite.net) where detailed outputs from all the tasks can be freely downloaded.

Acknowledgements and disclaimer

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NOTES

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