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FLOODING ERA-NET

Integrate, Consolidate and Disseminate
European Flood Risk Management Research

2nd ERA-NET CRUE Research Funding Initiative
Flood Resilient Communities – Managing the Consequences of Flooding
Final Report

CRUE Final Report

Flood Incident Management – A FRAMEwork for improvement – FIM FRAME

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Second Era-Net CRUE Funding Initiative: Flood resilient communities – managing the consequences of flooding

CRUE Research Report

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The intent of the research reports is to provide relevant information and to stimulate discussion of those having an interest in flood risk management. The results and conclusions of all reports produced under the **Second CRUE Funding Initiative on Flood Resilience** are made available to policy-makers and stakeholders at all levels, research funding bodies, universities, industries, practitioners, and the general public by way of the CRUE website (**http://www.crue-eranet.net**).

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ERA-Net CRUE was funded within the Sixth EU Framework Programme and introduced structure within the area of European research on flood risk management (FRM). Its vision was to support and develop an extensive co-ordination and integration of regional, national, and European research programmes, projects and policies in the field of Flood Risk Management. Within the CRUE ERA-Net two funding initiatives were introduced.

The second ERA-Net CRUE Research Funding Initiative **"Flood Resilient Communities – Managing the Consequences of Flooding"** was launched in support of the EU Floods Directive 2007/60/EC, which was introduced as a result of several severe flood events causing loss of life and property. Within this initiative seven joint research projects with test sites all over Europe are funded and focus on a broad spectrum of issues related to the enhancement of resilience. Besides, the scientific coordination project CORE CRUE is funded within this second call, to support the implement of the call and to disseminate its results.

Flood Incident Management – A FRAMEwork for improvement – FIM FRAME

CRUE Research Final Report

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A project fact sheet can be found at the end of this document.

Summary for decision-makers

Headline summary message

The research has developed a framework, known as the FIM FRAME method, to assist stakeholders responsible for the production of emergency plans for floods to assess and improve these plans. The FIM FRAME method can also be used to assist with the development of new emergency plans for floods or other hazards. The research has delivered the following:

- An insight into the similarities and differences in emergency planning for floods in England and Wales, France and The Netherlands
- An overview of the tools (e.g. checklist, guidance documents, methods and software) available to support the development and improvement of flood emergency plans
- Twenty two metrics were developed that allow emergency plans to be assessed and their "fitness for purpose" quantified
- A framework produced to analyse and strengthen emergency plans
- Piloting of the developed method in case studies in England, France and the Netherland with a wide variety of stakeholders
- Guidance document produced detailing the FIM FRAME method
- Dissemination of the method via a wide variety of routes

Contents of the report and the importance of the research

This report summarises the following:

- The aims and objectives of the research
- The development of the FIM FRAME method
- The application of the method in case studies in England, France and the Netherlands
- Contribution of the research to the overarching topics of the ERA-NET CRUE call
- Implications of the research for stakeholders and policy makers

The production of emergency plans in Europe specifically focused on floods is a relatively recent phenomenon. In England and Wales and the Netherlands, Acts of Parliament passed in 2004 have acted as a catalyst to the formulation of emergency plans for flooding. In France an Act passed in 2005 paved the way for the production of local level emergency plans. Until recently evaluation of emergency plans for floods has received little attention and often the emergency plans for floods have been found to be in need of improvement (Pitt, 2008, MEEDM, 2011), this is because:

1. Stakeholders are still evolving principles and procedures for the effective management of flood emergencies (Heath, 1998). There is also a consensus that emergency management is not a fully fledged profession (Crews, 2001).
2. The objectives of what is being evaluated are often blurred (Heath, 1998).
3. There is often a lack of openness when evaluating either the preparation for emergencies or post-event debriefings as a result of stakeholders feeling threatened by criticism or being vulnerable to having the blame for any perceived failures assigned to them (Heath, 1998).
4. Emergency plans specifically for floods are a relatively recent development and hence it is only in the past two or three years that a requirement for their evaluation has emerged.

Research carried out by Alexander has found that there is an "*enormous variety and lack of homogeneity"* amongst emergency planning documents in many parts of the world. Alexander postulates that this implies that there is *"a shortage of adequate standards [or metrics] for creating, evaluating and approving emergency plans*" (Alexander, 2002, 2003, 2005).

Aims and objectives

The overarching aim of the research was to produce a method to assist emergency planners and other key stakeholders such as water management organisations and emergency responders (i.e. the police and fire brigade) to assess, develop and improve emergency plans for flood events.

(i) An assessment of current emergency plans for floods

The first objective was to assess the "effectiveness" of a sample of flood emergency plans in England and Wales, France and the Netherlands. This was done by developing 22 metrics that could be applied to emergency plans for floods to provide a quantitative assessment of their fitness for purpose (See Lumbroso et al, 2011).

(ii) Evaluation of tools that be used improve emergency plans for floods

The second objective was to evaluate the current tools that are used to inform flood emergency plans and the ability of these tools to support future flood event emergency planning with the main aim of reducing residual risk (see Lumbroso and Vinet, 2011)

(iii) Development of a method to enable stakeholders to improve emergency plans for floods

The main objective of the research was to develop a method (or framework) known as the FIM FRAME method that emergency planners, flood risk managers and emergency responders can use to:

- Assess the "fitness for purpose" of emergency plans for floods
- Identify weaknesses and gaps in the plans
- Assist with the development of new plans and improvement of existing plans
- Provide guidance on the tools (e.g. checklists, guidance documents, software) that are available to help emergency planners improve plans

(iv) Piloting and refinement of the FIM FRAME method in a number of case studies in England, France and the Netherlands

The fourth objective of the research was to pilot and then refine the method developed in a series of case studies and workshops. A number of workshops were held as part of the piloting and refinement process. A summary of the locations of these workshops is provided below

(v) Dissemination of the results

The final objective of the research was to disseminate the results. This has been done via the publication of three comprehensive reports that document the main project outputs, the development of a guidance document to describe the FIM FRAME method, development of a web site that makes all the outputs to date readily available (www.fimframe.net/dissemination.html), research and consultation with stakeholders via a number of meetings, workshops, web-based surveys and a two day conference and the production of three peer reviewed journal papers two of which are reproduced in Appendix C and D respectively.

Results and key findings

The research produces a method to assist stakeholders to assess, develop and improve emergency plans for flood events. The method developed, known as the FIM FRAME method requires the input of the key stakeholders via one or two one-day workshops. The method comprises the following steps:

(i) **Appraise** - Identify aspects of the plan on which to concentrate during the workshop. This is done via appraising the plan via a series of 22 metrics that were developed as part of the research. The metrics developed broadly fall into six categories as follow:

1. Objectives, assumptions and target audience
2. Organization and responsibility
3. Communication
4. Flood hazard
5. Flood risk to receptors (e.g. people, buildings, critical infrastructure)
6. Evacuation

(ii) **Tackle** - Describe the aspect of the plan identified for improvement and identify potential issues. After this potential resolving actions are identified. This is done by the development of entity diagrams and cross-tables

(iii) **Implement** – agree actions needed to update the plan

To what extent the actions in the implementation plans are carried out is dependent upon the resources available to the relevant stakeholders. The application of the FIM FRAME method allows the following to be established for an emergency plan for floods:

- Weaknesses and gaps in the plan. This is done by applying 22 metrics that have been developed as part of the project
- To establish how the plan can be improved in some cases by the application of tools (e.g. checklists, guidance documents or software)
- To identify what tools are available to emergency managers to assist them in improving plans

The method can also be used to develop new plans. The overall result will be an improvement in emergency plans and this will in turn help to improve the resilience of communities to major flood events.

The research found that there is a discrepancy between the level of detail required by emergency planners and the actual level of detail that is available within emergency plans for a number of issues. This discrepancy is smaller for the metrics related to communication and organisation. It can therefore be concluded that the emergency plans do not comply with the requirements on issues related to receptors such as critical infrastructure, people and buildings.

The effectiveness of an emergency plan is a difficult factor to measure and several stakeholders indicated that this can only truly be assessed accurately after the plan has been used in a flood. Many emergency planners stated that a well defined description of the roles, responsibilities and communication is essential for a plan to be effective and these aspects tend to be well covered in the three countries studied. However, other more technical aspects such as accessibility of roads during floods, evacuation, and the depiction of flood hazard and impacts of floods on critical infrastructure can be considerably improved. To conclude the main challenge for emergency planners is to avoid filling plans with generic text and to provide an appropriate level of specific detail in the plan whilst ensuring the usability of the plan.

From the research carried out it would appear that many flood risk managers are often not aware of the tools that are available to assist them in providing information to emergency plans for floods. Based on the online survey of flood managers in England and Wales and France, the three main obstacles to tools not being used appear to be:

1. Lack of awareness of the methods that are available
2. Availability of data
3. Lack of communication between flood risk managers and the stakeholders such as emergency services and local authorities responsible for writing the plans

Implications for stakeholders

The implications for the stakeholders responsible for emergency planning for floods are as follows:

- The research found a discrepancy between the level of detail required by emergency planners and the actual level of detail that is available within emergency plans for a number of issues. In some cases emergency planners need to work more closely with flood risk managers to fill these gaps
- There is also in some cases a division of responsibility. For example in the case of certain aspects of flood risk management (e.g. estimation of loss of life; evacuation times) it is not always clear who should take the lead (i.e. flood risk managers or emergency planners). This may be because some of the types of tools for improving emergency plans are perceived to fall outside the remit of all the stakeholders. This can mean that tools are not used because there is a "responsibility gap" through which the use of the tools falls.

In formulating emergency plans for floods it would appear that "expert judgement" is often used by stakeholders rather than specific tools. There is a need for the training of stakeholders in tools that help to improve emergency plans, especially more "technical" tools that can assess the following:

- Accessibility of inundated roads
- Optimisation of the location of shelters and safe havens
- Damage to critical infrastructure
- Optimal evacuation routes
- Effects of improvements in flood warning on the risk to people
- Methods to assess potential injuries and loss of life

Recommendations for decision makers

Emergency plans produced for floods are often inconsistent. For example in France adjacent communes can have very different emergency plans. Discrepancies between different plans can cause problems when they are implemented. There needs to be an overarching organisation to ensure consistency of plans and also to ensure that different plans covering different spatial areas or topics are correctly linked up. Emergency plans for floods often deal with a limited number of scenarios. This means that the emergency plans produced often do not deal with the concept of "possiblism" i.e. thinking in terms of "worst cases" and that which is possible. This is potentially more enlightening for emergency planners. Possibilism and counterfactuals ("what if" scenarios) offer the promise of thinking "outside of the box". They disrupt routine thought patterns, stretch the imagination and potentially produce creative solutions, which can allow people to make systems more resilient and can even promote social betterment (Clarke, 2006). Policy makers should ensure that plans take into account "possiblism".

Currently the emphasis of emergency plans for floods is on the organisation, roles and responsibilities. These are important aspects which were noted as being the most important for an emergency plan to be effective. However, issues related to the risks that floods pose to people and buildings, as well as access routes into flooded areas were often not well covered in plans. Many emergency planners and responders indicated that they would like to see more information on risks to receptors (e.g. people, buildings, industrial facilities, critical infrastructure) included in plans.

Contents

1 Introduction

This report forms the final report of the ERA NET CRUE research project entitled Flood Incident Management – A FRAMEwork for improvement (FIM FRAME). This chapter gives the background to the problem that the research addressed and how the research was structured. It also provides definitions of the terms "resilience" and "community" as used within the research.

1.1 Background to the problem

During the last two decades flood risk management policies in many European Union (EU) countries have evolved significantly (Tapsell & Ball, 2007). The paradigm of attempting to reduce the flood risk as much as possible purely through structural measures has progressively been overtaken by a more holistic approach to flood risk management (Lagadec, 2002). The management of the residual risks has become a priority for natural hazards such as floods. This shift in paradigm has led to more effort being focused on producing emergency plans specifically for floods. The overarching aim of these plans is to allow communities to survive and recover as rapidly as possible from the effects of inundations.

Recently, the emergency management of floods in Europe has placed increasing importance on developing enhanced preparedness capacities. In this regard, the concept of emergency management has shifted from a primary focus of responding to the flood and its impacts to one of increased attention to communities becoming more resilient to the impacts of floods. The capacity to respond effectively remains important; however, emergency responders and planners are looking more intently at the earlier stages of emergency planning and how plans for floods can be improved. It is also important that these plans include preparations for low probability, high consequence events (Jonkman and Kelman, 2005, Jonkman, 2007). In June and July 2007 England and Wales was hit by widespread flooding. A review of these floods found that the amount of information made available at the local level for emergency response planning was insufficient (Pitt, 2008). A summary of recent floods in England and Wales and their impacts is given in Table 1.1.

France has also recently been subject to a number of extreme floods. On 28 February 2010 at 2 o'clock in the morning the "tempête" (storm) Xynthia hit the French Atlantic coast. The storm surge combined with a high tide and large waves caused flood defences to fail along the coast from the Gironde near Bordeaux to the Loire Estuary. Over 50,000 ha of land were flooded and 47 people died as a result of the storm. Most people died as a result of the flooding although a small number of people died as a result of storm debris. The French Departments of Vendée and Charente-Maritime suffered the most damage (Kolen et al, 2010). It has been estimated that the damage caused by the flooding may have cost in excess of €1.2 billion (Le Figaro, 2010). On 15 June 2010 there was an extreme flash flood which struck the Var Department in the French Mediterranean region. This resulted in 28 deaths and hundreds of million of Euros of damage. Over 1,000 people were evacuated from their houses, and 175,000 houses were left without electricity. A summary of recent floods France and their impacts is given in Table 1.2. A report by the Ministère De L'Ecologie Et Du Développement Durable Directions Régionales De L'Environnement (MEEDDM) in February 2011 entitled "Plan submersions rapides: Submersions marines, crues soudaines et ruptures de digues" (Rapid inundation plan: Coastal floods, flash floods and dike failures) indicated that emergency response to floods could be improved. The reports by Pitt (2008) and MEEDDM (2011) both make it clear that in both England and Wales and France the emergency response to floods could be improved.

Table 1.1 Recent major floods and their consequences in England and Wales

Date	Location	Consequences
2009	Severe flooding experienced over north-west England and south-west Scotland during the period 18 to 24 November	500 homes and businesses flooded, eight bridges destroyed, damage estimated at £100 million
2007	Widespread and severe flooding affecting many rivers in June and July 2007 including the lower Severn basin, headwater tributaries of the Thames, as well as Yorkshire and Humberside	14 deaths, 55,000 homes and 6,000 businesses inundated. Over £3 billion of damage
2005	The town of Carlisle, in the north-west of England, suffered severe flooding	The consequences included: three deaths; 1,925 homes and business flooded; 3,000 people being made homeless for up to 12 months, 40,000 properties without power
2004	Flash flooding in Boscastle in Cornwall	58 properties flooded and four destroyed. Damage to buildings and services estimated at £2 million
2000	Widespread flooding in November 2000 throughout England and Wales	8,000 properties were flooded with the total damage estimated to be approximately £500 million
1998	Extensive areas of the Midlands flooded	Flood damage estimated at £1.5 billion

(Sources: Dartmouth Flood Observatory, 2010; Marsh & Hannaford, 2007; Rhodda, 2010)

Table 1.2 Recent major floods and their consequences in France

Date	Location	Consequences
15 June 2010	Var Département in southern France	28 people killed as the result of flash floods.
28 February 2010	West Atlantic Coast, Vendée and Charente regions of western France	47 people killed as the result of coastal flooding owing to dike failures
15 November 2005	Southern France, Perpignan area	Two people killed as the result of flash floods
6 to 9 September 2005	Gard and Herault areas and Nimes. Lunel and Montpellier	Two people killed as the result of flooding
1 to 3 December 2003	Southern France - Rhone valley - Marseilles and Lyon areas. Bouches-du-Rhone region. Vaucluse, Ardeche, Charlieu, Avignon, Orange. Herault, Gard, Arles, Ardeche.	Nine people killed as the result of fluvial floods, flash floods and dike failure. Damage estimated at €1.5 billion
8 September 2002	Gard, Herault and Vaucluse departments. Nimes and Avignon areas. Aramon, Sommieres, Russon.	23 deaths as the result of flash floods. Damage estimated at €1.19 billion

(Sources: Dartmouth Flood Observatory, 2010; Kolen et al, 2010; EM-DAT-CRED, 2011)

Historically, flood risk management in the Netherlands has been based on building dikes high and strong enough to prevent floods that had occurred in the past from happening again. This strategy of embankment construction has been carried on for 1,000 years and resulted in a country that has come to rely almost completely on its flood defence system. Until recently, Dutch flood risk management was all about preventing floods from happening. Contingency planning has until recently received little attention (Ten Brinke, 2010). An evaluation of flood risk management policy showed that the Netherlands is not

prepared for the situation where extreme conditions cause large-scale flooding (Ten Brinke, Bannink, & Ligtvoet, 2008). As a consequence of this there is also a need to improve the emergency planning for extreme flood events in the Netherlands. The most recent flood in the Netherlands resulting in casualties occurred in 1953. In 2009 a national exercise was carried out aimed at the evaluation of the preparedness of the Netherlands for a large flood threat. The exercise resulted in recommendation on improving emergency plans for floods.

The quality of the response to an emergency is only as effective as the reliability of the information which is available to inform the response (MacFarlane, 2005). The response to a flood is often based on the information contained in an emergency plan. An emergency plan may be defined as a "*coordinated set of protocols for managing an adverse event, whether expected or untoward in the future*" (Alexander, 2005). Recent decades have seen significant increases in the number, scope and complexity of incidents and disasters. The process of constructing a written emergency plan is of great benefit to organisations that have to respond to an emergency (Fischer III, 1996). It is now generally agreed that for places that are significantly at risk of hazards authorities should be required to produce emergency plans (Alexander, 2005). Grunfest and Handmer (2001) also note that emergency planning is the best way to significantly reduce the loss of life from floods especially for flash floods where lead times are short.

The assessment of crisis management processes and emergency plans is fundamental for their improvement; however, most theorists and practitioners pay only a passing reference to the process (Heath, 1998). Existing literature to assess emergency plans is often unhelpful and there have been few attempts to establish the principles of evaluating plans beyond summary checklists (Barton, 1993; Albrecht, 1996; Heath, 1998).

The production of emergency plans in Europe specifically focused on floods is a relatively recent phenomenon. In England and Wales and the Netherlands, Acts of Parliament passed in 2004 have acted as a catalyst to the formulation of emergency plans for flooding. In France an Act passed in 2005 paved the way for the production of local level emergency plans. In all three countries emergency planning for floods is initially the responsibility of local government. Although regional and national flood emergencies cannot be managed exclusively at a local government level the essential remedy to an emergency situation is almost inevitably applied at a local scale (Drabek and Hoetmer, 1991).

There are several reasons put forward as to why the evaluation of emergency plans for floods has until recently received such little attention and why the plans themselves may be in need of improvement. It has been postulated that this is because:

1. Stakeholders are still evolving principles and procedures for the effective management of flood emergencies (Heath, 1998). There is also a consensus that emergency management is not a fully fledged profession (Crews, 2001).
2. The objectives of what is being evaluated are often blurred (Heath, 1998).
3. There is often a lack of openness when evaluating either the preparation for emergencies or post-event debriefings due to stakeholders feeling threatened by criticism or being vulnerable to having the blame for any perceived failures assigned to them (Heath, 1998).
4. Emergency plans specifically for floods are a relatively recent development and hence it is only in the past two or three years that a requirement for their evaluation has emerged.

Research carried out by Alexander has found that there is an "*enormous variety and lack of homogeneity*" amongst emergency planning documents in many parts of the world. Alexander postulates that this implies that there is *"a shortage of adequate standards [or metrics] for creating, evaluating and approving emergency plans*" (Alexander, 2002, 2003, 2005) and that "*virtually no appropriate standards seem to exist*" (Alexander, 2005). Alexander also found that there was little in the way of metrics via which the "fitness for purpose" of emergency management plans can be developed. There are also no methods available to allow the relevant stakeholders to identify the "weaknesses" and "gaps" in their plans and to suggest tools and methods via which they can be improved.

To have a realistic understanding of the risks for low probability flood events it is often important to utilise tools (e.g. checklist, guidelines, methods to assess risk, software) to assess, for example, the impact the failure of critical infrastructure, such as water, energy, waste and transport systems, can have in terms of damage caused to the environment, cost to the economy, and loss of life. Clarke (1999) pointed out for many emergency planners it can be easier to produce symbolic, "*fantasy*" documents than to engage in forthright admissions of real dangers and the uncertainties that they create. Perry and Lindell (2003) suggest that emergency management processes should be based on an accurate knowledge of the threats. Currently there is little evidence that flood risk managers responsible for advising emergency planners on these issues are making use of the full range of tools available to them. This has in some cases resulted in flood emergency plans that are merely symbolic and that as Clarke (1999) states "*are used as forms of rhetoric to convince audiences that they ought to believe what an organization says*" and that have "*little instrumental utility in them*". One of the issues addressed by this research was to look at the tools that are currently available to flood risk managers to assist them in assessing possible risks posed by floods and to help them ameliorate emergency plans so that they address the issue of "*possibilism*".

Using statistics and knowledge of previous events can limit the "*out of the box*" thinking that is needed to explore future possibilities (ten Brinke, 2010). It is important that policy makers think about worst case disasters even though they may seem purely hypothetical events (Boin et al, 2005; Clarke, 2006) because "*things that have never happened before happen all the time*" (Sagan, 1993). Thinking in terms of "worst cases" and that which is possible ("possibilism") can be more enlightening in terms of emergency planning (Clarke, 2006). To have a realistic understanding of the risks for low probability events it is often important to utilise tools to assess, for example, the impact the failure of critical infrastructure, such as water, energy, waste and transport systems, can have in terms of damage caused to the environment, cost to the economy, and loss of life.

1.2 The overall aim of the research and the organisation of the Work Packages

The overarching aim of the research was to produce a method to assist emergency planners and other key stakeholders such as water management organisations and emergency responders (i.e. the police and fire brigade) to assess, develop and improve emergency plans for flood events. The research was carried out in six Work Packages (WPs) as follows:

- WP1 - Effectiveness and robustness of flood emergency plans
- WP2 - Comparison of currently available tools for the emergency planning of floods
- WP3 - Development of a method to improve emergency plans for flood events
- WP4 - Case studies utilising the developed method to improve emergency plans working together with emergency responders, emergency planners and other stakeholders
- WP5 - Dissemination of the results
- WP6 - Management and coordination

The relationship between the six WPs is shown in Figure 1.1.

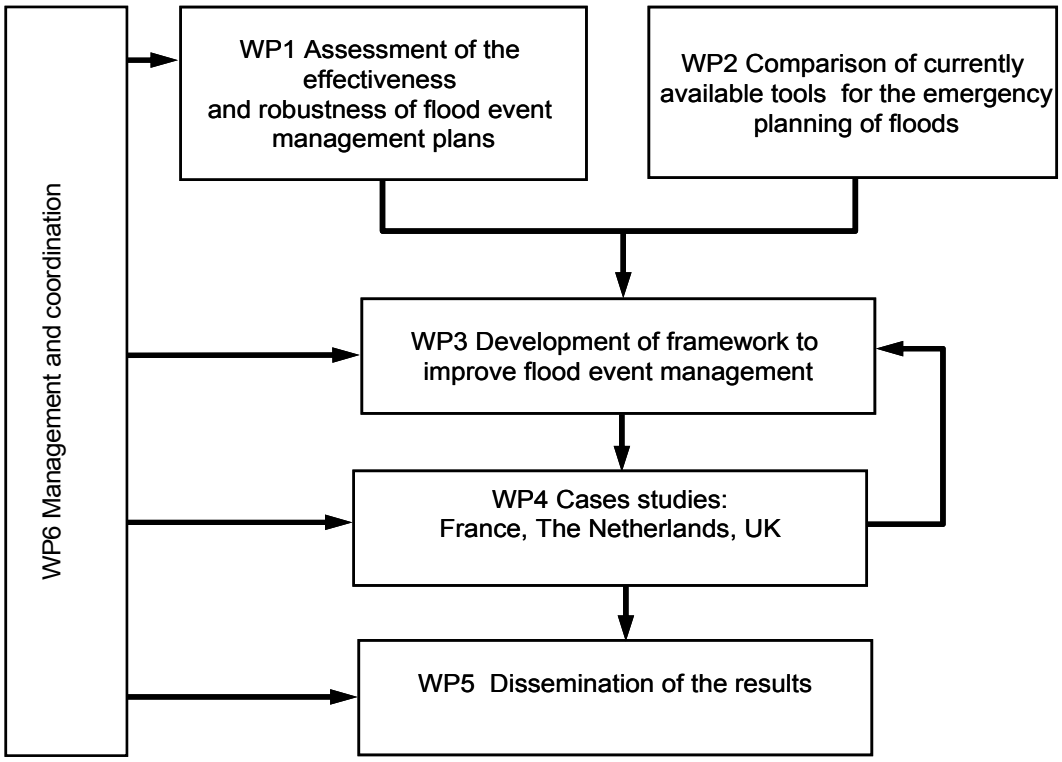


Figure 1.1 Relationship between the FIM FRAME Work Packages

1.3 Definitions of the terms "resilience" and "community"

In terms of this research the terms "resilience" and "community" have been interpreted in the following ways. Resilience has been interpreted as "*the ability of a community to return, quickly and easily, to normal after it has been flooded*" (adapted from De Bruijn & Klijn, 2001, De Bruijn, 2005). Community has been interpreted as "*a social group of any size whose members reside in a specific locality and share the same governance structure or other social characteristics*". With reference to the FIM FRAME project the overarching aim is how emergency plans for floods can be improved to allow communities to survive and recover as rapidly as possible from the effects of floods, which will lead them to being more resilient, and reduce the consequences of future floods.

2 Objectives

The objectives of the research can be summarised as follows:

(i) An assessment of current emergency plans for floods

The first objective was to assess the "effectiveness" of a sample of flood emergency plans in England and Wales, France and the Netherlands. This was done by developing 22 metrics that could be applied to emergency plans for floods to provide a quantitative assessment of their fitness for purpose (See Lumbroso et al, 2011).

(ii) Evaluation of tools that be used improve emergency plans for floods

The second objective was to evaluate the current tools that are used to inform flood emergency plans and the ability of these tools to support future flood event emergency planning with the main aim of reducing residual risk (see Lumbroso and Vinet, 2011)

(iii) Development of a method to enable stakeholders to improve emergency plans for floods

The main objective of the research was to develop a method (or framework) known as the FIM FRAME method that emergency planners, flood risk managers and emergency responders can use to:

- Assess the "fitness for purpose" of emergency plans for floods
- Identify weaknesses and gaps in the plans
- Assist with the development of new plans and improvement of existing plans
- Provide guidance on the tools (e.g. checklists, guidance documents, software) that are available to help emergency planners improve plans

(iv) Piloting and refinement of the FIM FRAME method in a number of case studies in England, France and the Netherlands

The fourth objective of the research was to pilot and then refine the method developed in a series of case studies and workshops. A number of workshops were held as part of the piloting and refinement process. A summary of the locations of these workshops is provided below:

- Ipswich, England, 28 July 2010
- Sheffield, England, 11 November 2010
- Dordrecht, the Netherlands, 18 November 2010
- Utrecht, the Netherlands, 30 November 2010
- Piolenc, France, 8 December 2010
- Tarascon, France, 4 January 2011
- Sheffield, England, 18 April 2011

(v) Dissemination of the results

The final objective of the research was to disseminate the results. This has been done via a number of routes as follows:

- Publication of three comprehensive reports that document the research that has been carried out
- Development of a guidance document to describe the FIM FRAME method and the tools available to improve emergency management plans
- Development of a web site that makes all the outputs to date readily available (www.fimframe.net/dissemination.html)

- Research and consultation with stakeholders via a number of meetings, workshops, web-based surveys and a two day conference
- Production of three peer reviewed journal papers, as well as magazines aimed at emergency planners and flood risk managers

3 Methodology

3.1 FIM FRAME method

3.1.1 Context and aim of the method

To produce a method to assist emergency planners and other key stakeholders such as water management organisations and emergency responders (i.e. the police and fire brigade) to assess, develop and improve emergency plans for flood events.

3.1.2 Field of application

Crisis management; Emergency planning; Risk reduction

3.1.3 How to apply the method

Input and resources

The method developed requires the input of the key stakeholders via one or two one-day workshops. No other resources are required. The workshops held need to have the following steps:

(iv) **Appraise** - Identify aspects of the plan on which to concentrate during the workshop
(v) **Tackle** - Describe the aspect(s) of the plan identified for improvement and identify potential issues. After this potential resolving actions are identified. This is done by the development of entity diagrams and cross-tables
(vi) **Implement** – agree actions to update the plan

To what extent the actions in the implementation plans are carried out is dependent upon the resources available to the relevant stakeholders.

Expected results

The application of the FIM FRAME method allows the following to be established for an emergency plan for floods:

- Weaknesses and gaps in the plan. This is done by applying 22 metrics that have been developed as part of the project
- To establish how the plan can be improved in some cases by the application of tools (e.g. checklists, guidance documents or software)
- To identify what tools are available to emergency managers to assist them in improving plans

The method can also be used to develop new plans. The overall result will be an improvement in emergency plans and this will in turn help to improve the resilience of communities to major flood events.

Assessment of results

The measurement of a successful application is if after the method has been applied the emergency plan is further refined to fill the gaps and strengthen the weaknesses in it.

Scale of application

The method produced is not scale specific it can be applied to local scale, regional and national plans.

Degree of implementation

The method will be implemented by emergency planners, emergency responders, flood risk managers

3.1.4 Example

The FIM FRAME method was applied successfully in four cases studies in England, France and the Netherlands (see Annex C for more details). The example of stakeholders developing an entity diagram that is part of the "tackle" step of the method to risks to vulnerable people is shown in Figure 3.1.

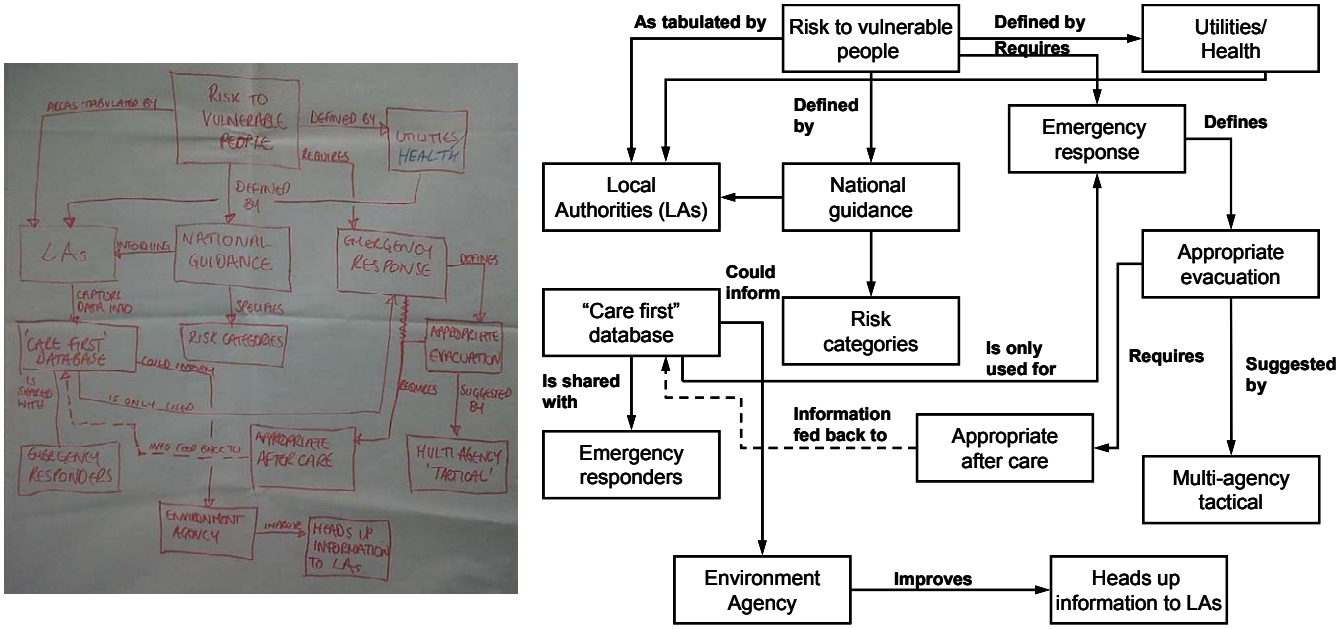


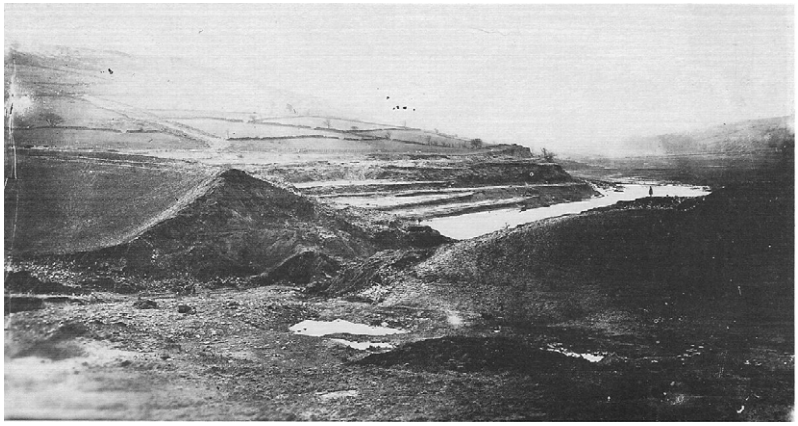
Figure 3.1 Entity diagram developed at a workshop to look at 'risks to vulnerable people'

4 Case studies

4.1 City of Sheffield, England

4.1.1 Main characteristics

Major type of flood: Surface water floods and dam failure
Past flood events: Dam failure, 1864; pluvial and fluvial flooding, 2007
Environmental setting: The case study focused on the city of Sheffield and the application of tools to assess the impact of the failure a dam near Sheffield
Socio-economic setting: The city of Sheffield has a population of approximately 547,000.



Photograph of the Dale Dyke Dam that failed in 1864

4.1.2 Level of stakeholder involvement

The following stakeholders were involved in the case study:

- Environment Agency who are responsible for flood risk management
- Local emergency planners responsible for writing the emergency plan
- The fire and rescue services
- The police

These stakeholders were engaged via a number of meetings and workshops.

4.1.3 CRUE activities

The FIM FRAME method was applied to the Multi-Agency Flood Plan (MAFP) that had been developed for Sheffield. The MAFP was scored using the developed metrics. The case study was used to refine the method. A breach scenario was created for a reservoir in the area. This helped raise awareness of the use of tools to improve emergency plans.

4.2 Tarascon, France

4.2.1 Main characteristics

Major type of flood: Fluvial and flash floods
Size of catchment area: 90,000 km²
Past flood events: December 2003
Environmental setting: Tarascon is located in the Rhone floodplain but is protected by flood defences. The dikes have failed in the past leading to flooding
Socio-economic setting: Tarascon has a population of 14,000 people and many industrial plants have been built in the floodplain

Tarascon during the 2003 floods

4.2.2 Level of stakeholder involvement

The municipality of Tarascon and fire brigade participated in a workshop held in January 2011. They hosted a researcher from March to June 2011. The fire services were closely linked with the research. The researcher seconded to the municipality assisted in drawing up flood maps for emergency planning management and looking at other flood scenarios including previous historical events.

4.2.3 CRUE activities

Tarascon has a well established flood emergency planning. The work carried out was aimed at improving the set of maps to enhance crisis management. An estimate of the flood risk to people for the commune was made. Another objective achieved by the case study was to “test” a scenario for a major flood and to map the informal knowledge of emergency managers.

4.3 Piolenc, France

4.3.1 Main characteristics

Major type of flood: Fluvial and flash floods
Size of catchment area: 54 km² for Rieu de foyro, 70,000 km^2 for the Rhone River and 1,100 km^2 for the Aygues River
Past flood events: 1994 on the Rhone, 2002 flash floods, 2003 on the Rhone
Environmental setting: Piolenc is a commune in the Vaucluse department in the Provence-Alpes-Côte d'Azur region in south-eastern France. It has a population of about 4,600.

Flooding in the centre of Piolenc during the 2002 floods

4.3.2 Level of stakeholder involvement

The municipal authority was involved in the preparation and the participation in a workshop in December 2010. Fire services at local and Département level participated in the workshop. These stakeholders agreed ways in which the current flood emergency plan could be improved.

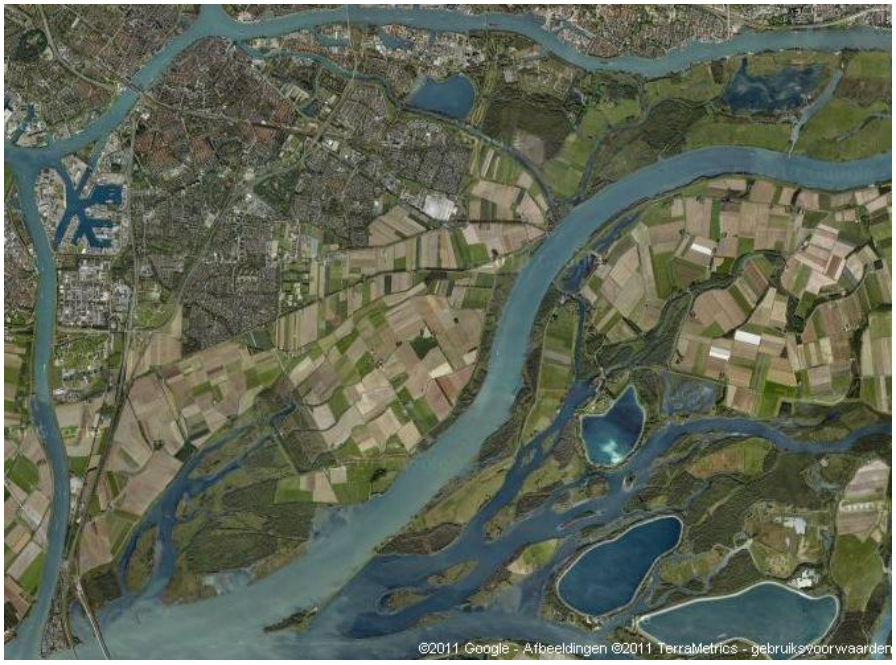
4.3.3 CRUE activities

It was found that the flood emergency plan for the Piolenc needed to be improved. The FIM FRAME method was applied to the plan. Ways in which the current plan could be improved were agreed with the stakeholders. One of these measures was the setting up of a flood warning system in the commune.

4.4 City of Dordrecht, The Netherlands

Major type of flood: A combination of fluvial and coastal
Past flood events: 1 February 1953

Environmental setting: The city of Dordrecht is located on an island in the Rhine estuary. The Island has an area of 90 km².
Socio-economic setting: Dordrecht is a city in the Dutch province of South Holland. It has approximately 118,000 inhabitants.



Aerial view of the city of Dordrecht

4.4.1 Level of stakeholder involvement

There was a high level of stakeholder involvement with the following stakeholders responsible for the emergency flood plan engaged through the research:

- City of Dordrecht
- Province of South Holland
- Police
- Fire brigade
- Water Board Hollandse Delta

4.4.2 CRUE activities

The FIM FRAME method was applied to the flood plans for Dordrecht. The focus was on the improvement of the evacuation strategy of the plan. Results from the workshop were used to refine the FIM FRAME method. In addition the evaluation of alternative evacuation strategies demonstrate the use of evacuation tools as a useful source to improve emergency plans.

5 Results and discussion

5.1 Introduction

The chapter summarises and discusses the results of the research that include the following:

- A consistent assessment approach to assessing emergency management plans for floods
- An improved understanding for emergency planning organisations and other stakeholders on what is considered to be a "fit for purpose" emergency plan
- A review and guidance on the tools that are currently available to assist in improving and developing emergency plans
- The development of a new framework, known as the FIM FRAME method that allows relevant stakeholders to assess and to improve emergency plans for floods
- The development of guidance for stakeholders using the results from case studies illustrating how the FIM FRAME method can be implemented

In order to get a full overview of the results the following stand-alone Annexes accompany this final report and that can also be downloaded from the FIM FRAME web site:

- Annex A covering the results of WP1 - The effectiveness and robustness of emergency plans for floods
- Annex B covering the findings of WP2 - Comparison of currently available tools and enabling technologies for the emergency planning of floods
- Annex C detailing the findings of WP4 - FIM FRAME case studies: England, France and the Netherlands
- Annex D covering the guidance document produced for the FIM FRAME method

5.2 Assessment of emergency plans for floods

To assess the "fitness for purpose" and effectiveness of emergency plans for floods the following tasks were carried out:

- Twenty-two metrics were developed to assess flood emergency plans. These fall into six categories as follow:
    1. Objectives, assumptions and target audience
    2. Organization and responsibility
    3. Communication
    4. Flood hazard
    5. Flood risk to receptors (e.g. people, buildings, critical infrastructure)
    6. Evacuation
- Thirty-eight flood emergency plans in England and Wales, France and the Netherlands were assessed using these metrics. The development of the metrics also allowed the plans to be "scored" in a quantitative manner
- An online survey was sent to stakeholders in England and Wales, France and the Netherlands. The questions focused on the requirements for information in the plan development stage, and its

usefulness and required level of detail. In total 208 people responsible for formulating and contributing to emergency plans responded to the survey
- Face-to-face meetings and consultations were held with emergency planners and responders in England and Wales, France and the Netherlands with regards to the effectiveness of emergency plans for floods

The review of the emergency plans found that there was often a lack of homogeneity between the emergency plans. Many of the plans reviewed had what could be classed as a large amount of generic "cut and paste" text on flooding but had limited text on local or regionally specific issues. It appears from the research that many of the responders would like more specific information especially with regards to the nature of the flood hazard and the accessibility of roads to emergency services and other vehicles for different flooding scenarios. In many densely populated areas it would be relatively easy to develop such maps for different probabilities of flood events.

Metrics related to organisational aspects of the plan such as: plan activation; roles and responsibilities; communication with other agencies; and target audience and updating scored well in all three countries. However, the assumptions made by the plans did not appear to be well defined. Details of previous floods although covered reasonably well in England and Wales, and France were not covered well in the Netherlands; this probably as a result of the fact there have been no major flood events in the Netherlands since 1953.

Metrics related to the possible impacts of floods on receptors such as businesses; critical infrastructure; people; vulnerable people and Natural Hazard Triggering a Technological Disaster (NaTech) all scored well below average in all three countries, as well as the metrics concerned with evacuation aspects. The metric covering the relationship between complementary plans in England and Wales scored "above average"; however, in France and the Netherlands this metric scored "below average" indicating that there may be a "disconnect" between different complementary plans and that if other plans are referenced there is often not a detailed or clear link provided to them.

As part of the online survey carried out the responders were asked to briefly list up to five criteria that they believed make a flood emergency management plan effective. The various responses for each country were grouped under generic headings. The top five generic responses are given in Table 5.1. In all three countries stakeholders indicated that for plans to be effective the roles and responsibilities should be clearly defined. One responder summed up that an effective flood emergency plan needed to have "*Roles and responsibilities clearly spelt out and agreed (with no assumptions made by any organisation)*".

The role of "trigger levels" also featured in many responses in all three countries. A trigger level can be defined as "an event causing the automatic invocation of a procedure". Many responders stated that for a plan to be effective clear triggers are needed to invoke actions and responses. Clarity, adaptability, accessibility and brevity of the plan were also mentioned by many responders as being important; however, the research found that the ease of navigation of a plan may actually play a more important part in its accessibility rather than its length.

Information on the flood hazard was also seen as important. Responders stated that they would like to see the inclusion of larger maps or maps showing more detail; maps highlighting "hotspots" and the inclusion of the flood maps on integrated GIS systems. Details of flood depths and velocities were also seen as important, as well as having a number of different flood scenarios.

Table 5.1 Criteria perceived by stakeholders to make a flood emergency plan effective

Rank	England and Wales	France	The Netherlands
1	Roles and responsibilities	Roles and responsibilities	Roles and responsibilities
2	Trigger levels	Trigger levels	Information on the flood hazard and related information
3	Information on the flood hazard	Information on the flood hazard	Clarity and accessibility of plans
4	Clarity and brevity of the plan	Adaptability and simplicity	Training in the use of the plan
5	Relationship with other plans	Training in the use of the plan	Trigger levels

The research found that there was a discrepancy between the level of detail required by emergency planners and the actual level of detail that is available within emergency plans for a number of issues. This discrepancy is less critical for the metrics related to communication and organisation. It can therefore be concluded that the emergency plans do not comply with the requirements on issues related to receptors such as critical infrastructure, people and buildings.

A detailed report has been produced as part of WP1 describing the work that has been carried out (see Annex A). This has been appended as Annex A to this report. A paper entitled "An assessment of flood emergency plans in England and Wales, France and the Netherlands" based on this work was published in the Natural Hazards Journal in July 2011. This paper is reproduced in Appendix C.

5.3 A review of currently available tools for the emergency planning of floods

A brief review of tools that are available in the three countries was carried out. The tools reviewed fall into the following categories:

- Guidelines and checklists
- Flood hazard mapping tools
- Tools related to assessing the risk to people, vehicles, evacuations times and safe havens

Research was undertaken with flood managers to gain an idea of the level of awareness that they had of the tools that have been developed and that could be potentially used to improve flood emergency plans. Stakeholders were engaged through two main methods:

- Face-to-face discussions and meetings
- An online survey in English, Dutch and French that was disseminated to flood managers within the three partner countries

For each of the countries the flood managers were asked about the tools, methods and guidelines that they currently use or knew of that could be of assistance in formulating emergency plans for floods.

The research also investigated what tools are actually being used by flood managers to help them inform emergency plans, and also the reasons why tools were not being used. Finally flood managers were asked to provide comments on tools, methods or guidance that could usefully contribute to improving emergency plans for floods. In England and Wales there was 53 Environment Agency staff who responded to the survey of which 39 completed all the questions. In France 77 flood managers commenced the survey with 31 people completing all the questions. It is important to note that in the

Netherlands the response rate to the survey was low. There were eight responses of which five people worked for a Dutch research institute who produce tools for flood risk management.

From the research carried out many flood managers are often not aware of the tools that are available to assist them in providing information to emergency plans for floods. Based on the online survey of flood managers in the three countries, the two main obstacles to tools not being used appear to be:

1. Lack of awareness of the methods that are available
2. Availability of data

In formulating emergency plans for floods it would appear that "expert judgement" is often used rather than specific tools. Many responders to the survey mentioned that they used a combination of information rather than specific methods or tools. For example in the survey in England and Wales around half to a third of the responders stated that they were aware of or used the following methods to inform Multi-Agency Flood Plans (MAFPs):

- Accessibility of inundated roads
- Optimisation of the location of shelters
- Damage to critical infrastructure
- Optimal evacuation routes
- Effects of improvements in flood warning on the risk to people
- Methods to assess potential injuries and loss of life

However, none of the 44 responders who are involved in providing information to assist with the formulation of MAFPs explicitly mentioned any methods or tools that provide such information.

In France the awareness level of the tools and methods available would appear to be lower than that in England and Wales and the Netherlands. The lack of awareness in general may be as a result of a need to improve the dissemination of the tools and the relevant research. The lack of awareness of tools to assess the consequences of flooding or to assess potential damage has already been pointed out in many articles and reports in France (Hubert & Ledoux, 1999).

In all three countries there would appear to be a requirement for some form of guidance on what tools are available, what data they require and how they can be implemented to give information that can be used to improve emergency plans for floods. A detailed report has been produced as part of WP2 describing the work that has been carried out. This has been appended as Annex B to this report. A paper entitled "Tools to improve the production of emergency plans for floods – are they being used by the people that need them?" is to be published in the Journal of Crisis and Contingencies Management later in 2011. This paper is reproduced in Appendix D.

5.4 Development of the FIM FRAME method to improve and develop emergency plans for floods

A framework, known as the FIM FRAME method, for preparing or enhancing a flood emergency management plan, has been developed. This method has been designed to be:

- Simple, to be applied by anyone without specific training
- Transportable, to be applied independently anywhere and by any flood emergency management team
- Generic, to allow it to be adapted by the user for their specific purpose

The FIM FRAME method is structured in three steps:

1. Appraise – applying the metrics to 'flag up' general issues
2. Tackle - structuring\de-structuring the process and identifying specific issues
3. Implement - taking actions forward and updating the plan

The framework has been based on methods developed by Mayon-White and Dyer (1997). Figure 5.1 shows a diagram of the developed framework.

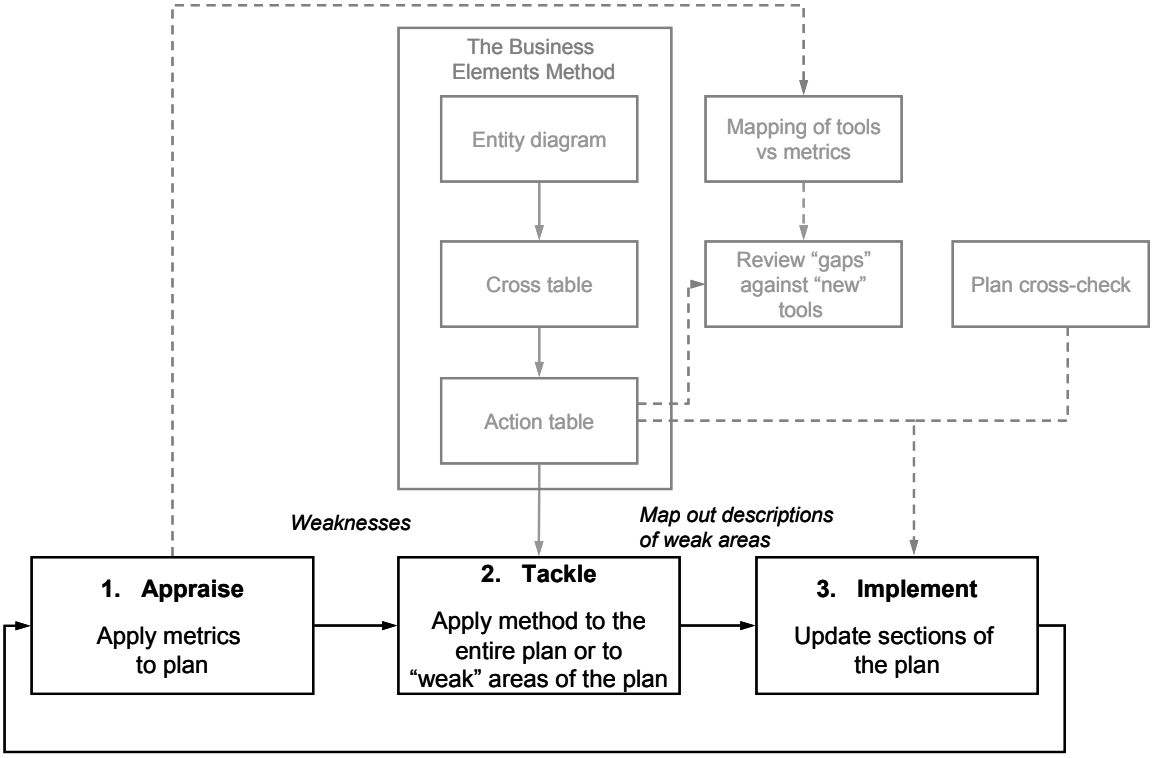


Figure 5.1 Diagram of the proposed framework

The three steps do not need to be applied sequentially and the framework can be used by starting from any of them. For example, if no plan is in place the framework can be applied starting from step 2. If some issues have already been identified e.g. as result of a post-emergency appraisal or an exercise, then the starting point could be step 3. The framework can also be used to re-appraise a plan after its last update. The guidance document produced as part of this work should be referred to gain a fuller understanding of the FIM FRAME method (see Annex D).

5.4.1 Step 1 -"Appraise" - Apply metrics to identify general issues or weaknesses

In order to appraise an emergency plan for floods 22 metrics were developed. The set of metrics developed can be:

- Applied to emergency plans for floods at a range of geographical scales ranging from a regional to local level
- Generic but at the same time be clear and focused to avoid misinterpretation
- Measurable

The metrics used to appraise a plan are given in Appendix B in this report. The metrics allow for the plans to be "scored" in a quantitative manner. For example a score of "1" would be given for a metric where the level of detail is low"; "2" where the level of detail is medium and "3" where the metric is treated in a high level of detail. By averaging the metric scores, an overall score of a plan can be obtained. In addition the average score per metric for the evaluated plans gives an insight into which metrics are addressed within the plans and to what level of detail. The average scoring range for the developed metrics was divided into five equally distributed bands between a score of 1 and 3. These scoring bands are given in Appendix B of this report.

It is important to note that if a metric is not covered in an emergency plan for a flood but is included and covered in sufficient detail in a clearly referenced, complementary plan then the metric should score a "3" (i.e. a high level of detail). For example in the case of the metric for "evacuation routes" if these are clearly shown in a generic evacuation plan that covers a wide range of hazards and this evacuation plan is clearly referenced in the emergency plan for floods then the "Evacuation routes" metric should score a "3".

The appraisal of the plan consists of assessing the plan against the metrics developed. This appraisal achieves an initial understanding on how the plan is likely to perform and what are the main weaknesses.

5.4.2 Step 2 - "Tackle" - structuring\de-structuring the process and identifying specific issues

Stage 2 ('Tackle') is based on an interpretation of how the 'Business Elements Method' could be applied for emergency planning (Mayon-White and Dyer, 1997). The Business Elements Method (BEM) is a tried and tested guide for analysing any process (or event); in this case the flood emergency plan. This method consists in examining the process in terms of five factors:

- Processes and procedures
- Roles and responsibilities
- Data and information
- Tools
- Audit

Considering these elements can help to produce a clearer picture of the process, and assist in gaining an understanding of the interdependencies between the different components. This can help to identify possible issues and provide a clear understanding of how to address these and how these can affect the process if they are not addressed.

This step can be performed for the whole plan or just for particular aspects, (e.g. for metrics that obtained a low score in the "Appraise" step). The "Tackle" step aims to go through specific processes (or components of the plan) and expand them into their constituent "items or entities", each of these being analysed both individually and in combination with the other items they are linked to. This analysis is based on the application of the five factors of the Business Elements Method that have been adapted to comprise three subsequent steps:

(i) Describe the process - the **Entity diagram**
(ii) Process\Responsibilities\Tools\Information - the **Cross-table**
(iii) Identify and tackle the issues – the **Action table**

For each of these steps there corresponds a specific outcome: the Entity diagram, the Cross-table and the Action table; the latter will be used as the basis for the implementation and the updating of the plan as part of Step 3 – "Implement". Further details of the method and examples are provided in the Guidance document produced.

5.4.3 Step 3 "Implement" - taking actions forward

This step should start from the issues and relative actions identified by the Action table. It can also start from specific issues identified elsewhere, e.g. directly through the appraisal of the metrics or by other means e.g. a post-event assessment. This step should include:

a. Plan cross-check, to identify specific parts of the plans that cover (or should cover) the issue.
b. Update the section of the plans, identifying detailed measures that should be taken to include the specific issue in the plan or to modify the plan so that the specific issue is covered.
c. Reviewing the action list and push forward the implementation plan.

Once the issue is described and the Tackling Actions identified in the Action Table, the Implementation part of the table needs to be filled in. For each of the identified Actions, the following need to be specified:

Priority	What is the degree of importance of the particular actions (in terms of High, Medium, and Low) and\or what is the sequential order in the list of actions (whether this action needs to be done in 1st place, 2nd, 3rd...)
Resources	What are the resources needed (in terms of time, people and\or money) for fulfilling this action and where\how these resources are secured
Timeline	List of specific sub-actions with relative timelines
Plan to be updated?	The answer can simply be YES\NO. This column simply aims to capture any actions that should result in an update of the plan

This step will translate the actions identified in the Action table into specific measures of implementation into the plans, including identifying a timeline for the implementation of the measures and resources that are needed for the implementations. The whole table, supported by the Entity Diagram and the Cross-Table, will also provide strong and documented evidence of the reason for which the actions, and relative resources, are needed.

This can provide:

- A strong business case that will help to put the actions into practice by demonstrating the importance of securing resources
- A 'to do' list that can help prioritise the actions, if resources are limited, and tacke the most important issues first
- Evidence for demonstrating the importance of the identified actions to those involved in the planning process, helping to engage with them and gaining a collaborative attitude

The proposed framework was tested in a workshop held with emergency planners and responders in England and Wales. It was then used in four other workshops in England, France and the Netherlands. The outcome of these workshops was used to refine the FIM FRAME method. The FIM FRAME method has been set up to be generically applicable.

Feedback from stakeholders at the initial workshops indicated that the method had the following benefits:

- Good for identifying gaps and assumptions
- Provides a logical method for analysing plans
- Allows the collection and collation of detailed information required for flood emergency plans and also provides a gap analysis at the same time

Feedback from the initial workshop indicated that although the method was found to be useful in analysing gaps in and improving emergency plans the method needed to be "streamlined" in order to make it simpler

to use. This was achieved by shortening and simplifying the handout describing the framework, and by providing examples of the entity diagram and cross table to facilitate the workshop discussions and application of the method.

5.5 Dissemination of the research

The dissemination activities were important if the project was to be successful. Details of the research activities carried out as part of the project detailed in Table 5.2.

Table 5.2 Dissemination activities

Date	Place	Description
September 2009 to date	Sheffield, England	Ongoing dialogue and dissemination with stakeholders in the Sheffield case study area
September 2009	Wallingford, England	Meeting with Environment Agency flood incident staff to discuss the metrics and outputs of project
October 2009	Rome, Italy	Presentation of FIM Frame project at the ERA NET CRUE Rome meeting
October 2009	Not applicable	Project web site www.fimframe.net set up
November 2009	Ipswich, England	Meeting with emergency planners
November 2009 to January 2010	Throughout France	Face to face meetings held with emergency planners to discuss the metrics and the output of the project
November 2009	Throughout the Netherlands	Various face to face meetings with emergency planners held by the project team
December 2009	Paris, France	Meeting held with project partners to disseminate the objectives, direction and outputs of the project
December 2009	Wallingford, England	Meeting with Environment Agency flood incident staff to discuss outputs of project
December 2009	Sheffield, England	Meeting held with stakeholders in Sheffield case study area to discuss the project and disseminate the objectives
January 2010	Throughout the England and Wales	On line survey in English sent to emergency managers
January 2010	Throughout France	On line survey in French sent to emergency planners
January 2010	Throughout the Netherlands	On line survey in Dutch sent to emergency planners
January 2010	Throughout England and Wales	On line survey in English sent to flood risk managers
January 2010	Throughout France	On line survey in French sent to flood risk managers
January 2010	Throughout the Netherlands	On line survey in Dutch sent to flood risk managers
February	Reading, England	Meeting held with Environment Agency staff to disseminate the objectives of the research and the development of the metrics

Table 5.2 Dissemination of the research - continued

Date	Place	Description
March 2010	Birmingham, England	Meeting held with UK Project Board to review project progress, particularly the WP1 and WP2 draft reports
May 2010	Not applicable	Production of report detailing WP1 work disseminated to relevant stakeholders
May 2010	Not applicable	Production of report detailing WP2 work disseminated to relevant stakeholders
May 2010	Roche Sur Yon, France	One day meeting with emergency services to discuss the use of enabling technologies and tools in the production of emergency plans for floods
June 2010	Not applicable	Production of note on proposed framework disseminated to relevant end users
June to September 2010	Gard Département, France	Various meetings with emergency managers for the production of PCSs. Report produced and disseminated in France
June to September 2010	Herault Département, France	Meetings with various mayors responsible for emergency planning. Report produced and disseminated in France
June to September 2010	Orb River basin, France	Various meetings with emergency managers for the production of PCSs. Report produced and disseminated in France
June 2010	Throughout France	Short ten page briefing note produced in French to disseminate the results of WP1 and WP2 to French stakeholders
June 2010	Sheffield, England and Wales	Meeting held with the fire service and emergency planners to discuss enabling technologies that could be used in the case study
July 2010	Ipswich, England and Wales	Workshop for testing proposed framework
July 2010	Roche Sur Yon, France	Meeting with emergency planners
August 2010	Not applicable	Paper entitled “Agent-based modelling to inform flood emergency planning and management” accepted for publication in the Journal of Emergency Management
October 2010	Madrid, Spain	Presentation of FIM FRAME project at the ERA NET CRUE Madrid meeting
November 2010	Dordrecht, The Netherlands	FIM FRAME project results presented at the Workshop on assessing the FIM Frame method with stakeholders.
November 2010	Utrecht, The Netherlands	FIM FRAME project results presented at the Workshop on assessing the FIM FRAME method with stakeholders.
December, 2010	Piolenc, France	Workshop on the application of FIM FRAME method on the PCS of Piolenc
January 2011	Tarascon, France	Workshop on the application of FIM FRAME method on the PCS of Tarascon
January 2011	Montpellier, France	Two day conference with 185 participants, who were mostly emergency planners, held at the University of Montpellier III
January/February 2011	Ourika Valley Authority, Morocco	Assessment of flash flood forecasting and management in Ourika Valley. Workshop on applying FIM FRAME method o the flood management issues

Table 5.2 Dissemination of the research - continued

Date	Place	Description
February 2011	Not applicable	Submission of a paper on an analysis of loss of life during two recent floods in France to the Natural Hazards Journal
January to July 2011	Tarascon and neighbouring communes, France	Various meetings with emergency managers to discuss tools that could improve the PCSs
March 2011	Mayotte Island, Indian Ocean	Assessment of the tsunami emergency response in Mayotte Island in the Indian Ocean. Meeting with stakeholders based on FIM FRAME method analysis
March 2011	Paris, France	FIM FRAME meeting held in Paris
April 2011	Sheffield, England	Workshop held with Local Resilience Forum in Sheffield
June 2011	Delft. The Netherlands	Presentation of FIM Frame project results at Deltares.
June 2011	Montpellier, France	Public Presentation by research student entitled: "optimisation des PCS et de la gestion du risqué inondation au moyen d'outils SIG dans le Grand Delta du Rhône". at the University of Montpellier and in Tarascon.
June 2011	Not applicable	Four fact sheets produced for the case studies that were carried out
July 2011	Tarascon, France	Face to face meeting in Tarascon to discuss the conclusions of FIM FRAME report
July 2011	Not applicable	Paper entitled "An assessment of flood emergency plans in England and Wales, France and the Netherlands" published in the Journal of Natural Hazards
August 2011	Not applicable	Paper produced entitled "Tools to improve the production of emergency plans for floods – are they being used by the people that need them?" submitted and pending publication in the Journal of Contingencies and Crisis Management
August 2011	Not applicable	Guidance document on FIM FRAME method produced
August 2011	Not applicable	Report on case studies produced
August 2011	Not applicable	Production of the final FIM FRAME report
September 2011	Montpellier, France	Public Presentation of the research report entitled "La submersion marine en Languedoc-Roussillon : analyse de sa prise en compte au sein des Plans Communaux de Sauvegarde" at the University of Montpellier
September 2011	The Netherlands	Article on the project results for a popular Dutch magazine aimed at emergency planners or water managers (in progress)
September 2011	The Netherlands	Presentation of the project results to the Ministry of Transport, Public Works and Water Management
September 2011	London, England	Final workshop with key stakeholders in England and Wales
September 2011	Graz, Austria	Final ERA NET CRUE meeting and presentation at the final conference
October 2011	Throughout Rhone valley, France	General training exercise emergency planning for floods in the Rhone Valley
November 2011	Tarascon, France	Meeting with the Tarascon Commune and the University of Montpellier and local stakeholders to disseminate the FIM FRAME project results
December 2011	France	Translation of guidance document into French

5.6 Specific outcomes and lessons learned

The specific outcomes and lessons learned are summarised in the box below.

Specific outcomes

- Twenty two metrics were developed that allow emergency plans to be assessed and their fitness for purpose quantified
- FIM FRAME method produced to analyse and strengthen emergency plans
- Piloting of the FIM FRAME method in four case studies in England, France and the Netherland with a wide variety of stakeholders
- Guidance document produced detailing the FIM FRAME method
- Dissemination of the method via a wide variety of routes

Lessons learned

There is currently a need to have simple metrics via which emergency plans for floods can be assessed as well as a generic method to help develop new and improved existing plans. The consultation with a range of stakeholders helped to produce a relatively simple method that fills these gaps. The research illustrated the importance of working closely with stakeholders when developing such methods.

6 Contribution of the project to the overarching topics of the call

This chapter details how the work carried out contributed to the following overarching topics related to the ERA-NET CRUE call.

6.1 Connection to the Floods Directive

In terms of the implementation of the preliminary flood risk assessment and the flood hazard and flood risk maps that form part of the Floods Directive (2007/60/EC), these are not applicable to this research. However, the research will contribute to the production and implementation of flood risk management plans. Flood risk management plans should focus on prevention, protection and preparedness (EC, 2007); this encompasses emergency plans and planning, particularly the impacts on receptors.

The results of the research undertaken to date, including the online surveys, give a good overview of the aspects of emergency planning that need to be improved within each of the three countries. The research has shown that often tools (e.g. software, guidelines and methods) which can produce useful information to improve emergency plans are often not currently being used by emergency planners. The FIM FRAME method produced by the research provides emergency planners with a simple and flexible instrument for evaluating and improving their emergency plans across Europe.

The work that has been carried out brings the different tools developed within the FIM Frame project together and provides an easy to use method for evaluating and improving the emergency plans and process. These outputs will help to improve flood risk management plans.

6.2 Participation

From the start of the project, close contact has been maintained with the affected parties. This has been done through the face-to-face interviews, through internet surveys asking the affected parties for their input, opinion and experiences, through a number of workshops and by holding two conferences attended by approximately 180 emergency planners. This has resulted in a high level of participation in the research. The research has been carried out in close cooperation with the Environment Agency, the Dutch National Water Board and emergency planners in England and Wales, France and the Netherlands. The contact with the affected parties has impacted the development of the surveys used in the research and the development of the FIM FRAME method so that it is compatible for the needs of emergency planners, emergency responders and flood risk managers.

In all three countries the general public are currently not directly involved in the creation of emergency plans for floods. However, the FIM FRAME method that has been developed as part of the research could help to facilitate the process of engaging the public in the future. The project has and will contribute valuable lessons to public authorities/institutions. For example, the research has shown that at present emergency plans for floods tend to be inconsistent and are not always “fit for purpose”. The method produced as part of the research will help to bring together the stakeholders responsible for producing emergency plans such as the Environment Agency in England and Wales, Water Boards in the Netherlands and local authorities in France. The research has also shown that enabling technologies,

such as tools, the results of which can help to improve the content of emergency plans are generally not being used by flood managers and emergency planners. The case studies and guidance that are being produced as part of this research will help to improve this situation.

The principles of good governance suggest that this must be: coherent (with good communications between all parties); proportional; open (with access to information); effective; participatory and engaging. Recent flooding in Europe (e.g. England 2007 and France 2010) has highlighted that currently local responses to flood events are often too reactive and may not meet the needs of communities. Proactive action is necessary to support communities. The research has produced metrics that allow authorities to assess the strengths and weaknesses of their emergency plans. The FIM FRAME method provides a generic method for improving and formulating emergency plans for floods. The method should contribute to good governance in the countries where it is being developed as many of the people responsible for the implementation of emergency plans in all three countries are elected officials.

The project has also helped to contribute to good governance by helping to ensure that all the relevant stakeholders can be heard and have fair access to the decision making processes when emergency plans for floods are drawn up. The FIM FRAME method enables relevant stakeholders to understand how the plan has been produced and how it can be improved.

6.3 Harmonisation

Although it is seen from the case studies that a wide range of flood situations occur across Europe, the way emergency planning is tackled, shows many similarities. The generic FIM FRAME method has been developed to support the emergency planning in a uniform manner which will assist harmonisation. The results of the research with stakeholders showed that there is a concern amongst emergency planners about the lack of consistency and the gap between national and local scale emergency plans. The framework that is being produced is generic and it can be used for both national and local emergency planning, and allow site-specific parts of flood plans to be considered in more detail, whilst remaining within the bounds of the overall plan. This will also help to aid harmonisation between emergency plans for floods produced at different scales (e.g. local, regional and national).

6.4 Restrictions

The FIM FRAME method produced by the research is not scale or flood specific as such it is not restricted by social/political/economic characteristics of the area being planned for, the type of flood or uncertainties. In selecting the case studies, the project team sought to choose different types of flood hazards (e.g. fluvial, coastal, surface water and dam break floods) as well as different flood risks (e.g. people, properties). This has allowed the outputs from the research to be tested against as many different flooding combinations as possible. The developed FIM FRAME method is designed to be generic and cut across the national differences and will provide a consistent appraisal methodology and guidance. This has been demonstrated by the fact that staff at the University of Montpellier III have applied the FIM FRAME method in the Island of Mayotte in the Indian Ocean and also in Morocco. The FIM FRAME method to date remains untested for the development of new emergency plans for floods.

6.5 Enhancement of resilience

The project has contributed to the enhancement of the resilience and adaptive capacity of a range of stakeholders. The focus of the project has been on producing a method to evaluate and improve emergency plans. The metrics that have been developed as part of the project allow the “quality” of an emergency plan for floods to be quantified. This helps stakeholders to assess the effectiveness of the

plan, identify gaps and improve the plan which helps to improve the resilience of the community to extreme flood events.

7 Implications for stakeholders

Research has shown that the demand for information during an emergency usually accelerates at a rate far above that of supply. This leads to what may be termed a "demand-provision gap" (MacFarlane, 2005) or "information gap". In most cases this is not because the information does not exist, but because it is not actually included in an emergency plan and thus often not accessible at the point and time of need. The key question that needed to be addressed in England and Wales, France and the Netherlands was how it can be established if emergency plans for floods are "complete" or comprehensive in order to reduce the information gap as much as possible. Figure 7.1 shows that the "information gap" can be reduced by improving an emergency plan.

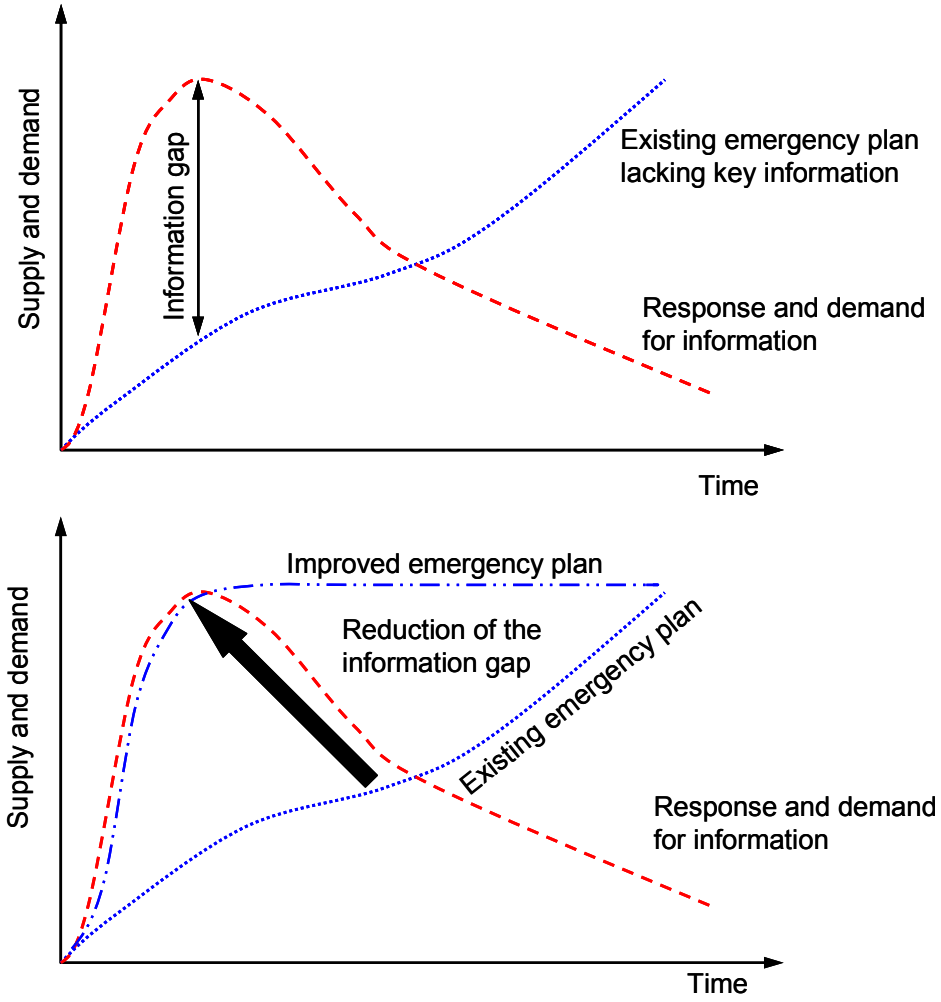


Figure 7.1 The "information demand provision gap" during an emergency event

The implications for the stakeholders responsible for emergency planning for floods are as follows:

- The research found there to be a discrepancy between the level of detail required by emergency planners and the actual level of detail that is available within emergency plans for a number of issues. In some cases emergency planners need to work more closely with flood risk managers to fill these gaps
- There is also some times a case of division of responsibility. For example in the case of certain aspects of flood risk management (e.g. estimation of loss of life; evacuation times) it is not always clear who should take the lead (i.e. flood risk managers or emergency planners). This may be because some of the types of tools for improving emergency plans are perceived to fall outside the remit of all the stakeholders. This can mean that tools are not used because there is a "responsibility gap" through which the use of the tools falls.

The floods of 2007 in England and the failure of coastal defences resulting in 47 fatalities in the Vendée region of France show that the two countries remain unprepared for extreme flood events (Pitt, 2008 and MEEDDM, 2011). A recent report on critical infrastructure by the Institution of Civil Engineers (ICE) in the UK provides the following example showing that the concept of planning for the "worst case" or "possibilism" is often not considered. The ICE report illustrates the failure to plan with the example of the Atomic Weapons Establishment site at Burghfield in the UK that was flooded in 2007. All the radiation detection alarms were disabled. If the floodwaters had penetrated only a little further it could have led to the spread of radioactive material, forcing the evacuation of thousands of people and leaving the area near the site uninhabitable for centuries (ICE, 2009).

In the face of low probability events some emergency planning organisations may suffer from poor "intelligence" gathering and processing or even a "*it can't happen here*" mentality (McConnell & Drennan, 2006). However, as the cases of New Orleans in 2005 and the "Great North Sea floods" that hit Britain and the Netherlands in 1953 demonstrate that such extreme events do occur. Emergency planning should be based on a wide variety of scenarios including extreme floods. Even for the worst credible flood there are in some cases simple measures that are not always "obvious" that can be demonstrated using relatively simple tools (e.g. location of safest routes to flooded zones; optimum location of shelters).

The research found that the two main obstacles to tools not being used to improve emergency plans for floods were:

1. Lack of awareness of the methods that are available
2. Availability of data

In formulating emergency plans for floods it would appear that "expert judgement" is often used by stakeholders rather than specific tools. There is a need for the training of stakeholders in tools that help to improve emergency plans especially more "technical" tools that can assess the following:

- Accessibility of inundated roads
- Optimisation of the location of shelters and safe havens
- Damage to critical infrastructure
- Optimal evacuation routes
- Effects of improvements in flood warning on the risk to people
- Methods to assess potential injuries and loss of life

Although the use of expert judgement is an important part of dealing with flood events and compiling emergency plans, there is a need to challenge 'accepted knowledge' from time to time to ensure that it is still fit for purpose. Therefore, although the FIM FRAME method was sometimes viewed as being too time-consuming, it does allow stakeholders to challenge their accepted procedures and views and to audit the procedures they are currently working with.

8 Policy recommendations (National/European level) and further research needs

8.1 Policy recommendations

The following recommendations have been made:

Data related issues
Emergency plans for floods should be in the public domain. In England and Wales, France and the Netherlands this is the case for the majority of these types of plans. However, it is sometimes difficult to obtain the data. Some data related to "sensitive" sites such as dams, power stations and water treatment plants are often not readily available to emergency planners.

Policy related issues
Emergency plans produced for floods are often inconsistent. For example in France adjacent communes can have very different emergency plans. Discrepancies between different plans can cause problems when they are implemented. There needs to be an overarching organisation to ensure consistency of plans and also to ensure that different plans covering different spatial areas or topics are correctly linked and consistent.

Emergency plans for floods often deal with a limited number of scenarios. This means that the emergency plans produced often do not deal with the concept of "possiblism" i.e. thinking in terms of "worst cases" and that which is possible. This is potentially more enlightening for emergency planners. Possibilism and counterfactuals ("what if" scenarios) offer the promise of thinking "outside of the box". They disrupt routine thought patterns, stretch the imagination and potentially produce creative solutions, which can allow people to make systems more resilient and can even promote social betterment (Clarke, 2006). Policy makers should ensure that plans take into account "possiblism".

Scientific related issues
Stakeholder groups involved in the overall management of floods should review their own use of tools, both in the formulation of plans and in managing the emergency response. Reasons for not using certain tools should be documented and agreed. Requirements for additional information or tools should be communicated to those responsible for commissioning such services, so that opportunities for filling these gaps can be investigated.

There is also a need to establish common databases and GISs. Many emergency planners at a local level do not have access to these or data sets showing critical infrastructure (such as water treatment plants, power stations). Access to these tools would help to improve the consistency of emergency plans.

Practitioner related issues
Practitioners should audit their use, or lack of use, of tools and should proactively seek further information to enable them to make an informed decision on whether to utilise them. In this regard, practitioners require more training in the types of tools that are available to help them improve their plans.

At the very least, practitioners should be encouraged to apply the 22 metrics to their plans, since this does not require a significant input, and to review the scores and whether any update is necessary.

8.2 Further research needs

The following research is required to further assist the improvement of emergency plans for floods:

- Further development, refinement and testing of the metrics by which the emergency plans can be assessed
- A wider assessment of emergency plans. Although as part of the research some 38 emergency plans were assessed, there is a need for an assessment of more plans especially in France where there will be approximately 10,000 PCSs being produced
- A refinement of the FIM FRAME method is required. This would require further work with the stakeholders at a number of workshops
- There is clear need to provide further simple tools (e.g. checklist, guidance and software) via which emergency plans can be improved. Many flood risk managers would appear to be unaware of the tools that are available to them to help strengthen and improve plans
- Following major floods there is a requirement for further research to identify the strengths and the weaknesses of plans. It is often only possible to fully assess the effectiveness of a plan once it has been used to respond to a major event
- A methodology could be produced to assist the capture of information following a major flood event, that would then be used in the application of the FIM FRAME method
- The FIM FRAME method should be used to develop new emergency plans in order to further refine it for this purpose

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Appendix A

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Appendix B

Table B1 Metrics for the appraisal of emergency plans for floods – Part 1

Metric	Level of detail		
	Low	Medium	High
Objectives, assumptions and target audience			
Aims and objectives of plan	Not detailed	Aims and objectives included but could be clarified further	Clearly stated aims and objectives including the area covered, types and sources of flooding
Target audience and updating of the plan	Not detailed	Audience defined and plan dated	Audience defined and how they will be notified of updates and modifications to the plan included
Assumptions made by the plan	Not detailed	Covers some aspects	Covers all aspects including: flood warning lead time; method by which rescue will be undertaken; implications of the failure of critical infrastructure
Organisation and responsibilities			
Actions, roles and responsibilities	Not detailed	Brief details of the roles and responsibilities related to the activation of the plan provided	Details of the roles and responsibilities related to the activation of the plan provided including health and safety and environmental considerations
Recovery	Not detailed	Brief details of how the recovery is managed	Details of how the recovery is managed including clean up, waste disposal, repairs to public assets, humanitarian assistance
Training and exercises	Not detailed	Brief details of training and exercise requirements	Internal and external (with other organisations) training and exercises outlined
Plan activation	Not detailed	Brief description of the thresholds or levels used to activate plan	Description of the thresholds or levels used to activate plan together with flow chart
Communication			
Communication with other agencies	Not detailed	Outlined in words	Detailed and the links shown diagrammatically
Communication with the public	Not detailed	Outlined in words	Detailed and shown the links shown diagrammatically
Management of the media	Not detailed	Outline media management strategy in place	Well defined media management strategy in place
Flood warning (if available)	Undefined	Levels of flood warning with details of the areas flooded at each level	Levels of flood warning with details of the areas flooded at each level and shown on a map
Relationship with complementary emergency plans detailed	Not detailed	Outlined in words	Detailed and the links shown diagrammatically

Table B1 Metrics for the assessment of emergency plans for floods – Part 2

Metric	Level of detail		
	Low	Medium	High
Evacuation			
Evacuation routes	Not detailed	Evacuation routes shown on a map	Evacuation routes detailed together with roads likely to be closed and their accessibility for emergency vehicles and other vehicles
Shelters/Safe havens	Not detailed	Safe havens/shelters shown on a map	Safe havens/shelters shown on a map with their capacity and facilities
Flood hazard			
Flood hazard map	Not detailed	Flood hazard map(s) showing extent	Flood hazard map(s) showing water depth and velocity
Details of previous floods (if available)	Not detailed	Brief description of historical flood	Description of historical floods with the cause and a brief description of the risk in terms of people and properties affected
Flood risk to receptors			
Flood risk to people	Not detailed	Number of people potentially affected included	Potential injuries and loss of life included and mapped for a range of scenarios
Flood risk to vulnerable people (e.g. elderly or disabled)	Not detailed	Areas where elderly/sick people live mapped	Numbers of vulnerable people defined with a response strategy
Flood risk to residential property	Not detailed	Number of properties defined	Number of properties defined together with those at risk of collapsing during an extreme flood
Flood risk to businesses	Not detailed	Number of businesses defined	Number and type of businesses defined together with potential losses
Flood risk to critical infrastructure (e.g. water supply, gas, electricity, police, fire brigade)	Not detailed	Number of pieces of critical infrastructure shown on the flood map(s)	Number of pieces critical infrastructure shown on the flood map(s) and an assessment of their likelihood of failure during a flood
Potential for NaTech hazards at industrial facilities (if present)*	Not detailed	Potential NaTech sites shown on map	Potential NaTech sites shown on map and brief details of the response

*Note: A NaTech is defined as technological hazard that is triggered by a natural hazard. For example the flooding of an industrial plant may lead to the release of a toxic chemical that poses a threat to humans, as well as flora and fauna

Table B2 Scores for the emergency plan

Average score	Average quality	Description to determine the quality of the flood emergency management plan
2.6 to 3.0	Good	There is little or no further information that could have been included in the plan. This can be considered as a 'Good' score with little room for improvement.
2.2 to <2.6	Above average	There is some further information that could have been included in the plan. This could be considered an "Above average" score.
1.8 to <2.2	Average	Considerably more information could have been included in the plan. This could be considered an "Average" score.
1.4 to <1.8	Room for improvement	There is information missing from the plan. There is "Room for improvement".
1.0 to <1.4	Considerable room for improvement	There is a large amount of additional information that could be included in the plan. There is "Considerable room for improvement".

Appendix C - Paper published in Natural Hazards Journal, July 2011

An assessment of flood emergency plans in England and Wales, France and the Netherlands

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Abstract

This paper details research carried out in England and Wales, France and the Netherlands on the evaluation of emergency plans for floods. To assess the flood emergency plans 22 metrics were developed. These metrics covered a range of issues from the aims and objectives of the plan to training and exercises. A number of emergency plans in each of the three countries were reviewed using these metrics and online surveys of emergency planners were carried out. The objectives of the surveys were to establish what information emergency planners believe is useful to incorporate in emergency plans and at what level of detail.

The developed metrics and survey of end users provided a basis to compare emergency plans. The effectiveness of an emergency plan is difficult to measure and end users often stated that this can only be assessed accurately after a plan has been used. Many emergency planners indicated that a well defined description of the roles, responsibilities and communication is essential for a plan to be effective. These aspects tended to be well covered in the evaluated plans. However, other more technical aspects such as accessibility of roads, evacuation, depiction of the flood hazard and impacts of floods on critical infrastructure can be considerably improved. The main challenge for emergency planners is to avoid filling plans with generic text and to provide an appropriate level of specific detail in the plan whilst ensuring the "usability" of the plan.

Key words
assessment; emergency plans; metrics; floods

1. Introduction

During the last two decades flood risk management policies in many European Union countries have evolved significantly (Tapsell & Ball, 2007). The paradigm of attempting to reduce the flood risk as much as possible purely through structural measures has progressively been overtaken by a more holistic approach to flood risk management (Lagadec, 2002). The management of the residual risks has become a priority for natural hazards such as floods. This shift in paradigm has led to more effort being focused on

producing emergency plans specifically for floods. The overarching aim of these plans is to allow communities to survive and recover as rapidly as possible from the effects of inundations.

Recently, the emergency management of floods in Europe has placed increasing importance on developing enhanced preparedness capacities. In this regard, the concept of emergency management has shifted from a primary focus on responding to the flood and its impacts to one of increased attention to communities becoming more resilient to the impacts of floods. The capacity to respond effectively remains important, however, emergency responders and planners are looking more intently at the earlier stages of emergency planning and how plans for floods can be improved. It is also important that these plans include preparations for low probability, high consequence events (Jonkman et al, 2005, Jonkman, 2007). In June and July 2007 England and Wales was hit by widespread flooding. A review of these floods found that the amount of information made available at the local level for emergency response planning was insufficient (Pitt, 2007). France has also been subject to a number of extreme floods over the past decade. The quality of the response to an emergency is only as effective as the reliability of the information which is available to inform the response (MacFarlane, 2005).

This paper describes research carried out in England and Wales, France and the Netherlands detailing how emergency plans for floods can be evaluated and thus improved. An emergency plan may be defined as a "*coordinated set of protocols for managing an adverse event, whether expected or untoward in the future*" (Alexander, 2005). Recent decades have seen significant increases in the number, scope and complexity of incidents and disasters. The process of constructing a written emergency plan is of great benefit to organisations that have to respond to an emergency (Fischer III, 1996). It is now generally agreed that for places that are significantly at risk of hazards authorities should be required to produce emergency plans (Alexander, 2005). Grunfest and Handmer (2001) also note that emergency planning is the best way to significantly reduce the loss of life from floods especially for flash floods where lead times are short.

The assessment of crisis management processes and emergency plans is fundamental for their improvement; however, most theorists and practitioners pay only a passing reference to the process (Heath, 1998). Existing literature to assess emergency plans is often unhelpful and there have been few attempts to establish the principles of evaluating plans beyond summary checklists (Barton, 1993; Albrecht, 1996; Heath, 1998).

The production of emergency plans in Europe specifically focused on floods is a relatively recent phenomenon. In England and Wales and the Netherlands, Acts of Parliament passed in 2004 have acted as a catalyst to the formulation of emergency plans for flooding. In France an Act passed in 2005 paved the way for the production of local level emergency plans. In all three countries emergency planning for floods is initially the responsibility of local government. Although regional and national flood emergencies cannot be managed exclusively at a local government level the essential remedy to an emergency situation is almost inevitably applied at a local scale (Drabek and Hoetmer, 1991).

There are several reasons put forward as to why the evaluation of emergency plans for floods has until recently received such little attention and why the plans themselves may be in need of improvement. It has been postulated that this is because:

1. Stakeholders are still evolving principles and procedures for the effective management of flood emergencies Heath (1998). There is also a consensus that emergency management is not a fully fledged profession (Crews, 2001).
2. The objectives of what is being evaluated are often blurred Heath (1998).

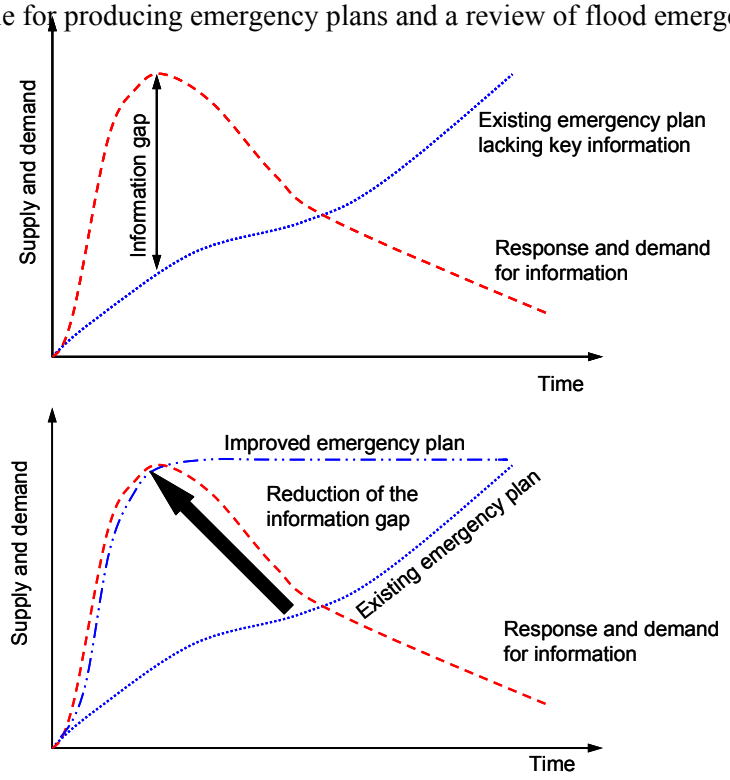
3. There is often a lack of openness when evaluating either the preparation for emergencies or post-event debriefings as a result of stakeholders feeling threatened by criticism or being vulnerable to having the blame for any perceived failures assigned to them Heath (1998).
4. Emergency plans specifically for floods are a relatively recent development and hence it is only in the past two or three years that a requirement for their evaluation has emerged.

Research carried out by Alexander has found that there is an "*enormous variety and lack of homogeneity*" amongst emergency planning documents in many parts of the world. Alexander postulates that this implies that there is "*a shortage of adequate standards* [or metrics] *for creating, evaluating and approving emergency plans*" (Alexander, 2002, 2003, 2005) and that "*virtually no appropriate standards seem to exist*" (Alexander, 2005). Alexander also found that there was little in the way of metrics via which the "*fitness for purpose*" of emergency management plans can be developed.

Figure 1 illustrates that the demand for information during an emergency usually accelerates at a rate far above that of supply. This leads to what may be termed a "demand-provision gap" (MacFarlane, 2005) or "information gap". In most cases this is not because the information does not exist, but because it is not actually included in an emergency plan and thus often not accessible at the point and time of need. The key question that needed to be addressed in these three countries was how it can be established if emergency plans for floods are "complete" in order to reduce the information gap as much as possible. A first step in this process was to address the following questions:

- Which elements are currently being addressed within emergency plans and at what level of detail?
- What makes an emergency plan for floods effective in the eyes of the primary stakeholders?

These questions were researched via the development of metrics, an online survey of stakeholders responsible for producing emergency plans and a review of flood emergency plans.



(Adapted from MacFarlane, 2005)

Figure 1 The "information demand provision gap" during an emergency event

2. Background to the emergency planning for floods in England and Wales, France and the Netherlands

In all three countries there are tiers of emergency planning ranging from national, regional to local plans. There are generic plans that focus on strategic planning covering issues such as organisation and responsibility, communication and evacuation. These plans cover other risks besides flooding. In England and Wales and the Netherlands there are underlying plans that focus on flooding. Emergency plans in France focus on a range of different hazards, including technological hazards, although in many areas flooding is the most important threat. The background to emergency planning for floods in each country is discussed below.

2.1 England and Wales

Flooding is a major natural hazard in the UK. In total, around 5.6 million properties in England and Wales, or one in six properties, are at risk of flooding. More than 5.3 million people live and work in 2.4 million properties that are at risk of flooding from rivers or the sea, one million of which are also at risk of surface water flooding. A further 2.9 million properties are susceptible to surface water flooding alone (Environment Agency, 2009a, 2009b). Five per cent of England's population lives in the 2,200 km² of land most at risk from flooding by the sea, while 10,000 km² is threatened by flooding from rivers. In all, about 10% to 15% cent of urban areas and about half the best agricultural land is at risk (Tunstall et al, 2004).

In June and July 2007 over 55,000 homes and 6,000 businesses were flooded as the result of widespread flooding and the related insurance claims were of the order of £3 billion (ABI, 2007). The floods had a significant impact on critical infrastructure over 100 sewage treatment works in the Midlands were affected. In Gloucestershire, the inundation of a water treatment plant left over 300,000 people relying on bottled water for several weeks and power supplies for over 40,000 homes were interrupted while temporary flood defences were installed at an electricity sub-station. Near Rotherham, the threat of failure of the Ulley Dam following the June 2007 rainfall was a primary factor in the evacuation of around 1,000 people (Marsh and Hannaford, 2007).

Emergency planning in the UK is governed by the Civil Contingencies Act 2004. There is a hierarchy of emergency planning in the UK. Issues such as evacuation, communication and the setting up of rest areas are generally covered by generic plans. These plans are then referenced by the Multi-Agency Flood Plan (MAFP) that includes specific information on flooding.

MAFPs are produced by the Local Resilience Forum. There are currently 47 Local Resilience Forums covering England and Wales that are based on the administrative boundaries of the police. Each Local Resilience Forum has to consider the flood risk across the whole area for which it is responsible. However, for some areas the response arrangements that are set out in generic emergency places are sufficient to cover the particular area at risk. For areas where the risk is higher more detailed MAFPs are required (Environment Agency/DEFRA, 2008). To date there have been some 323 MAFPs produced in England and Wales (Foster, 2010).

2.2 France

More than 40% of the 36,500 French communes are affected by floods and flooding is responsible for 80% of the damage attributable to French natural disasters (Pottier, 2005). It has been estimated that approximately 4.5 million people are at risk of flooding in France (Enjolras et al, 2008). In February 2010

the Atlantic storm named Xynthia caused extensive coastal flooding on the western seaboard of France resulting in 53 deaths and in June 2010 some 25 people were killed as the result of flash flooding in the south-west of the country (BBC, 2010;Hernu et al, 2010).

At a communal level in France there is the Plan Communal de Sauvegarde (PCS), i.e. "local protection plans". The PCSs were created to help municipalities take charge of the management of emergency planning at a local level (Direction De La Defense Et De La Securitie Civiles, 2004). It has been estimated that there are currently 5,000 PCSs in existence in France. In 2002 Lagadec remarked that "*deep resistance was the dominant characteristic of preparing for crisis situations in France*" (Lagadec, 2002). This statement is borne out to a certain degree by the amount of time it has taken to get less than half the PCSs in place.

The PCS is the first plan that is put into action when an emergency occurs. The PCS is activated by the mayor of each commune. French citizens expect the mayor and their representative at a commune level to be at the forefront of emergency management (Lagadec, 2002). At a departmental level there are plans that complement the PCS, which set out rescue and evacuation strategies. These plans are activated when an emergency becomes too difficult or large for local authorities to handle.

2.3 The Netherlands

International assessments of vulnerability to flooding present the Netherlands as one of the most vulnerable flood prone areas in the world (European Environment Agency, 2005; Alcamo et al, 2007). Until recently, Dutch flood risk management concentrated on preventing floods from happening, primarily through the construction of embankments, and emergency planning received little attention (ten Brinke et al, 2010).

The success of engineering projects to keep water out for over 50 years, such as the Deltaworks project, has resulted in public complacency. People do not believe that flooding will happen to them In the Netherlands, a survey conducted for the Ministry of the Interior found that only 3% of the population had made some preparations for flooding; 60% were not aware of the risks they face; and 80% felt safe in their environment (Pitt, 2007). Another recent evaluation of flood risk in the Netherlands showed that the country is not prepared for wide scale flooding and that of all the hazards, flooding poses the greatest societal risk (ten Brinke et al, 2008).

In the Netherlands safety is legally defined as a local responsibility. Local authorities are obliged to formulate emergency management plans for the potential risks within their area. Often flood risks are addressed on a regional scale through the cooperation of several municipalities and agencies involved in event management or within the context of the Safety Region. This is due to the fact that in the Netherlands the extent of a flood almost always exceeds the municipality boundaries. By October 2010 a new law on safety regions will become effective and by the end of 2010 25 Safety Regions should be operational.

A Safety Region is a regional cooperation of municipalities, police, fire brigades and health care organisations. Each Safety Region has to prepare a "crisis" or emergency management plan. Although the Bill has only recently been approved the majority of the 25 Safety Regions in the Netherlands have started drafting their emergency management plans many of which focus on flooding related issues.

3. Development of metrics to assess flood emergency management plans

3.1 The requirement for metrics

McConnell and Drennan (2006) point out that in a world of tight public expenditure constraints and extensive state interventions such as health, education, transport and defence, emergency planning is low on the list of political priorities. As a consequence funding for emergency planning is often low. In 2004 a survey of emergency planners in the UK found that 70% of respondents spent less than £100,000 per annum on planning for emergencies (Prachett, 2004).

Civil protection by its nature is an area that can easily be neglected. Local government emergency planning has often been the poor relation of local services. It is something never needed until it is required (O'Brien & Read, 2005). Although a Spending Review in the UK in 2004 doubled the amount of civil defence grant from £19 million to £38 million (HM Treasury, 2004), the reality is that emergency management at the local level will probably continue to be inadequately resourced not just in the UK, but also in France and the Netherlands, and therefore be unable to provide a service compatible with changing public expectations (O'Brien & Read, 2005). Given the relatively low level of support for emergency planners, there is a requirement for a simple set of metrics by which emergency plans for floods can be evaluated and any gaps in the plans identified by the primary stakeholders (e.g. emergency planners, fire brigades and the police), many of whom are not experts in the field of flood risk management.

A metric may be defined as a measure for something; a means of deriving a quantitative measurement or approximation for otherwise qualitative phenomena. Many emergency managers have expressed a need for metrics and guidance as they are often uncertain about the quality and appropriateness of their plans (Alexander, 2005; Environment Agency/DEFRA, 2009; Heath, 1998). This was confirmed by many stakeholders in the three countries, responsible for formulating emergency management plans for floods, consulted as part of the research. The evaluation of flood emergency plans is important to identify strengths and weaknesses in different approaches, as well as an aid in documenting improvements (or deteriorations) made over time. For organisations responsible for producing and evaluating plans, structured methods for evaluating such plans can be of great value.

3.2 The metric development process

It is important that the emergency planning process for floods is based on carefully devised scenarios and on a clear understanding of community vulnerability considerations, appropriate triggers for emergency action and the necessary requirements for responses to emergencies (Australian Government, 2009). Flood risk varies from place to place. It is important to note that whether an emergency plan is "acceptable" will be based on an individual assessment. The metrics developed had to be:

- Applicable to all the three countries taking part in the research
- Able to be applied to emergency plans for floods at a range of geographical scales ranging from a regional to local level
- Generic but at the same time be clear and focused to avoid misinterpretation
- Measurable
- Realistic given the various constraints related to emergency planning

The metrics were developed following a review of a wide variety of emergency plans and consultation with a range of stakeholders in the three countries and also drew upon recommendations made as the result of recent floods in England and Wales and France such as those detailed in the Pitt Review (2008),

Poulard (2009), Tricot (2008) and reviews in the Netherlands (ten Brinke et al, 2008, 2010) and documents produced by HM Government (2006) and DEFRA (2010) in the UK.

Other sources were also used to aid in the development of the metrics. These included the lessons learnt from major flood emergency exercises such as Triton 04 that took place in 2004 based on an extensive flood affecting nearly half of England and Wales (Environment Agency/Defra, 2004). This exercise involved over 60 organisations and almost 1,000 participants (Young, 2005). In September 2009, hundreds of fire fighters and rescue personnel from across Europe took part in a large scale and very realistic exercise simulating Europe's "worst credible flood event", an extreme tidal surge in the North Sea affecting the Netherlands and England and Wales (Hayden, 2009). An evaluation of this exercise, carried out by Bereens and Schneider (2009), also provided a useful insight as to the form the metrics should take. The results of work from various Exchange Forums on flooding such as European exchange circle on flood mapping (EXIMAP, 2007) and the European exchange circle on flood forecasting (EXCIFF, 2007), that brought together primary stakeholders from the fields of flood risk management and emergency planning from 15 countries throughout Europe were also used to inform the development of the metrics.

The need and support for the metrics with the end users was assessed during their development. This was done through a series of consultations and workshops. The metrics that resulted from the research cover the following areas:

- Aims and objectives of plan
- Target audience and updating of the plan
- Details of previous floods, flood hazard maps and flood warning
- Flood risk to people
- Flood risk to residential property and businesses
- Flood risk to critical infrastructure (e.g. gas, electricity and water supply infrastructure, police, fire brigade, health care related buildings)
- Potential for Natural Hazard Triggering Technological Disasters (NaTech) hazards triggered by floods at industrial or other facilities
- Evacuation routes
- Shelters/Safe havens
- Relationship with complementary emergency plans detailed
- Communication with other agencies, the public and the media
- Assumptions made by the plan
- Plan activation
- Actions, roles and responsibilities
- Recovery
- Training and exercises

A detailed list of the metrics developed is given in Appendix A of this paper.

4. Assessment of the emergency plans

The development of the metrics also allowed the plans to be "scored" in a quantitative manner. For example a score of "1"was given for an individual metric where there was a "Low level of detail"; "2" where the metric had an "Average level of detail" and "3" where the metric was seen to be "Detailed". If the average score of all the metrics is less then "2" then this indicates that there is "Room for improvement" in the plan. An average score above "2" indicates that the plan is "Acceptable" and that a score of three indicates that the plan is "Good".

The scoring range for the emergency plans was divided into five equally distributed bands between a score of 1 and 3 based on the average score of the metrics for each plan. The five bands in Table 1 tie in generally with other checklists that have been developed (e.g. Environment Agency et al, 2009). The "rating" of a plan from the scores is shown in Table 1.

Table 1 Scores for the emergency plan

Average score	Description to determine the quality of the flood emergency management plan
2.6 to 3.0	There is little or no further information that could have been included in the plan. This could be considered to be a "Good" plan with little room for improvement
2.2 to <2.6	There is some further information that could have been included in the plan to improve its effectiveness. This could be considered an "Above average" plan.
1.8 to <2.2	Considerably more information could have been included in the plan to help improve it. This could be considered an "Average" plan
1.4 to <1.8	There is some information missing from the plan. There is "Room for improvement"
1.0 to <1.4	There is a large amount of additional information that could be included in the plan that would help to improve it considerably. This could be considered a plan with "Considerable room for improvement"

It is important to note that in the application of the metrics to assess flood emergency plans, if an item was not included but its omission was fully justified (e.g. because it was covered in a complementary plan), then the particular metric was assessed as being "Detailed".

Detailed reviews of 41 plans were carried out using the metrics. The following were assessed:

- 13 Multi-Agency Flood Plans (MAFPs) in England and Wales
- 14 Plan Communaux de Sauvegarde (PCSs) and two higher level supporting plans in France
- 11 Safety Region Plans in the Netherlands and a National Response Plan

Each plan was scored using the developed metrics. This resulted in an average score per emergency plan and per metric.

4.1 Results of the assessment using the metrics

Table 2 provides an overview of the results of the assessment of the emergency plans carried out using the developed metrics. The review of the plans found that there was often a lack of homogeneity between the emergency plans. Often the same information was expressed in significantly different levels of detail. In England and Wales, two MAFPs did not include flood hazard maps and did not state if these were readily

available either in other plans or other forms (e.g. CD ROM or a secure web site). In the Netherlands many of the flood maps included in emergency plans had details of maximum water depths and velocities.

Many of the plans reviewed had what could be classed as a large amount of generic "cut and paste" text on flooding but had limited text on local or regionally specific issues. It appears from the research that many of the responders would like more specific information especially with regards to the nature of the flood hazard and the accessibility of roads to emergency services and other vehicles for different flooding scenarios. In many densely populated areas it would be relatively easy to develop such maps for different probabilities of flood events.

Table 2 The overall results of the scoring of the emergency plans per country

	England and Wales	France	The Netherlands
Average score of plans	1.9	1.9	1.7
Average plan score category	Average	Average	Room for improvement
Range of scores	1.3 to 2.3	1.1 to 2.4	1.2 to 2.3

The 22 metrics developed broadly fall into six categories as follow:

1. Objectives, assumptions and target audience
2. Organization and responsibility
3. Communication
4. Flood hazard
5. Flood risk to receptors (e.g. people, buildings, critical infrastructure)
6. Evacuation

An overview of the results of the comparison of these metric groups for the three countries is given in Table 3, with a comparison between the average metric scores for each country shown in Figure 2.

Metrics related to organisational aspects of the plan such as: plan activation; roles and responsibilities; communication with other agencies; and target audience and updating scored well in all three countries. However, the assumptions made by the plans did not appear to be well defined. Details of previous floods although covered reasonably well in England and Wales, and France were not covered well in the Netherlands; this is probably as a result of the fact there have been no major flood events in the Netherlands since 1953.

Metrics related to the possible impacts of floods on receptors such as businesses; critical infrastructure; people; vulnerable people and NaTechs (Natural Hazard Triggering a Technological Disasters) all scored well below average in all three countries as well as the metrics concerned with evacuation aspects. The metric covering the relationship between complementary plans in England and Wales scored "above average"; however, in France and the Netherlands this metric scored "below average" indicating that there may be a "disconnect" between different complementary plans and that if other plans are referenced there is often not a detailed link provided to them.

Figure 3 shows a graph of the average metric score for a plan against the number of pages in the plan. There is a relationship between total length of emergency plans, including appendices, and the mean metric score for England and Wales and to a lesser degree the Netherlands. One stakeholder who contributed to the research said that "*A simple plan without great detail, signposting where further*

information is, is preferable to a plan that includes all the information making it a bulky, dust gathering, document." However, the longest emergency plan reviewed in England and Wales stretched to 300 pages and was found by users to be "*compact and the information in it was relatively easy to locate*" following its use in an extreme flood event in November 2009. This may indicate that "ease of navigation" of the plan is likely to be more important than plan length. However, in France there appeared to be no relationship between the metric score and the plan length.

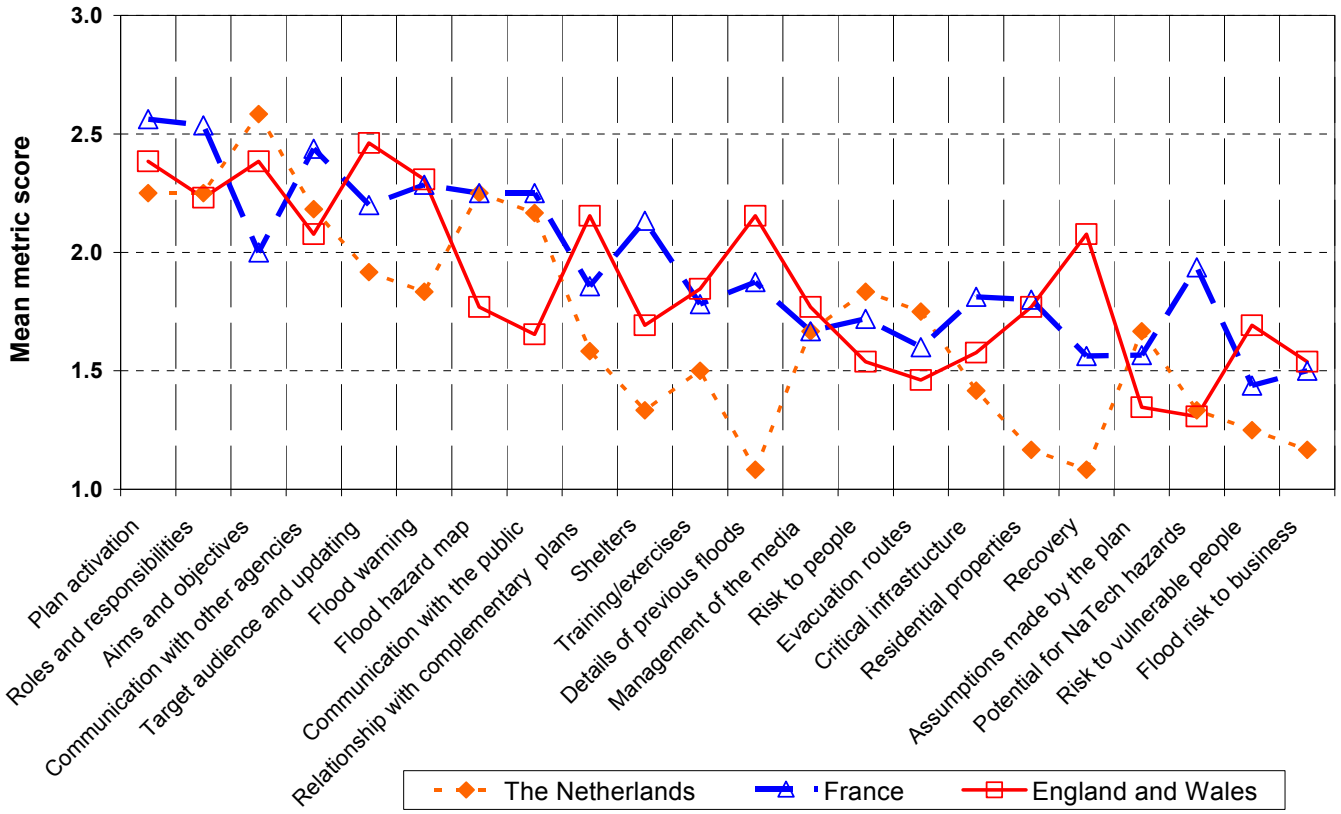


Figure 2 Comparison of the mean metric scores for the three countries

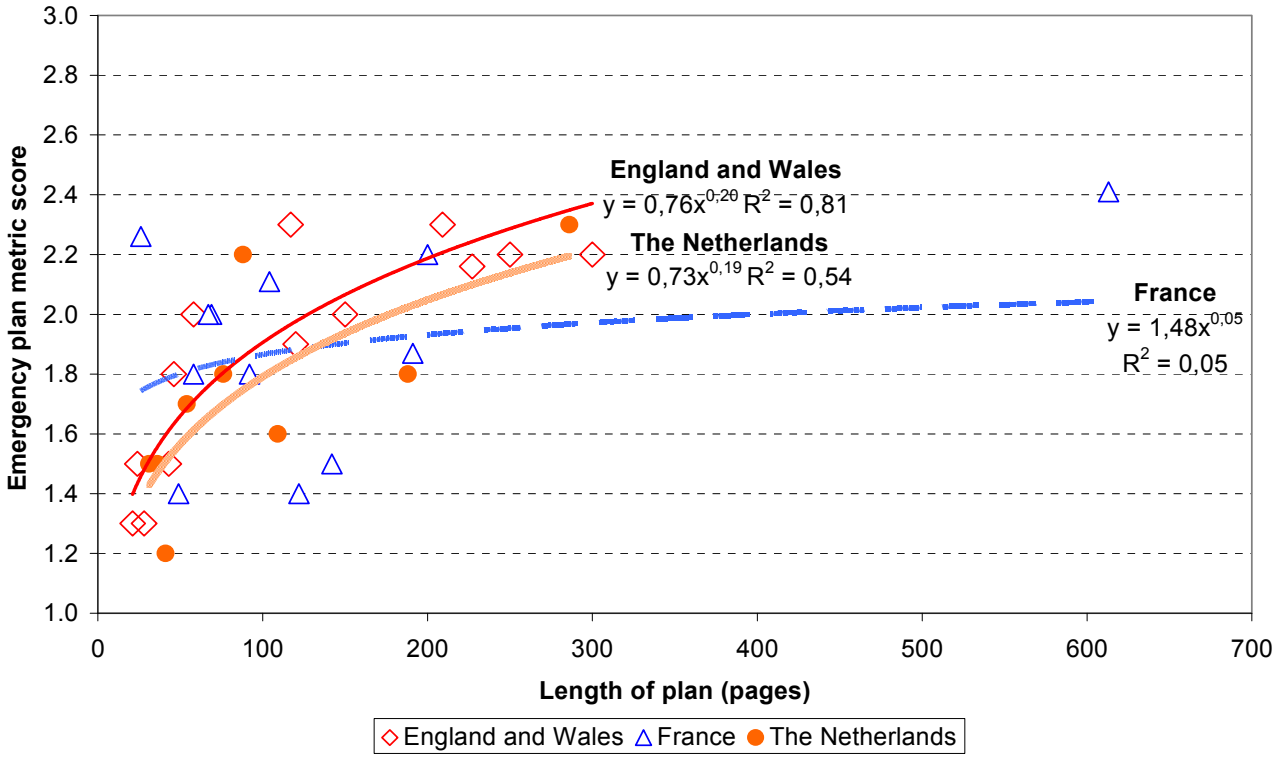


Figure 3 **The relationship between the length of emergency plan and metric scores for England and Wales, France and the Netherlands**

Table 3 **The overall results of the scoring of the metrics per country**

Score category	England and Wales	France	The Netherlands
Range of metric scores	1.31 to 2.46	1.44 to 2.56	1.08 to 2.58
Metric scores with average and higher scores	Objectives, assumptions and target audience Organization and responsibility Flood hazard	Organization and responsibility Communication	Objectives, assumptions and target audience Communication
Metric scores are "average", or where there was a large spread of scores	Communication	Flood hazard Objectives, assumptions and target audience Evacuation	Flood hazard Organization and responsibility
Metrics scores falling into the category "Room for improvement" or lower	Flood risk to receptors Evacuation	Flood risk to receptors	Flood risk to receptors Evacuation

4.2 Results of the surveys of emergency managers

An online survey was sent to stakeholders in the three countries. The questions focused on the requirement for information in the plan development stage, and its usefulness and required level of detail. In total 208 people responsible for formulating and contributing to emergency plans responded to the survey. This was made up of 95 people from England and Wales, 77 from France and 36 from the Netherlands. It is estimated that the survey reached the following approximate numbers of stakeholders: 350 in England and Wales; 250 in France; and 150 in the Netherlands. Table 4 gives a breakdown of the stakeholders who responded to the survey. In England and Wales, and the Netherlands most of the stakeholders responding to the survey worked for local authorities in an emergency planning role. In France the majority of the responders were from the fire service. This is because in 1884 the fire service was given responsibility for emergency services for all human disasters (Drouet, 1982). As a consequence it plays a larger part in emergency planning than in the other two countries.

Table 4 Breakdown of the types of stakeholders who responded to the survey

Type of organisation	Percentage of responses		
	England and Wales	France	The Netherlands
Emergency services (e.g. Fire and rescue services, police)	21.2%	55.3%	0%
Flood managers (e.g. flood forecasting, water management organisations)	2.4%	9.2%	0%
Health (e.g. ambulance service)	8.2%	0.0%	0%
Local authority or council	51.8%	31.6%	100%
Transport (e.g. roads, railway)	4.7%	0.0%	0%
Utility (e.g. communications, electricity, gas, water)	4.7%	2.6%	0%
Other	7.1%	1.3%	0%

The responders were asked to "score" the level of detail they felt there should be for a variety of subjects in an emergency management plan. The level of detail of the information was scored from 1 to 5, with 1 = "not detailed in the plan" and 5 = "very detailed". The details of the results are briefly discussed.

4.2.1 Metrics relating to objectives, assumptions and target audience, organization and responsibility and communication

Plan activation had the highest required level of detail for the three countries. Many stakeholders who contributed to the research stated that for an emergency plan to be effective, clear triggers, often related to specific flood levels at specific places, were needed to invoke actions and responses. There seemed to be a broad consensus that there needs to be clear definitions and guidance on how and when plans are activated.

It is interesting to note that in the review of the MAFPs in England and Wales, issues related to plan activation, communication with other agencies and the media, relationship with complementary plans all scored relatively well. It would appear that issues related to communication and responsibilities are currently relatively well covered by MAFPs. It should be noted that the assumptions made by MAFPs were often not explicitly stated.

In France information regarding communication can be classified in two groups. Information and communication required before the crisis such as target audience, plan activation and communication to public scored "above average". In contrast items related to the post disaster phase are often neglected.

4.2.2 Metrics relating to flood hazard, receptors and evacuation

From the review of the MAFPs in England and Wales using the developed metrics the level of detail of information relating to flood hazard, receptors and evacuation mostly fell into the category of either "room for improvement" or "considerable room for improvement". This would seem to suggest that apart from flood warning times there is not enough "relevant" information available to emergency planners to help them with the formulation of MAFPs.

In France flood hazard maps scored highly. Although in the two other countries many responders to the survey stated that they wanted flood maps that show information about depth and velocities of the flow, as well as detailed likely flow routes. The impacts of flooding on critical infrastructure were mentioned as being important by emergency planners; however, Figure 2 shows that the mean scores for this metric were low.

5. Effectiveness of emergency plans

As part of the survey the responders were asked to briefly list up to five criteria that they believed make a flood emergency management plan effective. The various responses for each country were grouped under generic headings. The top five generic responses are given in Table 5. In all three countries stakeholders indicated that for plans to be effective the roles and responsibilities should be clearly defined. One responder summed up that an effective flood emergency plan needed to have "*Roles and responsibilities clearly spelt out and agreed (with no assumptions made by any organisation)*".

The role of "trigger levels" also featured in many responses in all three countries. A trigger level can be defined as "an event causing the automatic invocation of a procedure". Many responders stated that for a plan to be effective clear triggers are needed to invoke actions and responses. Clarity, adaptability, accessibility and brevity of the plan were also mentioned by many responders as being important; however, as discussed above ease of navigation of a plan may actually play a more important part in its accessibility than its length.

Information on the flood hazard was also seen as very important. This is borne out by research carried out by Dymon (2003) that showed that maps for pre-event planning are essential to emergency management plans and that the lack of maps in plans causes problems. Responders stated that they would like to see the inclusion in plans of larger maps or maps showing more detail; maps highlighting "hotspots" and the inclusion of the flood maps on an integrated GIS system. Details of flood depths and velocities were also seen as important, as well as having a number of different flood scenarios.

Table 5 Criteria perceived by stakeholders to make a flood emergency plan effective

Rank	England and Wales	France	The Netherlands
1	Roles and responsibilities	Roles and responsibilities	Roles and responsibilities
2	Triggers levels	Trigger levels	Information on the flood hazard
3	Information on the flood hazard	Information on the flood hazard	Clarity and accessibility of plans
4	Clarity and brevity of the	Adaptability and simplicity	Training in the use of the plan

	plan		
5	Relationship with other plans	Training in the use of the plan	Trigger levels

6. Discussion of the results

To compare the plans with the requirements of emergency planners both the metric scores and stakeholder survey scores were normalised. Figures 4 and 5 show the difference between the normalised stakeholder survey and metric scores for "Objectives, assumptions and target audiences"; "Organization and responsibility"; and "Communication". The lower the score the further away the metric is from meeting stakeholders' expectations. A very low score (e.g. -0.6) indicates a considerable gap between the stakeholders' requirements and what is actually in the plan and a positive score indicates that the stakeholders' expectations have been exceeded by the plan. Figure 4 shows that in terms of "Objectives, assumptions and target audiences" and "Organization and responsibility" the plans reviewed went a long way to meeting the stakeholders' requirements. Metrics related to implementation of plans and organisation such as "plan activation"; "actions, roles and responsibilities", "flood warning"; "target audience and updating"; and "aims and objectives" scored well in all three countries. Many stakeholders who took part in the research indicated that it was important to have roles and responsibilities well defined in flood emergency plans for different levels of flooding. The scores of these metrics would indicate that in general emergency planners are covering these subjects well.

Figure 5 shows that in terms of "communication" the French flood emergency plans generally scored the best. This may be that unlike England and Wales, and the Netherlands, there is a requirement for French plans to be in the public domain. Relationships with complementary plans and communication with other agencies scored relatively well; however, it was clear that there is room for improvements in the plans with regards to communication with the media.

Figure 6 shows the different normalised scores for seven metrics related to "Flood hazard"; "Receptors"; and "Evacuation" compared with the normalised scores for the required level of detail as perceived by the stakeholders. The perceived "level of detail" of information on: flood risk to people; flood risk to property; critical infrastructure; evacuation; NaTechs; shelters; and flood maps is similar in all three countries. However, the metric scores for the three countries are low indicating that there is a discrepancy between the level of detail required by the stakeholders on these issues and the information that is actually provided in emergency plans. In the 2007 floods in England and Wales the emergency response was hampered as a result of an inadequate understanding of: the location of critical infrastructure sites; the mapping of their vulnerability to flooding; and the consequences of their loss (Pitt, 2007).

In the Netherlands evacuation routes and times was seen as one of the most important pieces of information for plans. In January 1995 some 250,000 people had to be evacuated in the Netherlands as a result of high water levels on the River Rhine and River Meuse (IDNR, 1996). As a result of this and the fact that the Netherlands is a low-lying country, with about 20% of its area and 21% of its population located below sea level (Centraal Bureau voor de Statistiek, 2008) and 67% of the land prone to flooding from the sea or the Rhine and the Meuse Rivers (ten Brinke et al, 2010), evacuation is higher up the emergency planning agenda in the Netherlands than in France, or England and Wales.

The metrics indicated that there is a difference in the way that flood hazard is depicted in emergency plans between the countries. In France and the Netherlands the metric score for flood hazard maps were both in the "above average" range. This is because in France and the Netherlands the flood maps included in the plans often include the maximum flood depth and sometimes maximum flood velocity, whereas in England and Wales only the maximum flood extent is generally shown. Many stakeholders consulted as

part of the research stated that maps showing maximum depths and velocities for different flood scenarios would be useful to them if they could be made available. In England and Wales it should be possible to produce such maps in areas where two dimensional hydraulic modelling has been carried out. Similarly in France there was a stated desire to have more detailed flood maps and also emergency plans that display different flood probabilities (e.g. the 1 in 30 or 1 in 50 year flood) rather than the 1 in 100 year hazard, which is often the case in France.

The Netherlands had the highest metric score for risk to people. This may be partly as a result of the fact that researchers in the Netherlands have pioneered methods to assess injuries and loss of life owing to flooding and that a sudden failure of flood defences could result in a large number of fatalities. In France and England and Wales there was "room for improvement" in the treatment of risk to people, particularly vulnerable groups.

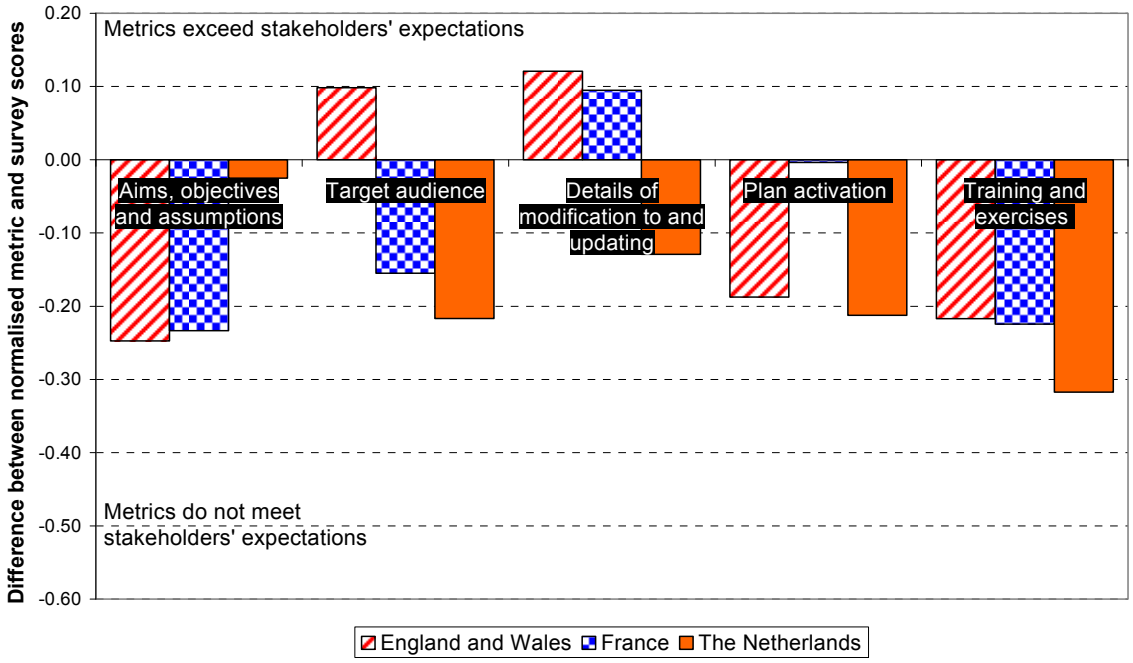


Figure 4 **Comparison of the difference between the normalised metric and stakeholder survey scores related to "Objectives, assumptions and target audiences" and "Organization and responsibility"**

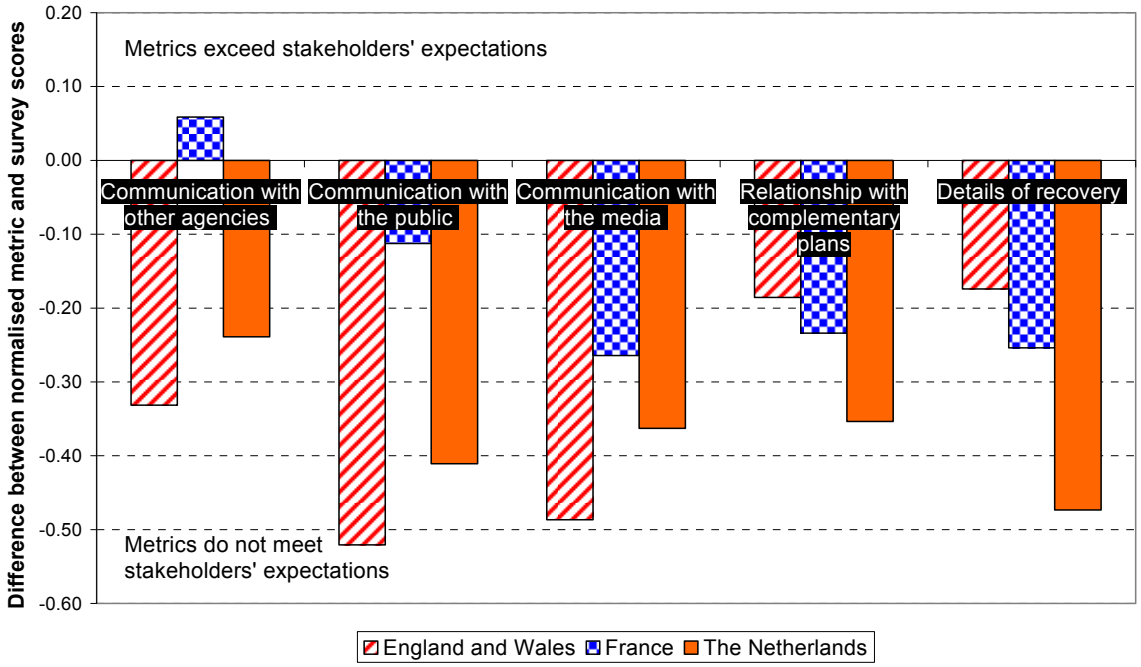


Figure 5 **Comparison of the difference between the normalised metric and stakeholder survey scores related to "Communication"**

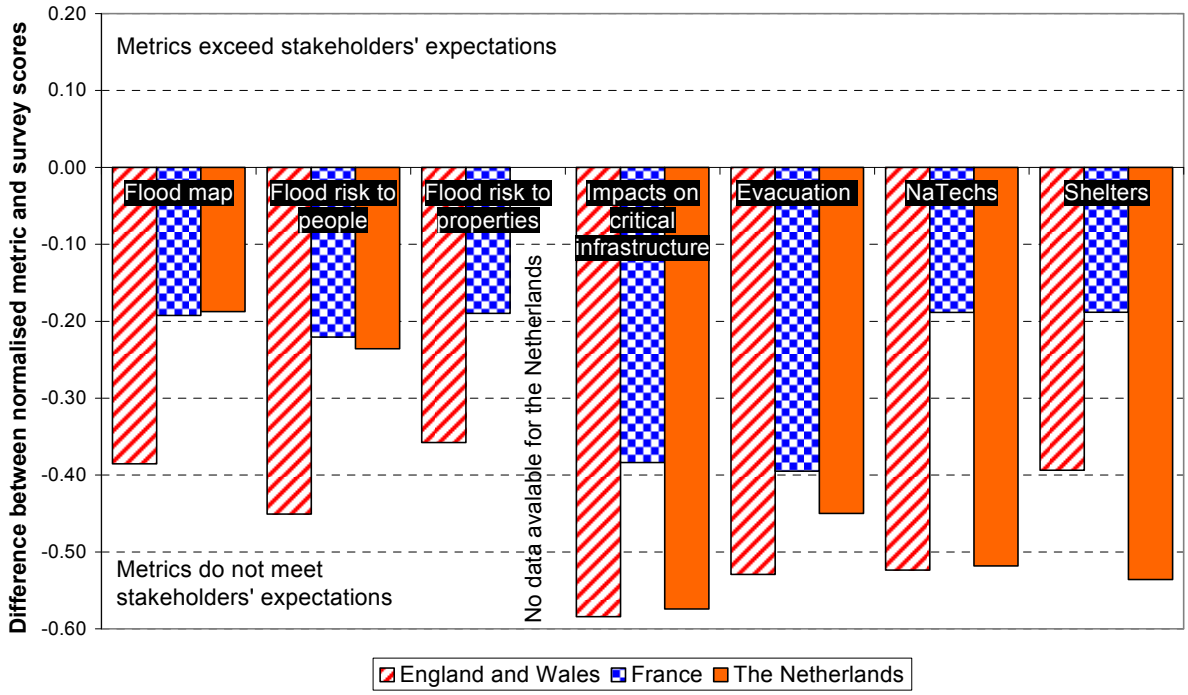


Figure 6 **Comparison of the difference between normalised metric and stakeholder survey scores related to "Flood hazard", "Receptors" and "Evacuation"**

In all three countries there was a lack of information in the examined plans on critical infrastructure. However, it was clear from the research undertaken with the stakeholders that they viewed "potential damage to critical infrastructure" and the "interdependence between at risk critical infrastructure" (e.g. the

failure of an electrical substation affecting a water treatment works) as being important information to include in emergency plans. However, this information was often not readily available to emergency planners.

In France, and England and Wales there was great emphasis given by the stakeholders on the accessibility of roads. The feedback on the emergency plan that was used recently in a recent large flood was that maps showing potential for road inundation outside the "formal flood maps" were of great use to emergency responders. In some regions of France methods are being developed specifically to assess the inundation of roads to assist emergency planners with their response.

In England and Wales there was only one plan that showed the location of industrial facilities in the floodplain. In France the metric for NaTech hazard scored higher than for the Netherlands and England and Wales; this is mainly because the PCS plans in France have a legal requirement to cover technological hazards. However, it is important to note that NaTech hazards are generally treated in isolation to other natural hazards in PCSs.

7. Case study

Cumbria is a non-metropolitan county in the north-west of England; in 2007 it had a total population of about 499,000. The county is bounded to the west by the Irish Sea. It is a predominantly rural area much of which is mountainous. In November 2009 Cumbria was subject to severe flooding. The rain gauge at the town of Seathwaite in Cumbria measured 314 mm of rainfall in 24 hours, which is equivalent to about a 1 in 500 year (0.2% annual probability) rainfall event. A total of 2,240 properties were flooded throughout Cumbria. Infrastructure was badly affected with eight bridges destroyed by floodwater and a further 1,800 closed for inspection (Rodda, 2010).

The Cumbria MAFP was reviewed as part of this work just before the November 2009 flood event occurred using the 22 metrics that have been developed. Using these metrics the plan was rated as "Above average", scoring 2.3. In February 2010 the use of the plan in the November 2009 floods was reviewed by the Local Resilience Forum (LRF). The plan was used by responders and at the Cumbria police headquarters. 'The Risk of Flooding' section was the most used section of the plan by responders and at the incident command centre. There were positive comments about the information on the maps particularly the local infrastructure, location of electricity sub-stations and care homes. Flooding "hot-spots" and roads with a flooding history outside the formal flood warning areas in the county were also seen as very useful both to strategic and tactical response (Cumbria LRF, 2010).

In terms of 'Actions Roles and Responsibilities' the response and resource forms in the plan were seen as useful and gave at a quick glance what resources responders possessed (i.e. manpower, sandbags, plant). Overall the plan was seen to "knit together" with complementary plans in Cumbria with the only duplication being with the roles and responsibilities section for 'Major Incidents', although the MAFP focuses more on roles and responsibilities with regard to flooding (Cumbria LRF, 2010). Despite being 300 pages long the plan was found to be "compact and information was quite easy to locate" (Cumbria LRF, 2010). In terms of negative comments, maps in the plan were not perceived to be large enough and there was a need to ensure incident rooms were pre-supplied with a suite of larger maps which could be annotated. It was also felt that flood maps could be extended beyond flood warning areas (Cumbria LRF, 2010).

The strengths of the MAFP picked out by the Cumbria LRF review of the plan were also identified by the review carried out as part of the research using the developed metrics. The following metrics: "Aims and objectives"; "Target audience and updating"; "Details of previous floods"; "Relationship with

complementary emergency plans"; "Plan activation"; "Actions, roles and responsibilities"; and "Recovery" were all rated as being "good". The review using the metrics also picked up that although there were flood hazard maps in the MAFP, and that the maps showed roads prone to inundation outside the formal Environment Agency Flood Map, there was still room for improvement in these maps. The accordance of the metrics with the review carried out by the Cumbria LRF provides evidence that the metrics are of use in assessing flood emergency plans and identifying areas where they can be improved to reduce the "information gap" in MAFPs.

8. Conclusions

The metrics developed as part of the research have proved to be a useful tool for assessing emergency plans and providing a basis to allow comparison of the plans. There will always be some subjectivity involved when applying the metrics; however, the metrics in the context of this research provide a basis to map the following:

- Where improvements can be made in the plans
- Requirements of the stakeholders

It is important to recognise that any metrics need to be revisited and possibly revised periodically either to take account of new circumstances or to adjust to the requirements of stakeholders.

There was found to be a discrepancy between the level of detail required by emergency planners and the actual level of detail that is available within emergency plans for a number of issues. This discrepancy is smaller for the metrics related to communication and organisation. It can therefore be concluded that the emergency plans do not comply with the requirements on issues related to receptors such as critical infrastructure, people and buildings.

The effectiveness of an emergency plan is a difficult entity to measure and several stakeholders indicated that this can only truly be assessed accurately after the plan has been used in a flood. Many emergency planners stated that a well defined description of the roles, responsibilities and communication is essential for a plan to be effective and these aspects tend to be well covered in the three countries looked at. However, other more technical aspects such as accessibility of roads during floods, evacuation, and the depiction of flood hazard and impacts of floods on critical infrastructure can be considerably improved. To conclude the main challenge for emergency planners is to avoid filling plans with generic text and to provide an appropriate level of specific detail in the plan whilst ensuring the usability of the plan.

9. Recommendations

It is important that once a flood emergency plan has been prepared it is treated as an ever-evolving document. It should be maintained systematically to ensure it remains up-to-date and fit for purpose. A regular screening of the plan using the developed metrics should be considered "good practice" for those who prepare or apply such plans. It is recommended that when emergency plans for floods are being formulated the "information gap" between what primary stakeholders require during a flood emergency and what is actually in the plan is assessed by applying the metrics developed as part of this research. It is recognised that the development of metrics to assess flood emergency plans is also an ongoing process. In the future, lessons learnt from where plans have been used to respond to large floods events should be used to further improve the metrics.

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Appendix A Generic metrics for the assessment of flood emergency plans in England and Wales, France and the Netherlands – Part 1

Metric	Level of detail		
	Low	Medium	High
Objectives, assumptions and target audience			
Aims and objectives of plan	Not detailed	Aims and objectives included but could be clarified further	Clearly stated aims and objectives including the area covered, types and sources of flooding
Target audience and updating of the plan	Not detailed	Audience defined and plan dated	Audience defined and how they will be notified of updates and modifications to the plan included
Assumptions made by the plan	Not detailed	Covers some aspects	Covers all aspects including: flood warning lead time; method by which rescue will be undertaken; implications of the failure of critical infrastructure
Organisation and responsibilities			
Actions, roles and responsibilities	Not detailed	Brief details of the roles and responsibilities related to the activation of the plan provided	Details of the roles and responsibilities related to the activation of the plan provided including health and safety and environmental considerations
Recovery	Not detailed	Brief details of how the recovery is managed	Details of how the recovery is managed including clean up, waste disposal, repairs to public assets, humanitarian assistance
Training and exercises	Not detailed	Brief details of training and exercise requirements	Internal and external (with other organisations) training and exercises outlined
Plan activation	Not detailed	Brief description of the thresholds or levels used to activate plan	Description of the thresholds or levels used to activate plan together with flow chart
Communication			
Communication with other agencies	Not detailed	Outlined in words	Detailed and the links shown diagrammatically
Communication with the public	Not detailed	Outlined in words	Detailed and shown the links shown diagrammatically
Management of the media	Not detailed	Outline media management strategy in place	Well defined media management strategy in place
Flood warning (if available)	Not detailed	Levels of flood warning with details of the areas flooded at each level	Levels of flood warning with details of the areas flooded at each level and shown on a map
Relationship with complementary emergency plans detailed	Not detailed	Outlined in words	Detailed and the links shown diagrammatically

Appendix A Generic metrics for the assessment of flood emergency plans in England and Wales, France and the Netherlands – Part 2

Metric	Level of detail		
	Low	Medium	High
Evacuation			
Evacuation routes	Not detailed	Evacuation routes shown on a map	Evacuation routes detailed together with roads likely to be closed and their accessibility for emergency vehicles and other vehicles
Shelters/Safe havens	Not detailed	Safe havens/shelters shown on a map	Safe havens/shelters shown on a map with their capacity and facilities
Flood hazard			
Flood hazard map	Not detailed	Flood hazard map(s) showing extent	Flood hazard map(s) showing water depth and velocity
Details of previous floods (if available)	Not detailed	Brief description of historical flood	Description of historical floods with the cause and a brief description of the risk in terms of people and properties affected
Flood risk to receptors			
Flood risk to people	Not detailed	Number of people potentially affected included	Potential injuries and loss of life included and mapped for a range of scenarios
Flood risk to vulnerable people (e.g. elderly or disabled)	Not detailed	Areas where elderly/sick people live mapped	Numbers of vulnerable people defined with a response strategy
Flood risk to residential property	Not detailed	Number of properties defined	Number of properties defined together with those at risk of collapsing during an extreme flood
Flood risk to businesses	Not detailed	Number of businesses defined	Number and type of businesses defined together with potential losses
Flood risk to critical infrastructure (e.g. water supply, gas, electricity, police, fire brigade)	Not detailed	Number of pieces of critical infrastructure shown on the flood map(s)	Number of pieces critical infrastructure shown on the flood map(s) and an assessment of their likelihood of failure during a flood
Potential for NaTech hazards at industrial facilities (if present)*	Not detailed	Potential NaTech sites shown on map	Potential NaTech sites shown on site and brief details of the response

*Note: A NaTech is defined as technological hazard that is triggered by a natural hazard. For example the flooding of an industrial plant may lead to the release of a toxic chemical that poses a threat to humans, as well as flora and fauna

Appendix D - Paper published in the Journal of Contingencies and Crisis Management

Tools to improve the production of emergency plans for floods – are they being used by the people that need them?

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Abstract

Major floods in Europe over the past decade have illustrated the impact of these events not only on the economy, but also on the health and well-being, as well as the safety of communities. In the past five years emergency plans, some of which focus specifically on flooding, have started to be developed in both England and Wales, and France. At present, tools, such as checklists, guidance and specialised software appear to be used rarely to improve the effectiveness of these plans. Research was undertaken with flood managers in the two countries who are responsible for providing technical input to plans. The objective was to establish why tools, methods or guidance that can usefully contribute to improving emergency plans for floods are often not being used. The research showed that many flood managers are often not aware of the tools that are available to assist them in formulating emergency plans for floods. It was concluded that there is a need for guidance on: what tools are available; what data they require; and how the tools can be implemented to provide information that can be used to improve emergency planning for floods.

1. Introduction

Major floods in Europe over the past decade have illustrated the potential impact of these events not only on the economy, but also on the health and well-being, as well as the safety of communities. During the last 20 years flood risk management policies have evolved significantly in various European countries (Tapsell & Ball, 2007). It is now widely acknowledged that flood risk cannot be completely eliminated through structural measures such as flood embankments. The paradigm of attempting to reduce the flood risk as much as possible purely through structural measures has progressively been overtaken by a more holistic approach to flood risk management (Lagadec, 2002). The management of the residual risks (e.g. damage to properties, casualties) has become a priority for natural hazards such as floods. This shift in the paradigm forms the background to the Flood Risk Management Plans (FRMPs) required as part of Directive 2007/60/EC on the assessment and management of flood risks known as the Floods Directive (EC, 2007). These FRMPs include event management plans and are at the core of many proposed flood mitigation strategies. Dealing with the impacts of flood events through emergency planning and response is has become a core activity of flood risk management organizations (Defra/Environment Agency, 2008). Research has shown that improving an emergency response to a flood event reduces vulnerability (Defra/Environment Agency, 2008).

Recent decades have seen significant increases in the number, scope and complexity of incidents and disasters. The process of constructing a written emergency plan is of great benefit to organisations that have to respond to an emergency (Fischer III, 1996). It is now generally agreed that for places that are significantly at risk of hazards authorities should be required to produce emergency plans (Alexander, 2005). In England and France there has certainly been a culture of ongoing improvement in flood risk management and disaster preparation over the past five decades. Disaster preparation is much less costly than the implementation of structural flood mitigation measures that in many cases often cost hundreds or even billions of euro (Defra/Environment Agency, 2008; Pitt, 2008). However, the production of emergency plans in Europe specifically focused on floods is a relatively recent phenomenon. In England and Wales an Act of Parliament passed in 2004 acted as a catalyst to the formulation of emergency plans for flooding. In France an Act passed in 2005 paved the way for the production of local level emergency plans. In both countries emergency planning for floods is initially the responsibility of local government. Although regional and national flood emergencies cannot be managed exclusively at a local government level the essential remedy to an emergency situation is almost inevitably applied at a local scale (Drabek and Hoetmer, 1991).

This paper focuses on emergency management plans for floods and the tools (e.g. checklists, guidelines, methods and software) that are available to flood risk managers to assist them to produce information that can be used to inform and improve the plans. The paper has been divided into five parts. The first part provides background to flooding in England and Wales, and France, and to the approaches to emergency planning for floods. The second part provides a brief summary of the types of tools currently available to flood risk managers that can contribute to informing flood emergency plans. The third part details research that was undertaken with flood risk managers in England and Wales, and France, responsible for the technical input to these plans, to assess what tools are currently being used by them. The objective was to establish why tools, methods or guidance that could usefully contribute to improving emergency plans for floods are some times not being used. The fourth part provides a discussion and the fifth part of the paper provides conclusions.

2. Background to emergency planning and flooding in the England and Wales and France

In both countries there are several tiers of emergency planning ranging from national, regional to local plans. There are generic plans that focus on strategic planning covering issues such as organisation and responsibility, communication and evacuation. These plans cover other risks besides flooding. In England and Wales there are underlying plans that focus on flooding known as Multi-Agency Flood Plans (MAFPs). At a communal level in France there is the Plan Communal de Sauvegarde (PCS) ("local protection plans"). The PCSs were created to help municipalities take charge of the management of emergency planning, although PCSs focus on a range of different hazards in many areas flooding is the major threat.

2.1 England and Wales

In England and Wales more than 5.3 million people live and work in 2.4 million properties that are at risk of flooding from rivers or the sea. A further 2.9 million properties are susceptible to surface water flooding alone (Environment Agency, 2009a, 2009b). In June and July 2007 over 55,000 homes and 6,000 businesses were flooded as the result of widespread flooding and the related insurance claims were of the order of £3 billion (ABI, 2007). The floods had a significant impact on critical infrastructure over 100 sewage treatment works in the Midlands were affected. In Gloucestershire, the inundation of a water treatment plant left over 300,000 people relying on bottled water for several weeks and power supplies for over 40,000 homes were interrupted while temporary flood defences were installed at an electricity sub-station. Near Rotherham, the threat of failure of the Ulley Dam following the June 2007 rainfall was a

primary factor in the evacuation of around 1,000 people (Marsh and Hannaford, 2007). The summer 2007 flooding caused damages of about £674 million to important national infrastructure and the operation of essential services. Total damage costs were greatest, in order of magnitude, for: water supplies and treatment; roads; electricity supply; agriculture and schools. National food supplies were not put at risk, although the floods made things worse in a year of general food shortages and high prices (Environment Agency, 2010). Table 1 provides details of the recent major floods in England and Wales.

Table 1 Recent major floods in England and Wales

Date	Location	Consequences
2009	Severe flooding experienced over north-west England and south-west Scotland during the period 18 to 24 November	500 homes and businesses flooded, eight bridges destroyed, damage estimated at £100 million
2007	Widespread and severe flooding afflecting many rivers in June and July 2007 including the lower Severn basin, headwater tributaries of the Thames, as well as Yorkshire and Humberside	14 deaths, 55,000 homes and 6,000 businesses inundated. Over £3 billion of damage
2005	The town of Carlisle, in the north-west of England, suffered severe flooding	The consequences included: three deaths; 1,925 homes and business flooded; 3,000 people being made homeless for up to 12 months, 40,000 properties without power
2004	Flash flooding in Boscastle in Cornwall	58 properties flooded and four destroyed. Damage to buildings and services estimated at £2 million
2000	Widespread flooding in November 2000 throughout England and Wales	8,000 properties were flooded with the total damage estimated to be approximately £500 million
1998	Extensive areas of the Midlands flooded	Flood damage estimated at £1.5 billion

(Sources: Dartmouth Flood Observatory, 2010; Marsh & Hannaford, 2007; Rhodda, 2010)

Emergency planning in the UK is governed by the Civil Contingencies Act 2004. In England and Wales the primary responsibility for planning for and responding to any major emergency rests with local organisations, acting individually and collectively through Local Resilience Forums (LRFs) (Defra/Environment Agency, 2010). There are currently 47 LRFs covering England and Wales that are based on the administrative boundaries of the police. The LRF is a multi-agency partnership made up of representatives from local public services, including the fire and ambulance services, local authorities, the health service and flood risk managers from the Environment Agency. In the context of the emergency planning framework Multi-Agency Flood Plans (MAFP) provide specific information on flooding. MAFPs are produced by the LRF. Each LRF has to consider the flood risk across the whole area for which it is responsible.

2.2 France

Flood risk is the most important natural disaster in France, in terms of the area at risk. More than 40% of the 36,500 French communes are affected by floods and flooding is responsible for 80% of the damage attributable to French natural disasters (Pottier et al, 2005). Approximately 20,000 km² of land is regularly affected by floods with 4.5 million people potentially affected (Enjolras et al, 2008). Table 2 provides a brief overview of some of the most serious floods that have occurred in France in the past ten years.

Table 2 Recent major floods in France

Date	Location	Consequences
15 June 2010	Var Département in southern France	28 people killed as the result of flash floods
28 February 2010	West Atlantic Coast, Vendée and Charente regions of western France	47 people killed as the result of coastal flooding owing to dike failures
15 November 2005	Southern France, Perpignan area	Two people killed as the result of flash floods
6 to 9 September 2005	Gard and Herault areas and Nimes. Lunel and Montpellier	Two people killed as the result of flooding
1 to 3 December 2003	Southern France - Rhone valley - Marseilles and Lyon areas. Bouches-du-Rhone region. Vaucluse, Ardeche, Charlieu, Avignon, Orange. Herault, Gard, Arles, Ardeche.	Nine people killed as the result of fluvial floods, flash floods and dike failure. Damage estimated at €1.5 billion
8 September 2002	Gard, Herault and Vaucluse departments. Nimes and Avignon areas. Aramon, Sommieres, Russon.	23 deaths as the result of flash floods. Damage estimated at €1.19 billion

(Sources: Dartmouth Flood Observatory, 2010; Kolen et al, 2010; EM-DAT-CRED, 2011)

Risk Prevention Plans (RPPs or Plan de Prévention du Risque (PPR)) are the documents in which floodplains are delineated in France. RPPs are set up by central government, through the responsibility of its local representative, the préfet. RPPs identify the limits of floodplains and map different flood hazard zones, each of which is associated to specific regulatory restrictions. In France an Act passed in 2005 paved the way for the production of local level emergency plans. In terms of emergency planning at a communal level there are now what are known as the Plan Communal de Sauvegarde (PCS), i.e. "the local protection plan". The PCSs were created to help municipalities taking charge of the management of emergency planning at a local level (Direction de la Defence et de la Securitie Civiles, 2004).

The PCS is the first plan that is put into action when an emergency occurs. The PCS is activated by the mayor of each commune. French citizens expect the mayor and their representative at a commune level to be at the forefront of emergency management (Lagadec & Guilhou, 2002). At a départemental level there are plans that complement the PCS, which set out rescue and evacuation strategies. These plans are activated when an emergency becomes too difficult or large for local authorities to handle. Approximately 10,000 French communes are required by law to have PCSs, to date only approximately 5,000 have been completed. In France the production of the PCSs is the responsibility of the elected mayor of each commune. Unlike England and Wales there is no method of stakeholder liaison to allow the incorporation of the expertise and local knowledge of flood risk managers directly into the plans.

2.3 Comparison between flood risk management policy and practice in England and Wales and France

Flood risk management policy in the two countries can be compared using a safety chain concept, developed by the Federal Emergency Management Agency in the USA, to address safety and security concerns. Ten Brink et al (2008) defined five links in the chain and compared the relative effort put into

each link in England and Wales and France. Table 3 illustrates that the relative effort put into each link in each of the two countries is almost the same and in that respect it could be considered that flood risk management policy is similar in both countries. However, there are considerable differences in the ways in which the policies are implemented, that are discussed below, and these inevitably have an effect on the emergency planning for floods and the tools that are used by flood managers to inform the plans.

Table 3 Definition of links in the safety chain and the relative effort put into each in England and Wales and France

	Link	Definition	Relative effort put into each link	
			England and Wales	France
Risk management	Pro-action	Eliminating structural causes of floods to prevent them from happening (e.g. avoidance of construction in the floodplain)	Strong emphasis	Average to strong emphasis
	Prevention	Taking measures beforehand that aim to prevent floods and limit their consequences (e.g. the construction of structural flood defences)	Average emphasis	Average emphasis
Emergency management	Preparation	Taking measures to ensure there is sufficient preparation to deal with floods (e.g. emergency planning)	Very strong emphasis	Very strong emphasis
	Response	Dealing with floods	Very strong emphasis	Very strong emphasis
	Recovery	Activities that lead to a rapid recovery from the flood to allow the situation to return to normal	Strong emphasis	Strong emphasis

(Source: Adapted from ten Brinke et al, 2008)

In terms of the management of flood defence assets, nearly a third of the dikes in France have no known owner or are in the hands of local residents or municipalities with insufficient funds to maintain them. In many cases it is not clear who manages the thousands of kilometres of flood defences along rivers and the French coast (Le Monde, 2010). Anziani (2010) states that in France "*it is imperative to change the complex and uncontrolled system of the management of flood defence dikes. Too many organisations are involved in their management. Despite increased regulatory control since December 2006 flood defence dikes are poorly maintained….it is essential that where maintenance responsibilities for levees are not defined that control is taken by a competent authority*". Throughout England and Wales there is some 38,000 km of flood defences and 46,000 flood defence structures (NAO, 2007). Unlike in France these are managed and maintained by one organisation, the Environment Agency. In France there is no national technical guidance on flood defence maintenance (Dupay et al, 2010). The other key difference in England and Wales is that the Environment Agency has established a rigorous system for classifying, recording and monitoring the condition of flood defence assets, including a database containing comprehensive information on the state of flood defences (NAO, 2007) that allows resources to maintain and operate them to be allocated systematically rather than on an ad hoc basis as appears to be the case in France.

In England and Wales the responsibility for fluvial and coastal flood forecasting and warning is also held by the Environment Agency. In France a national flood forecasting service, "Service Central d'Hydrométéorologie et d'Appui à la Prévision des Inondations" (SCHAPI) with 22 regional offices was sent up in 2003 (MEEDDM, 2004). Unlike the Environment Agency SCHAPI only forecasts fluvial flood flows and levels and it does not disseminate warnings to a wide variety of stakeholders in a number of different forms as is the case in England and Wales. The assessment of the probability of floods and the risk they pose is the responsibility of the Direction Régionale de l'Environnement, de l'Aménagement et du Logement (DREAL) in France. This is a separate organisation from SCHAPI and one that is not responsible for the management of flood defence assets. The fragmented manner in which flood risk management from a variety of sources (e.g. rivers, coasts, pluvial) is organised in France is in stark contrast to the more unified and holistic approach of the Environment Agency. The same is true of emergency planning for floods. In France there are no stakeholder forums that allow mayors to involve SCHAPI and DREAL in the drafting of the parts of the PCSs relating to floods that usually form the majority of the plans. In England and Wales the Environment Agency has a direct link and input into the production of the MAFPs via the LRFs. These differences in cultures of flood risk management between the two countries are reflected to a certain extent in the tools that are used by flood risk managers. This is further discussed in the fourth part of the paper.

2.4 Issues identified with flood emergency plans in England and Wales and France

As part of research recently undertaken to assess flood emergency plans in England and Wales and France 22 metrics have been developed (Lumbroso et al, 2011). These metrics cover a range of issues from the aims and objectives of the plan to training and exercises. The developed metrics and survey of emergency planners provided a basis to compare flood emergency plans in the two countries. An assessment of plans found that areas such as the roles, responsibilities and communication is essential for a plan to be effective and that these aspects tend to be well covered in the two countries looked at. However, other more technical aspects such as accessibility of roads during floods, evacuation, and the depiction of flood hazard and impacts of floods on critical infrastructure can be considerably improved (Lumbroso et al, 2010, 2011). There was often a discrepancy between the level of detail required by emergency planners and the actual level of detail that is available in the plans (Lumbroso et al, 2010, 2011). The discrepancy between emergency planners' requirements was found to greatest for matters related to the risk floods pose to people in terms of injuries and lose of life; buildings; critical infrastructure and accessibility to flooded areas (Lumbroso et al, 2010, 2011).

Recent research in the two countries has shown that many emergency planners believe that the effectiveness of a flood emergency plan can only truly be assessed accurately after the plan has been used to respond to a large flood event (Lumbroso et al, 2010, 2011). A recent evaluation of a flood emergency plan used in the county of Cumbria in northern England during severe, widespread flooding in November 2009 highlighted the usefulness of tools to assess the vulnerability of critical infrastructure such as location of electricity sub-stations and care homes, as well as the possible inundation of roads with a flooding history outside the formal flood warning areas. These were also seen as very useful both to strategic and tactical response by the police and other key emergency responders (Cumbria LRF, 2010).

Emergency plans both in England and Wales and in France currently make use of local knowledge from a wide range of stakeholders with regards to the impact historical floods, the vulnerability of stakeholders and the response during a flood event. Research carried out recently indicated that generally local knowledge was incorporated well into the plans as a result of stakeholder consultations and forums (Lumbroso et al, 2010b). However, in many parts of the two countries communities are heavily defended against flooding by structural mitigation measures and as a result have often not experienced flooding in

living memory. Clarke (2006) and ten Brinke (2010) make the case for "worst case thinking" and its application to emergency planning for flood events. Clarke argues that emergency plans should not be biased in favour of what has already happened in the past. Clarke (2006) also highlights the often narrow understanding of complex systems and laments the hubris that allows many stakeholders to think that they can be controlled and the selective understanding of the infrastructure informs failed disaster planning. Clarke argues when policy-makers plan for disasters, they too often think in terms of past experiences and probabilities ("probabilism").

Using statistics and knowledge of previous events can limit the "out of the box" thinking that is needed to explore future possibilities (ten Brinke, 2010). It is important that policy makers think about worst case disasters even though they may seem purely hypothetical events (Boin et al, 2005; Clarke, 2006) because "*things that have never happened before happen all the time*" (Sagan, 1993). Thinking in terms of "worst cases" and that which is possible ("possibilism") can be more enlightening in terms of emergency planning (Clarke, 2006). To have a realistic understanding of the risks for low probability events it is often important to utilise tools to assess, for example, the impact the failure of critical infrastructure, such as water, energy, waste and transport systems, can have in terms of damage caused to the environment, cost to the economy, and loss of life. Clarke (1999) pointed out for many emergency planners it can be easier to produce symbolic, "fantasy" documents than to engage in forthright admissions of real dangers and the uncertainties that they create. Perry and Lindell (2003) suggest that emergency management processes should be based on an accurate knowledge of the threats. It can be argued that if the approaches to emergency planning suggested by Clarke and Perry & Lindell had been taken in France the number of people that died as a result of the coastal flooding caused by "la tempête" Xynthia in February 2010 could have been significantly reduced.

A survey of 172 emergency planners in the two countries (Lumbroso et al, 2010, 2011) indicated that recent floods have raised the importance of the protection of the critical infrastructure (e.g. power stations, water supply networks) against the impact of floods, accessibility of flood zones, the vulnerability of buildings, as well as how loss life as the result of flood events can be reduced. However, there appeared from a review of MAFPs and PCSs undertaken little evidence that flood managers responsible for advising emergency planners on these issues were making use of the full range of tools available to them. This has in some cases resulted in flood emergency plans that are merely symbolic and that as Clarke (1999) states "*are used as forms of rhetoric to convince audiences that they ought to believe what an organization says*" and that have "*little instrumental utility in them*". The third part of this paper provides some background to the tools that are currently available to flood risk managers to assist them in assessing possible risks posed by floods and to help them ameliorate emergency plans so that they address the issue of "possibilism". The fourth part of the paper then investigates the use of tools amongst flood managers.

3. Background to tools

The tools that are currently readily available to assist flood managers in providing information on the flood risk to various plans can be broadly grouped into the following groups:

- Flood hazard mapping
- Assessment of risk to people from floods
- Estimation of the evacuation times zones at risk of inundation
- Assessment of the accessibility of roads
- Impacts of the failure of critical infrastructure

These tools are briefly detailed below.

3.1 Flood hazard mapping tools

Flood extent, depth, and velocity maps form the basic information for emergency planners, who have to prepare emergency plans (van Alphen et al, 2009). There is a large volume of information that already exists on flood hazard modelling and mapping tools. In the past decade the use of two dimensional hydraulic tools to model inundations has become increasingly prevalent in the two countries. This has meant that it is now possible to produce flood hazard maps that show not only flood extents, but also depths, velocities or a combination of these two parameters.

In England and Wales there are three main types of flood maps that are used to inform MAFPs, these are:

- **Fluvial and coastal flood map** that shows the maximum undefended flood extent
- **Surface water flood map** that shows areas that may be susceptible to surface water flooding
- **Reservoir inundation maps** that shows the maximum flood extent in the case of a dam failure

The above maps only show flood extents and give no indication of maximum depths or velocities. An example of a flood map produced by the Environment Agency is shown in Figure 1.

In France, the majority of flood hazard maps used in emergency plans are taken from a Plan de Prévention du Risque (PPR). PPRs are a legal requirement documenting the risks that a particular commune is prone to. The main objective of PPRs is to assist with spatial planning decisions. As a consequence of this, the maps contained in PPRs conform to these requirements and generally only show the maximum extent of a flood for a particular return period similar to the case in England and Wales.

The reference return period for flood maps for PPRs is the 1 in 100 year return period or a historical flood outline if this is greater than the 1 in 100 year extent. Owing to the fact that the flood maps in the PPRs are produced to regulate land use planning, they often do not meet the needs of emergency planners. This is because they rarely provide an “intermediary level of the flood hazard” (e.g. the 1 in 30 or 1 in 50 year flood extent) and they often do not often show other parameters that are relevant to emergency planners such as maximum floodwater velocities and depths.

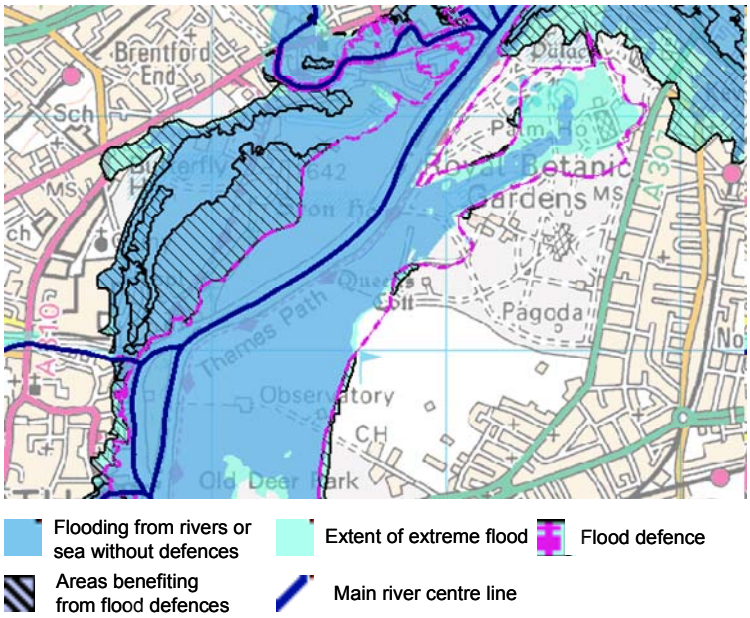

Figure 1 Example of a flood extent map of part of the River Thames

Apart from cases where important assets, such as critical infrastructure, are at risk, the maximum floodwater velocity is not calculated. In France a general assumptions is made that in the northern part of the country floodwater velocity is relatively "low" because floods are generally caused by rivers that rise relatively slowly (e.g. the Loire, the Seine). Whereas in southern France, where many areas are subject to flash floods, the flood water velocity is assumed to exceed 0.5 m/s everywhere.

The floods maps for emergency plans can be classified into three levels of details.

1. Maps showing just the maximum flood extent
2. Maps providing maximum flood extent and water depth
3. Maps showing maximum flood extent, depths and velocity

Ideally the maps should show these parameters for a range of return periods. There are some limited examples where maps including flood depth for a range of return periods have been included in emergency plans in France. In England and Wales, and France it can be concluded that the flood maps in emergency plans are generally based on flood hazard maps produced to regulate land use planning and not directly produced to assist with emergency planning.

3.2 Tools to assessing the flood risk to people

Despite the impacts of floods globally it is only recently that models have become available for the estimation of loss of life caused by inundations (Jonkman, 2007). There are a variety of tools that have been produced and that are available to inform emergency plans. These models include some form of "mortality function" that relates loss of life to various characteristics of the flood, depending on the complexity of the model. A brief overview of the tools that are available is described below.

The US Bureau of Reclamation (Graham, 1999) and Risk to People (Defra, 2006) methods provide simple means for assessing and mapping the risk of death or serious harm to people caused by flooding based on

empirical data. A typical output from these tools that can be of use to inform emergency plans is shown in Figure 2.

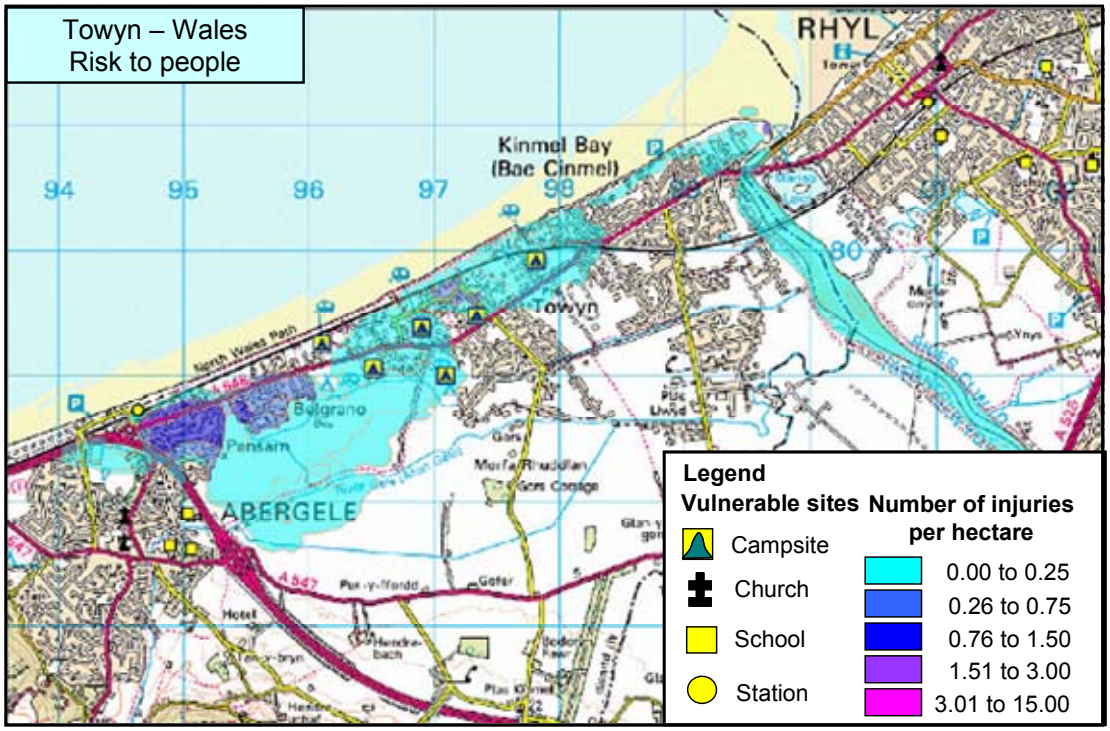

Figure 2 Example of a risk to people map of Towyn in Wales showing the potential number of injuries for a failure of the coastal flood defences

Other more complex models such as the Life Safety Model (LSM) and LifeSim models use detailed local data and capture the flood mechanisms that can cause fatalities (Johnstone et al, 2005; Aboelata & Bowles, 2005). The LSM is the most detailed of the tools available because it simulates an individual's fate during a flood event and includes a simple traffic model, a building collapse function and also simulates the possibility of vehicles being swept off roads by the floodwave (Di Mauro and Lumbroso, 2008). The LSM can be used to develop evacuation strategies for floods. The LifeSim model distinguishes groups of people, whose circumstances are comparable. The disadvantage of such an approach is that a large number of behavioural variables have to be assigned to the people potential affected by floods, for which very limited empirical information is available (Jonkman, 2007).

3.3 Tools to assess the evacuation times for floods

Evacuation has the potential to save lives, but can be costly in time, money, and credibility. Different types of evacuation can be distinguished such as: preventive evacuation; vertical evacuation to safe havens or shelters; or "shelter in place". The consequences in terms of reducing the risk to life depends on the required time to evacuate, which is related to the type of evacuation, characteristics of the area and type of flooding. Tools to assess the evacuation times for floods are important for stakeholders responsible for the efficient and safe movement of people during an evacuation. They can identify "bottlenecks" in the areas before they are experienced during an evacuation, and they can also be used to determine the impact of road closures due to flooding, the impact of phased evacuation on traffic loading, and other possible consequences.

In England and Wales, and France tools to assess evacuation times appear to be rarely used by emergency planners. However, there are a number of tools that have been developed for specific use in flood risk management mainly in the Netherlands. There are various scales at which evacuation modelling can be carried out. Macro-scale evacuation models are useful for obtaining first order estimates of evacuation times for relatively large areas. Meso- and micro-scale models are needed for detailed evacuation planning.

In some cases, for results to be useful, there is a need for individual receptors (e.g. people, houses, vehicles) to be modelled and for additional information to be provided (e.g. loss of life and injury estimates, effects of different management plans) not just evacuation times. Micro-scale models, although more time consuming to set up than macro models, provide emergency planners and other end users with more insight into the areas at greatest risk, and also provide decision makers with other risk metrics (e.g. number of collapsed buildings, loss of life, inundation of escape routes). However, to be effective such models should be applied to the whole area at risk. Such micro-scale models can also be used to inform flood emergency planning exercises.

3.4 Tools to assess accessibility of roads and the vulnerability of critical infrastructure and buildings

Information on industrial accidents triggered by natural events (NaTech) and damage to critical infrastructure are important for emergency plans. There are few readily available tools that can provide information on these. In the case of floods no simplified equipment damage models are available in the literature. There is only very limited data available to analyze in detail the damage caused by floods to industrial equipment. The information about past accidents recorded in industrial accident databases is usually not sufficiently detailed, in particular with respect to the description of the structural damage of equipment caused by the floods. There have been some limited tools available to assess NaTech hazards using simple damage functions such as those developed by Bonvicini et al (2009)

In terms of accessibility of roads in the early 1990s Keller and Mitsch (1992, 1993) carried out research on the stability of both cars and people in flood conditions. The research considered the physics of vehicles in floodwater conditions. The analysis of vehicle stability involved calculations for three types of common cars. This work has led to a simple guidance that can be used to inform the accessibility of roads during flood events.

In France since the creation of the PCS, tools to optimize evacuation routes and to assess the access to inundated areas are being developed such as “Itineris”. Itineris calculates the optimal route for rescue vehicles to access inundated areas taking into account roads cut off by floods or blocked by traffic. Prototype models have also been developed to map possible road inundations in the Gard region of the south-east of France, an area that is frequently subject to severe flash floods (Versini et al, 2010). The objective is link the inundation model with a road network model to provide emergency services with a forecast of what roads are likely to be closed a few hours before a major flash flood occurs.

A number of tools have been developed to assess the probability of buildings collapsing or being damaged during floods. For example Clausen & Clark (1990) developed simple methods for predicting flood damage to buildings during extreme floods based on the velocity and depth of the water. Work in this area has also been carried out by Lorenzen et al (1975) and Smith (1994).

4. The awareness and obstacles to the use of tools amongst flood managers

Flood risk managers in England and Wales and France who are responsible for providing information to inform the development of emergency plans for flood were engaged in the research through two main methods:.

- Face-to-face discussions
- An online survey in English and French that was disseminated to flood risk managers who provide technical input and advice to emergency planners and work with them to produce flood emergency plans within the two countries. In England and Wales 53 flood risk managers who work for the Environment Agency staff answered the online survey and in France 77 flood risk managers who work for both DREAL and SCHAPI responded to it

This allowed the level of awareness that they had of the available tools to be assessed.

4.1 The perceived use of tools to inform flood emergency plans

As part of the online survey flood managers in the two countries were asked which tools, methods and guidelines they used or knew of that were of use in formulating emergency plans for floods. The following choices given in the survey together with the responses are given in Table 4.

In relation to the perceived level of use of tools in the two countries, Table 4 shows that generally the use of tools to inform flood emergency plans is perceived to be much higher in England and Wales than it is in France.

The perceived level of use of fluvial flood hazards to inform emergency plans was very high (>90%) in both countries. Floodplain mapping and hydraulic modelling for rivers are both "mature sciences" in Europe with hundreds of millions of Euros worth of mapping studies and modelling exercises being undertaken in the past decade. As a consequence it is understandable that in both countries fluvial flood hazard maps are readily available and are used to inform plans. In France the level of awareness of tools to assess coastal hazards was low, around 20% compared to 80% in England and Wales**.**

Historically flooding from the sea has been higher up the political agenda in England and Wales than in France. This is probably because London is located on a tidal estuary and after 307 people died in the UK as the result of coastal flooding from the North Sea in 1953 the issue of coastal flooding and defence gained new prominence with British politicians (Gilbert, 1986). This led directly to a policy in England and Wales that focused on the raising and strengthening of coastal flood defences and the eventual construction of the Thames Barrier to protect London and the Thames Estuary (Penning-Rowsell et al, 2006).

In France, the low perceived level of the use of tools to assess coastal floods may be due to the fact that, until recently, the risks posed by coastal flooding in France were perceived to be relatively low by stakeholders. Historians such as Coeur argue that in France the focus has generally been on fluvial flood because the major cities and the political centres (i.e. Paris, Lyon, the Tourain region) are adjacent or traversed by France's largest rivers and have experienced the most extreme floods (i.e. River Rhone 1856 in Lyon, River Seine flood in Paris, 1910) (Coeur, 2002; Jackson, 2010). Although there have been coastal floods in the past in France (Garnier & Surville, 2010) owing to the centralized nature of the French Government system and the fact that the main centres of political influence are subject to fluvial flooding, flood prevention in France has focused mainly on major rivers rather than the coast.

Table 4 shows that the perceived level of use of tools was higher or the same in England and Wales than in France for all bar one type of tool. This may well reflect the fact that as discussed in part 2 of this paper flood risk management is more "joined-up" in England and Wales and less compartmentalized than it is in France. The disjointed organizational structure of flood risk management in France means that it is likely to more difficult to disseminate new methods and tools than it is in England and Wales. The survey results also bear out the fact that in France most flood risk managers tend to concentrate on the technical aspects of fluvial floods rather than having a more holistic approach to flood hazards and risk as is the case in England and Wales.

Table 4 Perceived level of use of tools to inform emergency plans by flood risk managers

Type of tool	Precentage of responders who perceive the tools as being used	
	England and Wales	France
Fluvial flood mapping hazard tools	98%	98%
Coastal flood hazard mapping tools	80%	18%
Methods to assess the flood hazard posed by dam failure	58%	43%
Methods to assess other sources of flood hazard (e.g. surface water flooding)	58%	38%
Tools to assess the accessibility of inundated roads and evacuation routes	53%	33%
Optimisation of shelters locations with respect to the flood hazard	51%	20%
Assessment of the damage to critical infrastructure by floods	49%	23%
Tools to assess optimal evacuation routes and times	42%	8%
Methods to assess how improvements in flood warning affect the risk to people	40%	30%
Methods to asesss possible injuries and loss of life caused by floods	36%	18%
Inter-dependency of critical infrastructure and the consequences of this	18%	13%
Tools to assess other hazards (e.g. NaTechs) that can be triggered by floods	13%	10%
Probability of building collapse triggered by floods	2%	5%

The most interesting part of the survey was that when asked the responders what tools they actually use very few flood managers explicitly named tools that can assess, for example, the accessibility of roads, damage to critical infrastructure, loss of life etc, even though they mentioned that they used them to inform their emergency management plans. This discrepancy between the perceived and actual use of tools by flood managers and the perceived obstacles to the use of the tools available is discussed below.

4.2 Obstacles to the use of the available tools

The primary objective of the survey was to assess the perceived obstacles to using tools by flood managers. Flood managers were asked if they currently used the tools and if not to classify the reason into one of the following: "Not relevant to emergency plans for floods"; "Unaware of the method"; "Cost"; "User friendliness issues"; "Availability of data"; "Other reasons". The results of the survey are discussed below under three main headings:

1. Tools to assess flood hazards from different sources
2. Tools to assess risk to people, evacuation routes, accessibility and flood warnings
3. Tools to assess risk to critical infrastructure, location of shelters, assessment of NaTechs and the probability of building collapse

4.2.1 Tools to assess flood hazards from different sources

Table 5 summarises the results of the survey for tools relating to flood hazard. The use of tools to assess fluvial floods in both countries was high. Only approximately 44% of responders in France stated that they currently use tools to assess coastal hazards, this contrasts with the 20% of responders who perceived that the output from these tools are currently used to inform emergency plans. With respect to assessing flood hazard from dams the major obstacle for these methods not being employed more frequently was "availability of data". Some 25% of responders in England and Wales and France indicated that this was an issue. Regarding assessing flood hazards from other sources (e.g. pluvial flooding) in France almost 20% of responders were unaware of methods to assess this hazard.

Table 5 Perceived obstacles to using tools to assess flood hazard from different sources

Response	Fluvial flood hazard		Coastal flood hazard		Dam flood hazard		Other sources of flood hazard	
	England and Wales	France	England and Wales	France	England and Wales	France	England and Wales	France
Currently used	88.6%	100.0%	70.6%	44.0%	42.9%	50.0%	51.5%	38.0%
Not relevant to plans	0.0%	0.0%	20.6%	17.0%	5.7%	0.0%	3.0%	10.0%
Unaware of method	5.7%	0.0%	2.9%	17.0%	11.4%	14.0%	9.1%	24.0%
Cost	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	3.0%	0.0%
User friendliness issues	2.9%	0.0%	2.9%	0.0%	2.9%	5.0%	6.1%	5.0%
Availability of data	0.0%	0.0%	0.0%	6.0%	22.9%	23.0%	24.2%	19.0%
Other reasons	2.9%	0.0%	2.9%	17.0%	14.3%	5.0%	3.0%	5.0%

It is noticeable that the use of tools to assess the coastal flood hazard is much higher in England and Wales than in France. This is mainly a result of the result of the differences in organisational aspects of flood risk management in the two countries discussed above. The current perceived use of tools to assess the hazard of flooding from dams was slightly higher in France and this is probably a result of the recent reinforcement of legal requirements relating to dam safety.

It is interesting to note that the level of awareness regarding surface water flooding tools was much higher in England and Wales than in France. Much of the flooding that occurred in England in 2007 was the

result of pluvial flooding. The Environment Agency was one of the first organisations in the world to produce a national surface water flood map to identify areas likely to flood following extreme rainfall events. In France a national surface water flood map has not been produced. This explains the differences between the awareness levels. It should be noted that where responders to the survey indicated that the tools "were not relevant to plans" this was generally because they were in landlocked areas or catchments without dams so there no hazard posed by coastal flooding or dam breaks.

4.2.2 Tools to assess tools to assess risk to people, evacuation routes, accessibility and flood warnings

Table 6 shows the perceived obstacles for tools to assess risk to people, evacuation routes, accessibility and flood warnings. The perceived use of methods to assess the risk to people in England and Wales is higher than France. This is to be expected as a major research project on this subject commissioned by the Environment Agency was completed in 2006 (Defra/Environment Agency, 2006). The results of this work have fed directly into a number of planning policies; however, despite this there were still almost 63% of responders who remained unaware of these tools. In France little work on the risk that floods pose to people has been carried out. The general low level of awareness of methods in both countries of risk to people methods may also be a result of the fact that estimating fatalities for theoretical natural disasters can be a very politically sensitive issue (Flores & Smith, 2010).

Table 6 Perceived obstacles to using tools to assess risk to people, evacuation routes, accessibility and flood warnings

Response	Injuries to people and number of fatalities		Accessibility of roads		Optimal evacuation routes		Improvements in dissemination of flood warning	
	England and Wales	France	England and Wales	France	England and Wales	France	England and Wales	France
Currently used	14.3%	5.0%	31.4%	20.0%	31.4%	16.0%	45.7%	26.0%
Not relevant to plans	5.7%	5.0%	0.0%	0.0%	0.0%	0.0%	5.7%	0.0%
Unaware of method	62.9%	68.0%	48.6%	35.0%	57.1%	47.0%	34.3%	53.0%
Cost	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%
User friendliness issues	0.0%	5.0%	5.7%	0.0%	0.0%	5.0%	0.0%	0.0%
Availability of data	14.3%	11.0%	11.4%	40.0%	8.6%	26.0%	5.7%	16.0%
Other reasons	2.9%	5.0%	2.9%	5.0%	2.9%	5.0%	8.6%	0.0%

Only a few of the flood risk managers who responded to the survey (<32%) were aware of tools to assess the accessibility of roads in flood zones and to assess optimal evacuation routes. For example discussions with one responder indicated that in the case of assessing the accessibility of roads to emergency vehicles often "rule of thumb" methods were used (i.e. emergency services would be told that roads were inaccessible if the depth of water covering a road is more than 200 mm) rather than a physically, based method such as those developed by Keller and Mitsch (1992, 1993). In France, in general, availability of data is seen as more of an issue than in England and Wales. Again the more joined up nature the organisation of flood risk management in England and Wales means that most of the data required to

utilise the various tools is held by one organisation, the Environment Agency, which is far from the case in France. For example the Environment Agency has access to the UK's digitised road network data. This data is not readily available to French flood risk managers.

The perceived use of tools to assess evacuation routes and improvements in the dissemination of flood warnings was again higher in England and Wales than in France. Again the more holistic approach to flood risk management by the Environment Agency is reflected in the higher level of use in England and Wales.

4.2.3 Tools to assess tools to assess risks to critical infrastructure, location of shelters, assessment of NaTechs and the probability of building collapse

Table 7 details the perceived use of tools relating to risks to critical infrastructure, building collapse, location of shelters and the assessment of other hazards that can be triggered by floods. Following the 2007 floods in England the impacts of flooding on critical infrastructure was raised key issues that need to be improved with respect to the emergency response to floods (Pitt, 2008; ICE, 2009). This is likely to explain the higher awareness of methods in England and Wales relative to France. Issues regarding the availability of data on this subject in both countries are summed up by two flood risk managers who stated that: "*It is very hard to acquire but more information on critical infrastructure and their likelihood of flooding would be very beneficial to emergency responders. This data at the moment is very sparse*"; and "*One of the largest risks is the limited knowledge we have of much of our infrastructure, in terms of location, nature, condition, and impact of failure. The disparate datasets for assets, in particular networks, makes the understanding of total risk difficult to assess.*"

With regards to the optimisation of shelter locations, assessment of other hazards triggered by floods and the probability of building collapse, these also had some of the lowest levels of awareness regarding the tools. Similar to the assessment of the accessibility of roads many of the responses to the survey suggested that "rule of thumb" measures were being used rather than methods that allowed the concept of "possibilism" to be addressed.

Table 7 Perceived obstacles to using tools to assess risks to critical infrastructure, location of shelters, assessment of NaTechs and the probability of building collapse

Response	Potential damage to critical infrastructure		Optimising the locations of shelters with respect to floods		Assessment of other hazards triggered by flooding		Probability of buildings collapsing during floods	
	England and Wales	France	England and Wales	France	England and Wales	France	England and Wales	France
Currently used	29.4%	17.0%	42.9%	24.0%	11.4%	11.0%	0.0%	6.0%
Not relevant to plans	0.0%	0.0%	0.0%	0.0%	2.9%	0.0%	3.0%	0.0%
Unaware of method	35.3%	56.0%	40.0%	59.0%	68.6%	53.0%	72.7%	56.0%
Cost	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
User friendliness issues	0.0%	6.0%	0.0%	0.0%	0.0%	11.0%	0.0%	17.0%
Availability of data	35.4%	22.0%	11.4%	12.0%	8.6%	26.0%	24.2%	22.0%
Other reasons	0.0%	0.0%	5.7%	6.0%	8.6%	0.0%	0.0%	0.0%

5. Discussion

The survey of flood risk managers in England and Wales and France showed although many flood risk managers used or were aware of methods to assess the flood hazard from various sources there was a low awareness of many of the other tools available. A typical level of awareness of the tools by flood risk managers available in the two countries is summed up by the following response: "*There are no dedicated tools or methods employed beyond standard datasets such as the flood extent map."* The research showed that generally over half of flood risk managers were not aware of the following types of methods and tools:

- Tools to assess risk to people, evacuation routes, accessibility and flood warnings
- Tools to assess risk to critical infrastructure, location of shelters, NaTechs and the probability of building collapse

User friendliness was not seen by the responders to be an obstacle to the use of tools; however, this may be linked to that fact that there was a high level of unawareness concerning these types of tools meaning that responders were unable to comment knowledgably on these issues. It is interesting to note that cost was not seen as a major constraint for the implementation of the methods. Very few users (<6%) indicated that the methods listed in the survey were not relevant to formulation of emergency plans for floods.

The survey of flood risk managers highlighted the need to raise awareness of them. Typical responses provided included: "*There may be guidance, methods, or tools in existence that I am unaware of. If so it would be good to give training on these tools to assist in producing emergency plans"* and *"Educate all staff involved with contributing to emergency plans about what tools are available to us to help us with the plans"*. The lack of dissemination of tools to assess the impacts on flood or to assess potential damage has already been pointed out in many articles and reports in France (Hubert & Ledoux, 1999); however, this would also appear to be the case in England and Wales certainly with respect tools that can be used to inform emergency plans.

There is also some times a case of division of responsibility. For example in the case of certain aspects of flood risk management (e.g. estimation of loss of life; evacuation times) it is not always clear who should take the lead (i.e. flood risk managers or emergency planners). This may be because some of the types of tools for improving emergency plans are perceived to fall outside the remit of all the stakeholders. This can mean that tools are not used because there is a "responsibility gap" through which the use of the tools falls.

The floods of 2007 in England and the failure of coastal defences resulting in 47 fatalities in the Vendée region of France show that the two countries remain unprepared for extreme flood events (Pitt, 2008 and MEEDDM, 2011). A recent report on critical infrastructure by the Institution of Civil Engineers (ICE) in the UK provides the following example showing that the concept of planning for the "worst case" or "possibilism" is often not considered. The ICE report illustrates the failure to plan with the example of the Atomic Weapons Establishment site at Burghfield in the UK that was flooded in 2007. All the radiation detection alarms were disabled. If the floodwaters had penetrated only a little further it could have led to the spread of radioactive material, forcing the evacuation of thousands of people and leaving the area near the site uninhabitable for centuries (ICE, 2009).

This failure to plan is also illustrated by the example of Canvey Island in the UK. Canvey Island is located in the Thames Estuary. The mean ground level is below the high tide level. The island is protected from floods by a network of embankments. The island is home to some 37,000 people (Lumbroso & Di

Mauro, 2008). In 1953 the flood defences failed and 58 people were killed as the result of the flooding. Access to Canvey Island is currently only possible by two roads both of which are connected to the same roundabout. Any disruption to these routes would hamper evacuation and severely limit access. A number of properties are vulnerable to flooding with 30% of the housing stock being bungalows and 45% of flats being located on the ground floor (Kelman, 2002).

Concerns regarding emergency planning have been raised by local communities who state that "major issues" include "*the lack of safe havens, lack of a fit for purpose emergency plan and of course the problems associated with evacuation amongst others*. *The Council has to date not provided evidence that it can confidently provide a robust emergency flood response strategy for Canvey Island, which would be cut off from the mainland for some considerable time during extreme flood conditions*" (CGC, 2009a). The risk posed by flooding the possibility of an extreme flood inundating the island has not appear to have been planned for this is despite the fact that urbanisation of Canvey Island, including caravans and mobile homes, has increased the vulnerability of its residents (CGC, 2009b).

As this paper demonstrates there are tools that could assist flood risk managers provide advice to emergency services on the location of safe havens, the accessibility of flooded routes in addition to assessing where the risk to people is highest. However, in England and Wales and France these tools appear to be rarely used by flood risk managers. The main reason would appear to be a lack of knowledge of what tools are available. However, in the UK there may also be an issue with technical capacity. Reports carried out on the skills required for flood risk management in the UK have pointed out that "*too few people are being trained to replace the ageing skilled workforce, and too few are acquiring the technical and managerial skills required to get full value from new techniques and technologies*." (Environment Agency et al, 2005; ICE, 2005) The down-sizing of public sector technical departments arising from out-sourcing has also left them short of mature professional staff with competencies in the key technical skills to enable these organisations to operate as consistently intelligent clients (ICE, 2005). This lack of technical capacity can in some cases discourage the use of new methods that are not viewed as being "mature".

In the face of low probability events some organisations may suffer from poor intelligence gathering and processing or even a "*it can't happen here*" mentality (McConnell & Drennan, 2006). However, as the cases of New Orleans in 2005 and the "Great North Sea floods" that hit Britain and the Netherlands in 1953 demonstrate it can happen here. Emergency planning should be based on a wide variety of scenarios including extreme floods. Even for the worst credible flood there are in some cases simple measures that are not always "obvious" that can be demonstrated using relatively simple tools (e.g. location of safest routes to flooded zones; optimum location of shelters).

6. Conclusions

From the research carried out many flood managers are often not aware of the tools that are available to assist them in providing information to emergency plans for floods. Based on the online survey of flood managers in the England and Wales and France, the three main obstacles to tools not being used appear to be:

1. Lack of awareness of the methods that are available
2. Availability of data
3. Lack of communication between flood risk managers and the stakeholders such as emergency services and local authorities responsible for writing the plans

Emergency plans for floods often contain limited information on flood scenarios (e.g. one or two flood extents) and often no information on flood depths and velocities. Plans usually contain actions on what to do at certain trigger levels without knowledge of the potential consequences (e.g. in terms of potential risk to life; accessibility of roads etc). The recent coastal floods in France showed although most of the risks were known by some organisations, this knowledge had not been translated into potential consequences in the relevant emergency management plans (MEEDDM, 2010). In formulating emergency plans for floods it would appear that "expert judgement" is often used rather than specific tools. Whilst local knowledge and expert judgement are important in formulating plans many consequences and emergency responses to extreme flood events can only be formulate using tools.

Many responders to the survey mentioned that they used a combination of information rather than specific methods or tools. For example in the survey in England and Wales around half to a third of the responders stated that they were aware of, or used the methods to assess: Accessibility of inundated roads; Optimisation of the location of shelters; Damage to critical infrastructure; Optimal evacuation routes; Effects of improvements in flood warning on the risk to people; and Methods to assess potential injuries and loss of life. However, none of the 44 flood managers who are involved in providing information to assist with the formulation of MAFPs in England and Wales explicitly mentioned any methods or tools that provide such information.

In France the awareness level of the tools and methods available was lower than in England and Wales. The lack of awareness in general may be as a result of a need to improve the dissemination of the tools and the relevant research and the fragmented nature of flood risk management in France. The lack of awareness of tools to assess the consequences of flooding has already been pointed out in many articles and reports in France (Hubert & Ledoux, 1999).

The split of responsibilities between flood management organisations and authorities responsible for emergency planning means that in some cases neither organisation wishes to be responsible for utilising tools such as loss of life and evacuation models. This is true in both England and Wales and France where the organizations responsible for emergency planning and response fall under different ministries.

Whilst it is acknowledged that some of tools may not yet be "mature" there are many relatively simple tools available that flood risk managers could commence using immediately. The research has indicated that there is to be a requirement for guidance on: what tools are available; what data they require; and how the tools can be implemented to give information that can be used to improve emergency planning for floods. It would also appear that flood risk managers and emergency planners have the potential to improve the effectiveness of emergency plans by working more closely together and start considering "possibilism" more in their plans by using tools that are currently available.

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Terms and definitions

Term	Definition
Catchment	The area from which water runs off to a given river
Consequence	An impact such as economic, social or environmental damage/improvement that may result from a flood
Critical infrastructure	The physical facilities, supply chains, information technologies and communication networks which, if destroyed, degraded or rendered unavailable for an extended period, would significantly impact on the social or economic wellbeing of a nation
Emergency management	The ensemble of the activities covering emergency planning, emergency control and post-event assessment
Flood	A temporary covering of land by water outside its normal confines.
Hazard	A physical event, phenomenon or human activity with the potential to result in harm. A hazard does not necessarily lead to harm
Receptor	Receptor refers to the entity that may be harmed (a person, property, habitat etc.). For example, in the event of heavy rainfall (the source) flood water may propagate across the floodplain (the pathway) and inundate housing (the receptor) that may suffer material damage (the harm or consequence). The vulnerability of a receptor can be modified by increasing its resilience to flooding.
Residual risk	The risk that remains after risk management and mitigation measures have been implemented. May include, for example, damage predicted to continue to occur during flood events of greater severity that the 100 to 1 annual probability event.
Risk	Risk is a function of probability, exposure and vulnerability. Often, in practice, exposure is incorporated in the assessment of consequences, therefore risk can be considered as having two components: the probability that an event will occur and the impact (or consequence) associated with that event. Risk = Probability multiplied by consequence
Stakeholders	Parties/persons with a direct interest (stake) in an issue
Uncertainty	A general concept that reflects our lack of sureness about someone or something, ranging from just short of complete sureness to an almost complete lack of conviction about an outcome.

Glossary of acronyms and abbreviations

BEM	◄	Business Element Method
CRUE	◄	Coordination of the research financed in the European Union on flood management
Defra	◄	Department for Environment, Food and Rural Affairs of the British Government
EC	◄	European Commission
FCERM	◄	Flood And Coastal Erosion Risk Management
FIM FRAME	◄	Flood Incident Management Framework for Improvement
GIS	◄	Geographic Information System
LRF	◄	Local Resilience Forum is a forum formed in a police area of the United Kingdom by key emergency responders and specific supporting agencies. It is a requirement of the Civil Contingencies Act 2004.
MAFP	◄	Multi-Agency Flood Plan produced by Local Resilience Forums in England and Wales
MEEDM	◄	Ministère De L'Ecologie Et Du Développement Durable Directions Régionales De L'Environnement of the French Government
PCS	◄	Plan Communal de Sauvegarde is a communal level plan in France to help with the emergency response to natural hazards (e.g. floods, landslides), technological hazards or health risks
WP	◄	Work Package

Table of project information

Joint project title	◄	**Flood Incident Management – A FRAMEwork for improvement – FIM FRAME**
CRUE Project No.:	◄	
Project partner #1 (Co-ordinator):	◄	Darren Lumbroso
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Project website:	◄	http://www.fimframe.net
Objectives	◄	The objectives were as follows: • To assess current emergency plans for floods • To evaluate tools that be used improve emergency plans for floods • To develop a method to enable stakeholders to improve emergency plans for floods • To pilot and refine the method in a number of case studies in England, France and the Netherlands • To disseminate the results
Background	◄	Emergency planning for floods
Research	◄	Development of a method to improve emergency planning for floods
Findings	◄	There is a need to improve emergency plans for floods and the use of tools that can improve them needs to be more widely disseminated. The metrics and the FIM FRAME method that have been developed have been found to be useful to assess and improve existing plans as well as developing new ones.
Implications (Outcome)	◄	There is requirement for more research into how emergency plans can be improved and to ensure that they meet stakeholders' needs. There is also a requirement for plans to take into account "possibilism" (i.e. "worst case" scenarios)
Publications related to the project	◄	See http://www.fimframe.net/dissemination.html for all the publications available