Integrate, Consolidate and Disseminate European Flood Risk Management Research

Research supported by the
2nd ERA-NET CRUE Funding Initiative for Research in Flood Risk Management







Flood resilient communities – managing the consequences of flooding

WP4 Case studies: England, France and the Netherlands
CRUE Research Report No 3: Flood Incident Management – A FRAMEwork for improvement – FIM FRAME

Prepared by the Joint Project Consortium consisting of

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Project Contract No: ERAC-CT-2004-515742
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DISCLAIMER

Flood Incident Management – A FRAMEwork for improvement
CRUE Research Report No 3: Case studies: England, France and the Netherland

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Published in 2011

ERA-NET CRUE is funded by the ERA-NET Scheme under the 6th Framework Programme
General Directorate for Research in the European Commission
Contract number: ERAC-CT-2004-515742

ERA-NET CRUE Funding Initiative on
Flood Risk Management Research

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Flood Incident Management – A FRAMEwork for improvement – FIM FRAME
Case studies: England, France and the Netherlands

CRUE Research Report No 3

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CRUE Funding Initiative on FRM

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Contents

1 Introduction

1.1 Background to the research

This report has been produced as part of Work Package 4 (WP4) of the ERA NET CRUE research project entitled Flood Incident Management – A FRAMEwork for improvement (FIM FRAME).

FIM FRAME is a 24 month project research project. The project is funded by:

- The joint Department for Environment, Food and Rural Affairs (Defra)/Environment Agency Flood And Coastal Erosion Risk Management (FCERM) Research and Development Programme and
- The Ministère de l'Ecologie, de l'Energie, du Développement Durable et de la Mer, en charge des Technologies Vertes et des Négociations sur le Climat (MEEDDM).

The research is being undertaken in the UK, France and the Netherlands. The project partners are:

- HR Wallingford, UK – Project coordinator;
- Deltares, The Netherlands;
- Gestion des Sociétés, des Territoires et des Risques (GESTER), University of Montpellier III, France;
- Laboratoire Central des Ponts et Chaussées (LCPC), Nantes, France.

The objectives of the research can be summarised as follows:

- To assess the "effectiveness" of a sample of current flood emergency plans in the UK, The Netherlands and France and to assess methods by which the plans can be improved;
- To evaluate the current tools and technical systems 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 (i.e. primarily loss of life);
- To establish how currently available tools (e.g. guidelines, models) can be used to improve emergency management plans for floods and whether there are any gaps in the tools that are available;
- To provide a framework by which emergency planning for flood incidents can be improved that will be tested in a number of case studies.

The research has been carried out in six Work Packages (WPs) as follows:

- WP1 - Effectiveness and robustness of flood event management plans;
- WP2 - Comparison of currently available tools for the emergency planning of floods;
- WP3 - Development of framework to improve flood event management;
- WP4 - Case studies utilising the developed framework 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 Work Packages is shown in Figure 1.1.

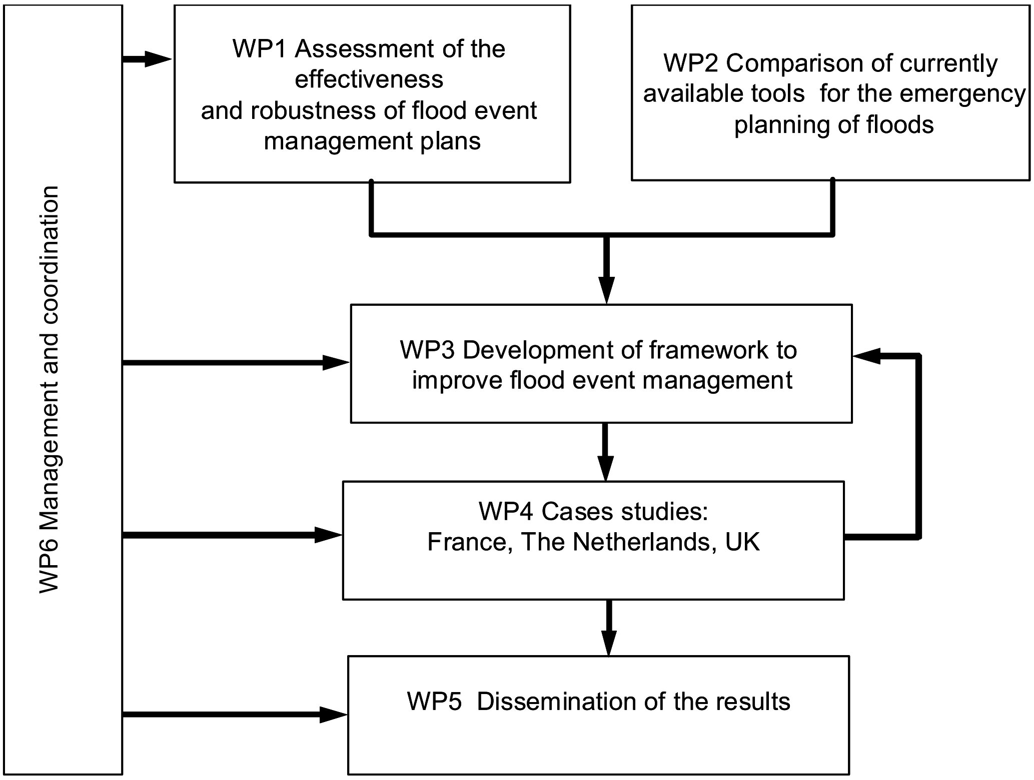


Figure 1.1 Relationships between the FIM FRAME Work Packages

1.2 Background to WP4

The main objective of the FIMFRAME project was to develop a framework or method to assess and enhance flood emergency plans. This framework will be part of practical guidance produces by the project which aims to provide an "integration" in the "good practices" for flood incident management. The project aims to achieve this objective through:

- To assess the effectiveness and robustness of current flood event management plans in England, Wales, the Netherlands and France;
- To evaluate the current tools that are used (or could be used) for flood event management planning and the ability of these tools to support the management planning and the management of future flood emergencies;
- To establish how currently available tools can be used to improve emergency management plans for floods and whether there are any gaps in the available tools
- To provide a framework by which flood incident management can be improved that will be tested in a case studies in France, The Netherlands and the UK.

As part of WP1 a number of emergency management plans for floods were assessed and their strengths and weaknesses described. WP2 presented tools that could help to fill the gaps in the plans. A survey highlighted the needs of flood managers in terms of tools to help them to enhance emergency plans for floods. A method called the FIMFRAME method has been developed as part of the research has been developed to help provide a tool to develop new and improve existing plans.

A number of case studies were carried out as part of WP4, the aim of these case studies was to test and apply the FIMFRAME method developed as part of the research. This report summarises the case studies and the feedback that was received from stakeholders relating to the implementation of the FIM FRAME method.

1.3 Structure of the WP4 report

The structure of this report is as follows:

- Chapter 1 details the context of the research and introduces WP4
- Chapter 2 gives an overview of the FIM FRAME method
- Chapter 3 presents the three case studies carried out in each country
- Chapter 4 provides details concerning how the method was applied in the case study areas
- Chapter 5 provides a summary of the feedback that was received from the stakeholders
- Chapter 7 details the conclusions
- Chapter 8 summarises the references used

2 Overview of the FIM FRAME method

2.1 Background

This chapter describes the FIM FRAME method for assessing and enhancing a generic flood emergency management plan. Building on the knowledge gained from the analysis of flood emergency plans in WP1, and the assessment of available tools for flood event managers (in WP2), a framework for the improvement of emergency plans based on the principles of the Business Elements Method was developed. This comprised a structured approach to the analysis and updating of such plans, and is illustrated in the following Figure 2.1.

The framework comprises three main components:

- Application of the metrics from WP1 to appraise an existing plan
- Use of an entity diagram, cross table and action table (taken from the Business Elements Method) to tackle the issues in existing or new plans
- Implementation of the improvements, possibly using tools to provide improved information.

This framework was designed to be:

- **Simple**, so that it can be applied by anyone without specific training.
- **Transportable**, so that that it can to be applied independently anywhere and by any flood emergency management team and to be adaptable to any kind of flooding (fluvial, flash flood, dike or dam failure…)
- **Generic**, to allow it to be adapted by the user for their specific purpose.

The framework 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 to address the issues and updating the plan

These steps are shown in Figure 2.1. These 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. In other cases, if some issues have already been identified e.g. as result of a post-emergency appraisal or an exercise, then the starting point can be set to be step 3. The framework can also be applied as a loop, re-appraising the plan after the last update.

In order to test and improve the framework, a workshop was held in Ipswich in July 2010, using the analysis of the Suffolk Multi-Agency Flood Plan (MAFP) carried out as part of WP1. The outcomes of this initial workshop and the views of the participants, came mainly from the Local Resilience Forum. Generally the framework was well-received, with most participants considering that they had gained a good understanding of it and that it could help them in their work. Certain aspects were considered to be somewhat academic, particularly the entity diagram, where further guidance and examples would be required to enable the general user to be able to produce one. This was seen as the most difficult area, whether one was starting at the Appraise or Tackle step, in terms of how detailed to make the entity diagram, and whether it was better to produce a high-level mapping initially.

The workshop materials were updated as a result of the Ipswich meeting, and this exercise was repeated with Local Resilence Forum (LRF) stakeholders from Sheffield in November 2010. This provides a direct comparison between the two sets of stakeholders. In general, the feedback was similar, indicating that the majority of participants had understood the framework and that it could provide useful insights into the development and update of flood emergency plans. Although positive, there were concerns over the lack of time and resources to apply the tackle stage, and that it might be better to simply apply the metrics to existing plans. However, more than one of the participants thought that the framework could be used as a training aid, particularly for new people involved in contributing to emergency plans.

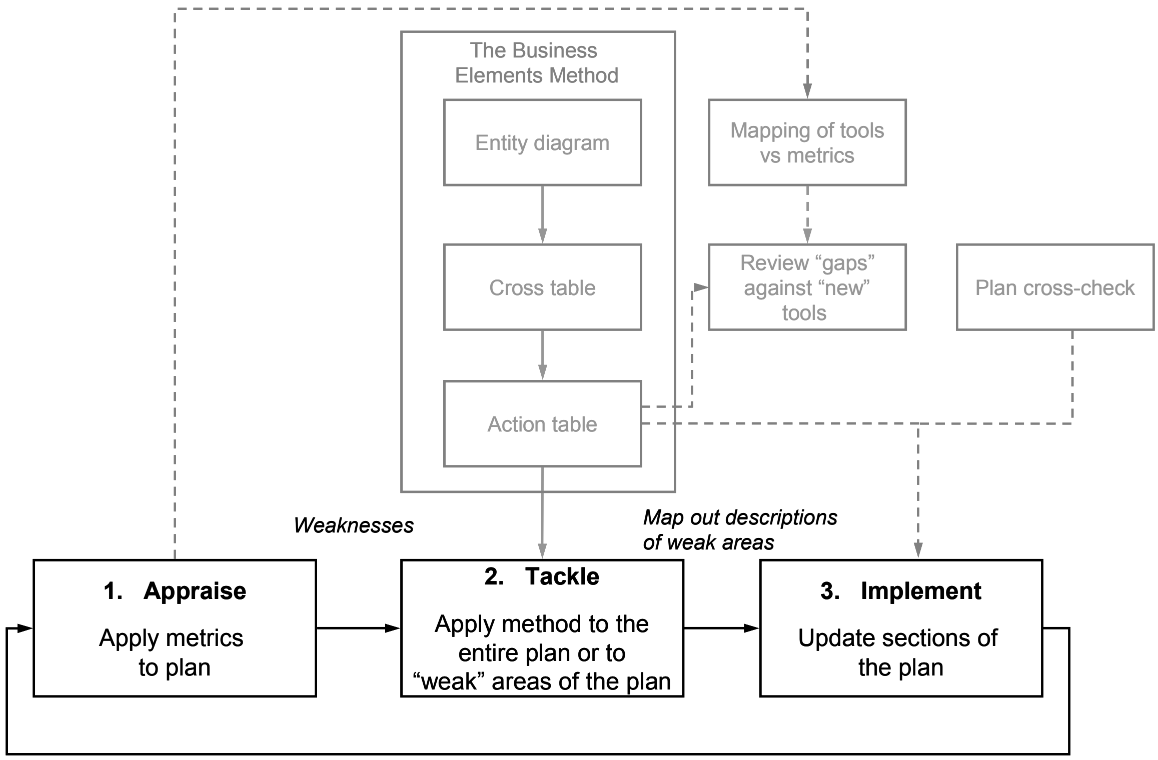


Figure 2.1 The emergency management analysis framework

The FIM FRAME method requires the application of the Business Elements Method, which is an approach for analysing any business process. The Business Elements Method is a tried and tested approach 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
- Roles and responsibilities
- Data and information
- Tools
- Audit

Considering these elements can help to produce a clearer picture of the process, and gain understanding on which are the interdependencies within the different parts that constitute the process. This can help in identifying, for example, possible issues or bottlenecks, and gaining a clear understanding of how to address these and how these can affect the process if they are not addressed.

The proposals given below for the ‘Tackle’ stage are our interpretation of how the method could be applied for emergency planning. This is because there is no rigid method, simply a recommended framework to use.

1. Appraise - Apply the metrics and flag up general issues or weaknesses

The appraisal of the plan consists in assessing the plan against the 22 metrics developed in WP1. This appraisal achieves an initial understanding on how the plan is likely to perform and what are the main weaknesses. The WP1 and FIM FRAME Guidance Document should be consulted for further details on the application of the metrics.

2. Tackle – “Structuring\de-structuring” the process and identifying specific issues

This step can be performed for the whole plan or only for particular aspects, for example those that obtained a low score in step 1. This step aims to go through specific processes (or plan components) 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 principles of the Business Elements Method (processes, roles and responsibilities, data and information, tools and audit) that in this application 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

To 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 update of the plan as part of step 3.

Step (i) Entity diagram

The first step consists in developing an entity diagram for the entire emergency process or for only a particular aspect (e.g. the plan activation or the identification of vulnerable people). The aim of this diagram is to include all the elements that constitute the emergency process and\or that have a role in the emergency planning or in the actual event. This diagram also aims to describe the relationship between such elements.

An ‘Entity Diagram’ is a diagram constituted by boxes and arrows. This diagram can be built to describe the entire process of formulating an emergency plan or focus on one particular aspect of the plan. The boxes contain specific ‘entities’. The ‘entities’ are the components that constitute the analysed aspect, which can be abstract entities (e.g. the warning, plan activation, the recovery, the evacuation) or physical entities (e.g. the police, the resources, the Strategic Coordination Group (SCG), the flood maps).

The arrows describe the relationship between such components. For each of the boxes, the following questions should be addressed:

- What does this entity do? (e.g. what is the process and who is responsible for the process)
- What does this entity provide? (e.g. what information is produced)
- Who does it inform? (e.g. who receives the information and who is responsible for passing this information)

- Who makes sure that this is done? (e.g. who audits the process)
- How this is done? (e.g. which tools are used\needed to produce the information or perform the process)

The answers to these questions might already be in a box in the diagram, and therefore an arrow can be drawn to connect the two boxes. Alternatively, another box should be added to identify the missing 'entity' and then connect the existing box with the new one. A typical entity diagram is shown in Figure 2.2.

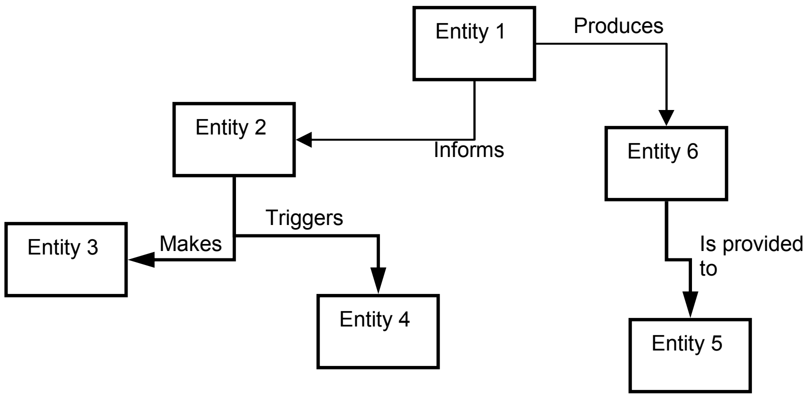


Figure 2.2 Example of an entity diagram

It should be noted that in developing the diagram, it is important to start from one specific topic (e.g. evacuation), which will constitute the first box. It is important at the start to challenge the attendees with the above questions, to help them to start producing the diagram.

Step (ii) - Cross-table - Process\Responsibilities\Tools\Information

The next step in the framework aims to consider each entity in the diagram. The outcome from step (ii) is a simple table containing all the entities in the first quadrant, the related roles and responsibilities in the second, the Information in the third and the tools in the fourth quadrant. This is shown in Figure 2.3.

1 Processes and procedures (what?)	**2 Roles\Responsibilities (who?)**
4 Tools (How?)	**3 Information (which data?)**

Figure 2.3 Structure of the cross table

Starting from one 'quadrant' of the cross table (e.g. Processes and procedures), the first question to ask will be:

Processes and procedures What does the entity do?

Once the process is described, the other part of the tables and the relative links should be completed by exploring:

FROM Processes and procedures TO Roles and responsibilities

Who is responsible for doing this? Who checks that this has been done?

FROM Processes and procedures TO Information
Which data or information are needed for doing this?

FROM Processes and procedures TO Tools
What tools are needed\used for doing this?

Once the links between Processes and procedures have been explored, the other quadrant of the tables should be analysed, starting from e.g. the Information quadrant:

FROM Information TO Roles&Responsibilities
Who uses this data? Who is responsible for providing this information? Who audits that this information is provided \ disseminated?

FROM Information TO Tools
How is this information produced? How is it communicated? Where\how is it stored?

FROM Tools TO Roles and responsibilities
Who owns the tools? Who has access to the tools?

This process is illustrated in Figure 2.4.

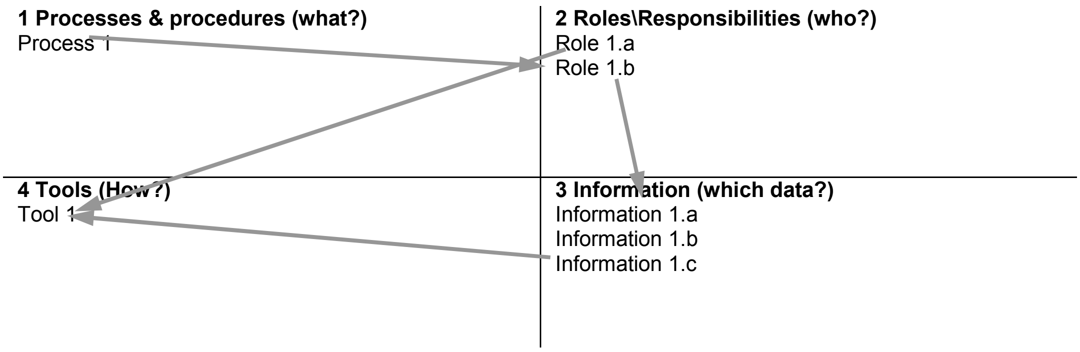


Figure 2.4 Filling in the cross table

This work should produce a better understanding of the elements of the process as well as of the links within the various elements. While constructing the Cross-table, certain issues can arise. These issues should be highlighted and will be discussed in detail in the next step.

Step (iii) – Action table

When identifying these links, certain issues can arise, for example:

- Identifying the links is not straightforward;
- Some links that should logically be in place do not exist in practice;
- Some information is not provided by any entity (e.g. neither tool nor person)
- Information is provided but not fed back to anyone

Once such an issue arises, this should be reported and described in the first column of the Action table. The blank action table is shown in Table 2.1Table 2.1.

Table 2.1 Action table – identifying 'Tackling actions'

Issues	Tackling actions					Implementation		
	How to address it? Actions	Who should bring it forward? Responsibility	What information is needed?	Is any tool needed?	Who checks this is done? Audit	Priority	Resources	Timeline

For each of the identified issues, the user can analyse how to address them by going through the questions proposed by the table, and filling the columns accordingly:

How to address it? Defining a specific Action(s) that is (are) needed to tackle the issue.

Who should bring it forward? Identifying who should be responsible for taking forward each of the specified actions.

What information is needed? Listing possible information and sources of information

Is any tool needed? Discuss if any particular tool is needed to create the required information, who owns the tool and how this can be used. The list of tools gathered in the FIM-FRAME project – WP2 should be consulted to see if any are appropriate to the specific issue

Who checks this is done? Assigning a physical person who should be responsible to audit and check whether the action is brought forward as well as whether this is done correctly

Once the issue has been analysed, the step (iii) should be repeated for the other identified issues. The outcome of this process is the Action Table containing tangible actions that should be undertaken and audits that should be introduced into the process, as well as identifying responsibilities for these actions.

This simple analysis can provide a guide for exploring the process and spot possible issues, especially due to the links within different aspects that might not have been fully covered in an emergency plan for floods, and therefore might cause possible "bottlenecks" to the process.

Listing these items in a table might help to keep track of them, and this can be of help to check whether these have been addressed in the next review of the plan.

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 shown in Table 2.2. For each of the identified Actions, the following need to should 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

Table 2.2 'Implementation'

Issue	Tackling actions					Implementation		
	How to address it? Actions	Who should bring it forward? Responsibility	What informationon is needed?	Is any tool needed?	Who check this is done? Audit	**Priority**	**Resources**	**Timeline**

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

Although the framework was considered useful for breaking the emergency planning process down into its constituent components, and that the various tools available would help in improving understanding, there were concerns over the time required to apply the framework to the majority of a plan. Several participants also thought the process was somewhat academic, particularly the construction of the entity diagram. Given that flooding is only one issue covered by the emergency planners in England and Wales, it was considered that there would be insufficient resources to apply the framework, except in special cases.

Building on this analysis, the framework has been produced with the objective of being refined and “ground truthed” through the collaboration of emergency planners. To be able to compare the results from the workshop, the same setup for the workshop was followed in the three countries. A few minor deviations were applied to account for the feedback of previous workshops and to account for the local and national contexts.

2.2 The workshops

The plans to which the framework was applied were chosen based on a number of criteria as follows:

- The scores that the plans received using the metrics that had been developed as part of WP2
- Willingness of local stakeholders to participate to the workshop
- The ability to compare plans between the three countries involved in the research

Table 2.3 provides a summary of the workshops held in the three countries. An initial workshop was held in July 2010 in Ipswich to test the FIM FRAME method and to allow adjustments to be made to it. Other workshops have been held between November 2010 and April 2011.

Table 2.3 Workshops held as part of the FIM FRAME project

Date	Location	Country	Plan	Kind of flood	Plan score	Selected metrics	Number of attendees
28 July 2010	**Ipswich**	**England**	**Multi-Agency Flood Plan (MAFP)**	**Fluvial and coastal floods**	**-**	**1- Details of previous floods 2- evacuation routes**	**8**
11 November 2010	**Sheffield**	**England**	**Sheffield MAFP**	**Urban flood and dam failure**	**2.14**	**- 1- Risk to vulnerable people 2- Media communic ation**	**14**
18 November 2010	Dordrecht	Netherlands	Regionaal Basisplan Overstromingen Zuid Holland Zuid, , specifiek Eiland van Dordrecht	Fluvial and storm surges flood (with dikes)	1.7	1- Evacuation 2- Loss of life	7
30 November 2010	Utrecht	Netherlands	Rampenbestrijd ingsplan (dreiging) dijkdoorbraak Kromme Rijn dijkring 44'	Fluvial floods with dikes	2.5	1- Evacuation : communicat ion to the public	3
8 December 2010	Piolenc	France	Plan Communal de Sauvegarde (PCS)	Flash flood and fluvial floods	1.4	1 - Flood warning 2 - Communica tion with the public	11
4 January 2011	**Tarascon**	**France**	**PCS**	**Fluvial floods with dikes**	**1.78**	**1 - Flood hazard map 2 - Warning system**	**11**
18 April 2011	**Sheffield**	**England**	**Sheffield MAFP**	**Urban flood and dam failure**	**2.14**	**1 - Evacuation routes 2 - Loss of life**	**6**

Note: Plans in bold relate directly to the case studies

3 Details of the case studies

3.1 Introduction

This chapter presents the main characteristics of the case studies. It gives details of the geographical features of the area, the context of flood emergency planning and the objectives and expected results of the case study.

3.2 Sheffield case study, England and Wales

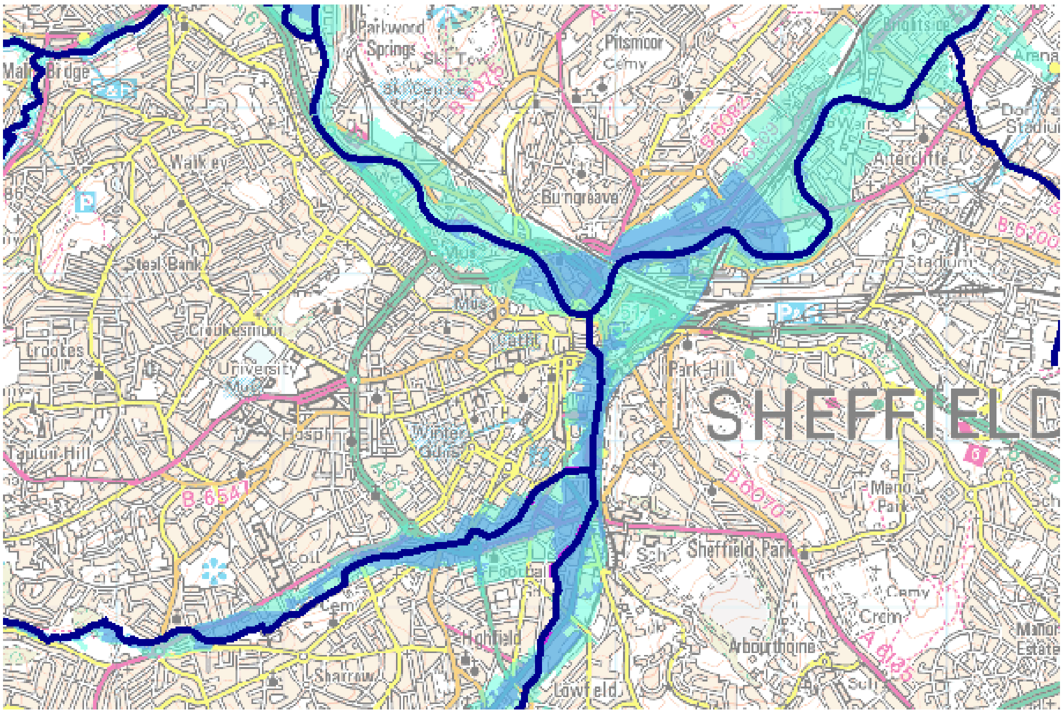
3.2.1 Background to the case study area

The city of Sheffield and its surrounding areas was chosen as the case studay area for England and Wales. Sheffield is located in South Yorkshire has a population of approximately 535,000.. Geographically, Sheffield is famous for being sited on seven hills, with the centre sitting within a natural amphitheatre at the confluence of five rivers: Don, Sheaf, Rivelin, Loxley and Porter. There are a number of large dams located upstream of Sheffield many of which are over 150 years old. In 1864, 270 people were killed as the result of the collapse of the newly-built Dale Dyke Dam, upstream of Sheffield. The presence of such a great number of reservoirs poses a major risk to people due to a possible dam failure and subsequent flooding of the downstream areas.

As a result of its geographical location and topography, the city can experience flooding from a variety of sources. Although the rivers in the city are relatively small, heavy rainfall on the Pennine hills can result in fluvial flooding in certain areas. The fact that the city is surrounded by hills means that it is susceptible to pluvial flooding resulting from heavy rain, especially over the impervious areas. This was highlighted in summer 2007 when exceptional rainfall fell over the catchment on the 25 June, on what was already wet or saturated ground. Across England, June 2007 was one of the wettest months on record with some places experiencing double the normal monthly total. The city centre suffered extensive damage as the River Don overtopped its banks, with one fatality as a result of trying to cross a flooded road. Infrastructure was badly affected, with some businesses remaining closed until September. A major emergency operation was required, with some people being rescued by RAF helicopter.

Although the flood waters started to recede on the 26 June, a major incident was declared to the east of the city. Over 700 villagers from Catcliffe, near Rotherham, were evacuated after cracks appeared in the dam of Ulley Reservoir. Emergency services from across England pumped millions of litres of water from the reservoir to ease the pressure on the damaged dam, and the nearby M1 motorway was closed between junctions 32 and 36 as a precaution. For England and Wales, the summer 2007 floods, which occurred during June and July in various locations, was the largest flood event across the whole of Europe in terms of economic losses for the past decade.

With respect to the management of flood risk, the Environment Agency is the lead authority in terms of river and coastal flooding, and they provide publicly-available maps of such flooding so that homeowners can determine if they are at risk. An example of this flood map is shown in Figure 3.1, which shows the confluence of three rivers in the centre of the city. The dark blue areas are the 1% (annual probability) flood, and the light blue the extreme 0.1% probability flood. Maps for pluvial and dam break flooding are not available currently to the public.



(Source: Environment Agency, 2011)

Figure 3.1 Environment Agency flood map for Sheffield

The Emergency Planning Team of Sheffield City Council (SCC) is responsible for producing the Multi-Agency Flood Plan (MAFP), which is updated annually. This provides a framework for how the various responder organisations coordinate their activities during a flooding emergency, but does not replace the existing planning and operational arrangements in each organisation.

The MAFP is consistent with the South Yorkshire Strategic Framework Document, which outlines operating procedures for all aspects of major incident response and recovery in the region. A region-wide telecommunications plan for major incidents sets out the procedures between all the key agencies. The MAFP is also closely linked to a range of other flooding and emergency plans.

As part of the case study application, models were applied to simulate the impacts resulting from a dam failure, and how the resulting flood wave affects the downstream population in terms of loss of life. These models helped to demonstrate the use of enabling technology as part of the research.

3.2.2 Application of the FIM FRAME method to Sheffield – Step 1 - Appraise

Following a workshop in Ipswich in July 2010 and one in Sheffield in November 2010 to pilot the FIM FRAME method a final workshop was held on 18 April 2011 with the Local Resilience Forum in Sheffield to apply the final FIM FRAME method:

The objectives of this workshop were to:

- Apply the project metrics to the Sheffield Multi-Agency Flood Plan (MAFP)

- Use the FIM FRAME method to investigate the weaker areas of the plan, and identify possible improvements
- To provide a full test of the proposed FIM FRAME method to a MAFP
- To present the application of a Life Safety Model tool to a potential flood hazard in the Sheffield area.

The workshop comprised a series of group working sessions, to address each of the objectives, facilitated by HR Wallingford. Examples from the previous workshops were used to aid understanding of each step in the framework. The first activity was to apply the 22 metrics to the plan via a group discussion. The results are summarised in Table 3.1.

Table 3.1 Metric scores for the Sheffield MAFP

Metric	Level of detail			Score	Comments / Potential improvements
	Low	Medium	High		
Objectives, assumptions and target audience					
Aims and objectives of plan			●	3	
Target audience and updating of the plan			●	3	
Assumptions made by the plan		●		2	Provide more detail in the 'Scope' section
Organisation and responsibilities					
Actions, roles and responsibilities			●	3	
Recovery		●		2	
Training and exercises			●	3	
Plan activation		●		2	Include flow chart of activation actions
Communication					
Communication with other agencies		●		2	
Communication with the public		●		2	
Management of the media			●	3	Media management well signposted
Flood warning (if available)			●	3	Clear signposting to location of other maps
Relationship with complementary emergency plans detailed		●		2	
Evacuation					
Evacuation routes	●			1	Consider how to determine 'optimum' evacuation routes, and impact of flood on access
Shelters/Safe havens			●	3	Scored High because policy is not to include

Metric	Level of detail			Score	Comments / Potential improvements
	Low	Medium	High		
					this information in MAFP
Flood hazard					
Flood hazard map		●		2	
Details of previous floods (if available)		●		2	
Flood risk to receptors					
Flood risk to people	●			1	
Flood risk to vulnerable people (e.g. elderly or disabled)	●			1.5	Not realistic to provide up-to-date information as it changes daily
Flood risk to residential property		●		2	Residential and business properties need splitting out in the plan
Flood risk to businesses		●		2	“
Flood risk to critical infrastructure (e.g. water supply, gas, electricity, police, fire brigade)	●			1.5	
Potential for NaTech hazards at industrial facilities (if present)*	●			1	
	Average score			**2.14**	**An ‘Average’ plan**

The majority of the scores fell in the average or high category, with the plan overall obtaining an ‘average’ rating. The main weak areas were:

- Evacuation routes – no detail is provided, either on a map or in the text
- Detail is not provided on vulnerable people – there was a strong view that this information changes on a daily basis, and whilst the responders do receive updated information on a regular basis, it is not sensible to include this in the ‘static’ plan
- Critical infrastructure – although this is provided in a table, it is not included on a map
- NaTech hazards – in common with the majority of plans analysed to date, this information is not provided (or even known).

From this initial analysis it is clear that certain improvements could be made relatively easily, without the need for any new information or use of tools. Three possibilities are:

- Further explanation provided in the ‘Scope’ section on the assumptions made by the plan, such as what type of flood risks are considered
- A flowchart provided that summarises how the plan is activated and what roles the various responders take
- A diagram or flowchart is provided to show how the MAFP links in with other complementary plans, and what actions or events may require the use of each one.

With these simple changes, the average score would rise to 2.27, and the plan would then be assessed as ‘above average’.

3.2.3 *Case study application: Step 2 Tackle*

Based on this assessment, the group agreed to look at ‘Evacuation routes’ during the remainder of the workshop. The first part of the ‘Tackle’ phase was to build an Entity Diagram, as shown in Figure 3.2.

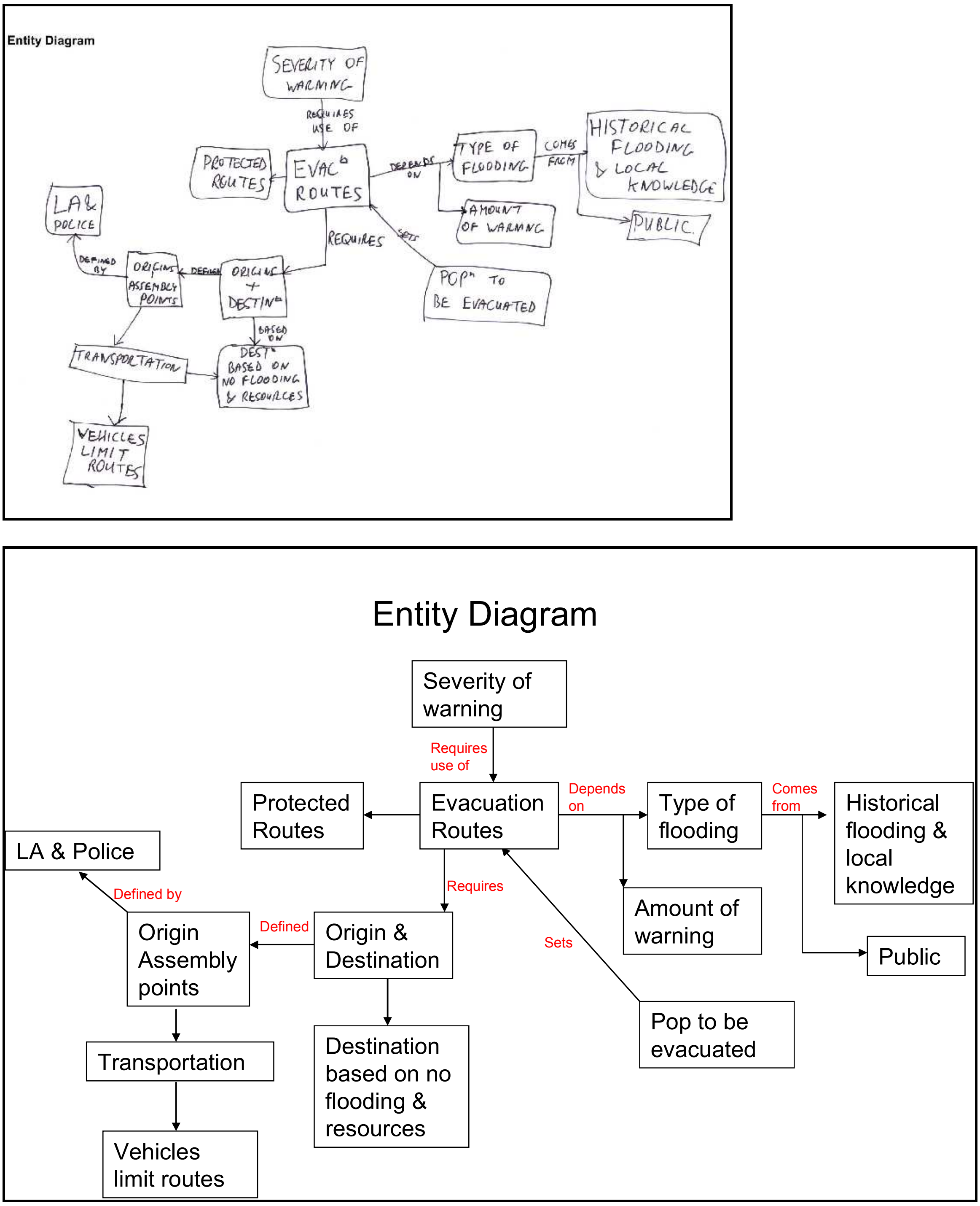


Figure 3.2 Entity diagram for ‘Evacuation Routes’

Part 2 of the 'Tackle' phase was to fill in the Cross Table, which breaks the entities down into:

- Processes and procedures
- Roles and responsibilities
- Information
- Tools

From the entity diagram, the various processes and procedures were identified, and inserted in the first quadrant. These were then assessed on the basis of who was responsible for them, what information was required, and whether any tools or other technology was used or needed. The resultant table is presented in Figure 3.3.

During this analysis, the participants were asked to note possible difficulties in identifying the links between the various items in the table. Lack of clarity or missing links are dealt with as 'red lights' in the tackle process. Such items are to be noted in the first column of the Action Table. From the group discussions two key issues were identified: how were the public informed of the need to evacuate, and where should they be told to go (if at all). These points are summarised in Figure 3.4.

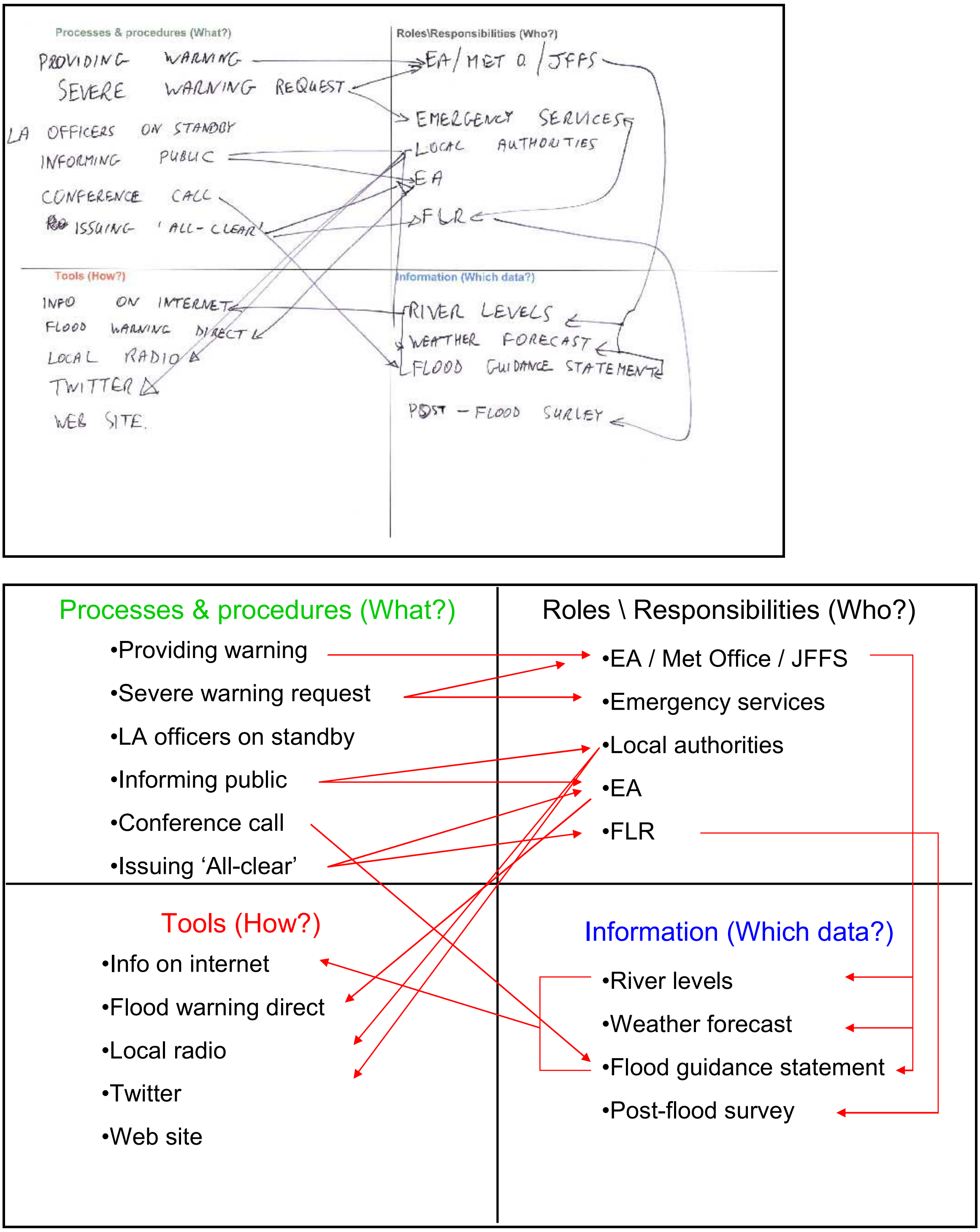
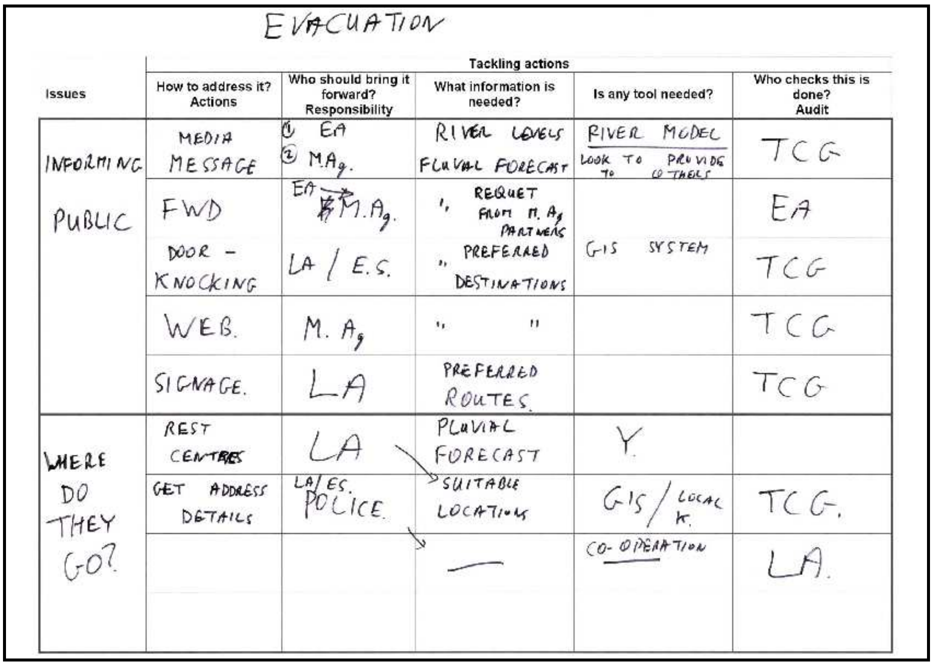


Figure 3.3 Cross Table for 'Evacuation Routes'



EVACUATION

Issues	Tackling actions				
	How to address it? Actions	Who should bring it forward? Responsibility	What information is needed?	Is any tool needed?	Who checks this is done? Audit
INFORMING PUBLIC	MEDIA MESSAGE	① EA ② M.Ag.	RIVER LEVELS FLUVIAL FORECAST	RIVER MODEL LOOK TO PROVIDE TO [illegible]	TCG
	FWD	EA → M.Ag.	" REQUEST FROM M.Ag PARTNERS		EA
	DOOR - KNOCKING	LA / E.S.	" PREFERRED DESTINATIONS	GIS SYSTEM	TCG
	WEB.	M. Ag	" "		TCG
	SIGNAGE.	LA	PREFERRED ROUTES		TCG
WHERE DO THEY GO?	REST CENTRES	LA	PLUVIAL FORECAST	Y	
	GET ADDRESS DETAILS	LA/ES. POLICE	SUITABLE LOCATIONS	GIS / LOCAL K.	TCG.
			—	CO-OPERATION	LA.

Evacuation

Issues	Tackling actions				
	How to address it? Actions	**Who should bring it forward? Responsibility**	**What information is needed?**	**Is any tool needed?**	**Who checks this is done? Audit**
Informing public	Media Message	EA M.Ag.	River levels Fluvial forecast	River model	TCG
	FWD	EA to M.Ag	Request from M.Ag partners		EA
	Door-knocking	LA / E.S.	Preferred Destinations	GIS System	TCG
	WEB	M.Ag	Preferred Destinations		TCG
	Signage	LA	Preferred Routes		TCG
Where do they go?	Rest centres	LA	Pluvial forecast	Y	
	Get address details	LA / Police	Suitable locations	GIS / Local knowledge	TCG
				Co-operation	LA

Figure 3.4 Action Table for ‘evacuation routes’

3.2.4 Feedback

Following the conclusion of the group sessions and the presentation of the Life Safety Model described in the next section, the participants were asked to provide feedback on the framework and the outcomes of the overall project. This is given in Table 3.2.

Table 3.2 General feedback from the attendees on the framework and the project

Overview of the framework
The Generic Metrics sheet very useful for a self assessment of current plans with some tailoring particularly around *flood risk to receptors*. Difficult to obtain accurate information about vulnerable people – changes on a daily basis, particularly vulnerability due to medical needs. *Flood risk to business* is addressed through promotion of business continuity planning to businesses in the flood risk area. Due to time restrictions, finding time to carry out follow ups such as entity diagrams on identified gaps or weaknesses would prove difficult. However the Action Table would probably be useful. It has to be remembered that emergency planning is not just about flooding and the metrics would be useful for other plans as well.
Metrics – very useful tool to find weaknesses in plans. Framework as a whole is very time-consuming to complete. I doubt we would have time to complete whole framework, particularly for an annual review. Not sure we would use the 'Entity' Diagram.
From EA re: Sheffield Plan More information required to provide for plans, e.g. • flood warning lead times • split of properties between domestic and business • better fluvial modelling • Pluvial flood forecasting difficulties • Awareness of the Flood Warning system and how it can be used beyond initial flood warning.
Use of metrics is good for seeing where a plan fits, in terms of how comprehensive or complete.
The metrics are good for assessing a plan. The most useful tool was the 'Action Table', although the 'Cross Table' was OK. Did not really like the 'Entity Diagram'; can't see how we would use it, too time-consuming.
Metrics – good for evaluation of a plan. Some minor issues re: choice of phrases / words. Life Safety Model – very good. • Needs to replay slower for better viewing / comprehension. • Implications for 3rd parties? (e.g. Media, dam owners)
Framework • Metrics very useful for self-assessment of plans – may need a bit of tweaking to refine definitions • Also must beware of writing a plan that fits the metrics – could result in over-detail / spurious accuracy Entity Diagram 1. Difficult at first, but useful as analysis tool Life Safety Model 2. Information on worked example needs to be discussed by LRF as soon as possible.

This final set of feedback confirms what was found in the other workshops held in England & Wales. Although the participants could see that the framework did provide a set of useful tools and approaches for analysing and improving their emergency plans, there were concerns over the available resources (time and people) to be able to apply it fully. There was also a clear concern over some of the ‘academic’ aspects, such as the entity diagram, which takes time to understand. As the entity diagram is a key component of the Business Elements Method, the final form of the framework guidance will need to address how best to explain and recommend its use. The provision of several and varied examples will help in this regard. The use of the metrics, developed in WP1, remains a useful tool for the improvement of plans.

3.2.5 Application of tools to address gaps and issues

Background

As a result of the need to develop and test the framework in a couple of workshops, the final case study application for Sheffield was delayed until April 2011. This did not allow for the findings from the workshop to be used to inform the selection of various tools to assist in improving or filling the gaps identified in the plan. However, discussions had been held with the South Yorkshire LRF prior to and at the start of the FIM FRAME project. From these discussions, an interest was expressed in applying an evacuation and loss of life model to one of the reservoirs that lies upstream of the city. This was to look at issues such as adequacy of warning, speed of flooding, evacuation options and potential injuries and fatalities.

Description of case application

The issue of fatalities or injuries resulting from a flood is an emotive topic, particularly when predicting what may happen in the future in a particular area. The Environment Agency is keen to avoid unnecessary concern from the dissemination of such information, without providing the right context for the study. For these reasons, the case study will remain anonymous, and is simply a typical reservoir situated in the Pennines, with a small stream below it that ultimately runs into the city centre. In the specific case used here, though, there is a small town immediately downstream of the dam that would be at severe risk if the dam failed.

Tools applied

Although the main tool application in the case study was the Life Safety Model (LSM), various other tools were also used, both as input to LSM but also as a comparison with this model’s results. A brief outline of each tool is given below.

TUFLOW

The main input for any loss of life technique is a representation of the particular flood hazard, which is usually produced by a hydrodynamic model. To represent the anticipated flood wave resulting from a failure of the dam, a two-dimensional model was used, based on the finite difference software TUFLOW. An existing model of the river was obtained from the Environment Agency and modified to include the dam break scenario.

TUFLOW is a computer program for simulating depth-averaged, two and one-dimensional free-surface flows such as occur from floods and tides. TUFLOW was originally developed for modelling two-dimensional (2D) flows, and stands for Two-dimensional Unsteady FLOW.

TUFLOW is specifically orientated towards establishing flow patterns in coastal waters, estuaries, rivers, floodplains and urban areas where the flow patterns are essentially 2D in nature and cannot or would be awkward to represent using a one dimensional (1D) network model.

Breach development

As the simulated flood is due to dam failure, a realistic representation of the event requires the modelling of breach initiation and growth. However, as stated in the FLOODsite website (2009), many gaps in knowledge, uncertainties and even contradictions remain when talking about breach prediction as much for the process leading to the breach as for the way to model it. The current degree of uncertainty in the prediction of breach initiation and formation processes is high in comparison to, say, the accuracy of modelling flow in a river. However, the accuracy of predicting breach initiation and breach growth through flood embankments, embankment dams and coastal dikes affects the accuracy of flood risk analysis and the degree to which flood risk management activities may be refined. In fact, the way in which a flood embankment might fail, or breach, directly affects the timing and volume of flood water that might be released. Consequently, breach initiation and growth processes have a significant role in determining subsequent flood impacts (FLOODsite website, 2009).

As the main purpose of the current study is not the breach modelling, a simplified approach was followed in the definition of the hydrograph of the water release from the dam: the literature available helps to assess the likely breach width, the failure time (i.e. the time from the first appearance of cracks to the final size of the breach) and the peak flow. These three parameters have been evaluated as a function of the depth and volume of the water above the breach, shown in Figure 3.5, the reservoir storage volume which is 2,450,240 m^3 and other parameters which are required for different equations available from the literature. These are given Table 3.3.

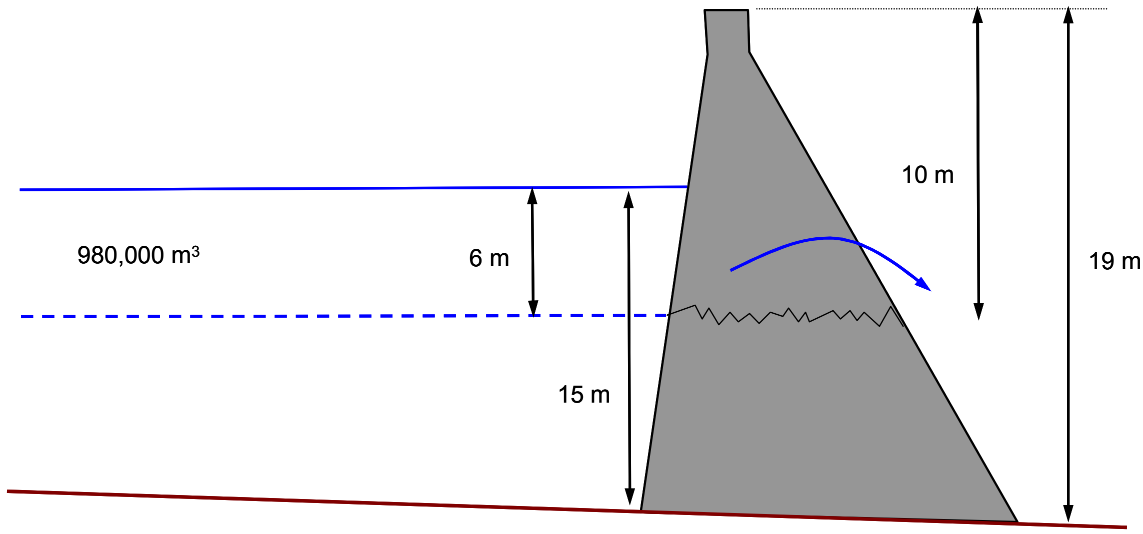


Figure 3.5 **Schematic view of parameters that are important to dam break**

Table 3.3 **Summary of breach calculation outputs**

Breach width equations	**Breach width (m)**
Bureau of Reclamation (1988)	18
Froehlich (1995)	23.078
Failure time equations	**Time of failure (hours)**
MacDonald and L.M (1984)	0.373
Von Thun and Gilette 1 (1990)	0.370
Von Thun and Gilette 2 (1990)	0.962
Froehlich (1995)	0.479
Bureau of Reclamation (1988)	0.254

A number of equations have been used to estimate the peak outflow due to the failure of the dam. The results varied between 126 m^3/s to 6230 m^3/s. This range is large and a reasonable estimate has to be selected to be used further in flow and life safety modelling.

Wahl (2004) presented a quantitative analysis of the uncertainty of various regression based methods for predicting embankment dam breach parameters and peak breach outflows. These included the ones that have been used for this case study. He concluded that the uncertainties of predictions of breach width, failure time, and peak outflow are large for all methods. Based upon his analysis, he found that the Froehlich peak flow equation has the least uncertainty which is about ±1/3 order of magnitude. Based upon that, the peak value estimated using the Froehlich equation (i.e. 328 m^3/s) has been used in this reservoir study.

To construct a flow hydrograph for this peak, the method recommended by the Risk Management for UK Reservoir Manual (2000) is used. This method estimated that the time to peak outflow would be 720 seconds and the total failure time would be about 6000 seconds. Assuming a triangular hydrograph shape, the following inflow hydrograph, shown in Figure 3.6, can be obtained.

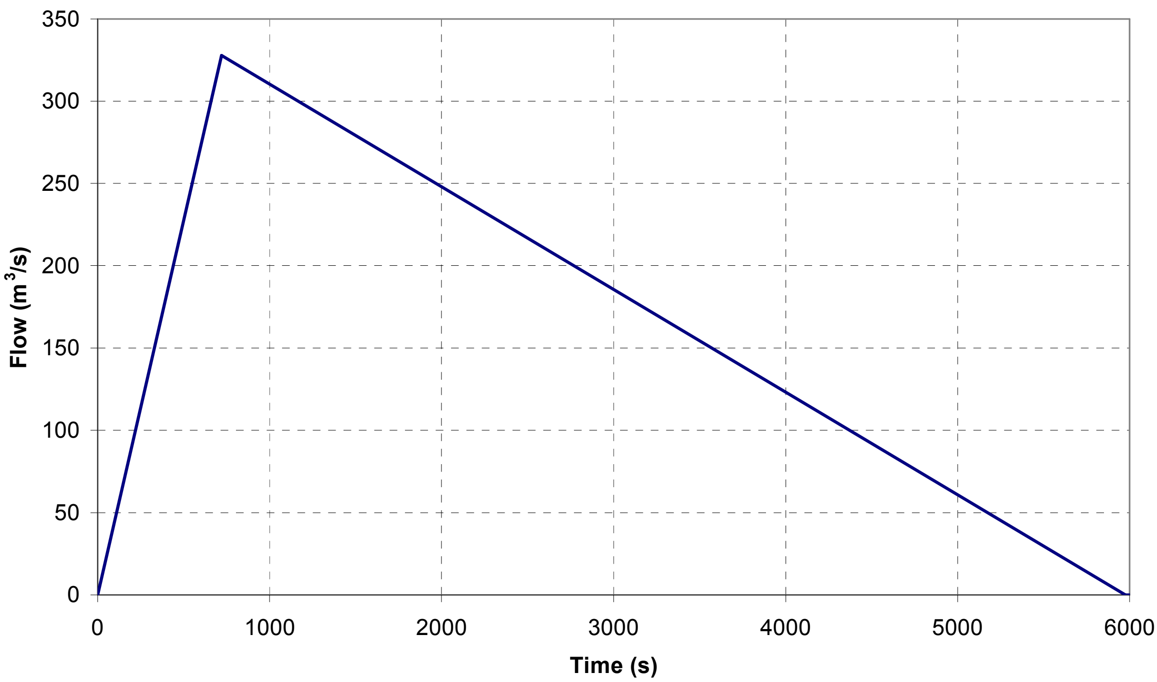


Figure 3.6 Hydrograph of the water discharge from the dam breach

This hydrograph was used then as a boundary condition for the Tuflow model. The time of the simulation was set up as three hours, whereas the water discharge from the collapsed dam lasts 1 hour 40 minutes (~ 6,000 seconds) with the flow peak occurring after 12 minutes (equivalent to 720 seconds).

Flood Risk to People

The 'Flood Risk to People' is a methodology to evaluate death or serious harm to people that occurs as a direct result of the flood either during or up to one week after the event. It also provides measures of annual average risk that can be used alongside annual average economic damage and other social and environmental criteria to improve flood risk management.

The model has been developed in England and Wales by the Department for the Environment, Food and Rural Affairs (Defra) and the Environment Agency. The Risks to People method considers the physical characteristics of the flood and the vulnerability of objects involved, to determine the overall flood risks to people. The method is based on three concepts:

- *Flood Hazard*, describes the flood conditions in which people are likely to be swept over or drown in a flood, and is a combination of flood depth, velocity and the presence of debris.
- *Area Vulnerability,* describes the characteristics of an area of the floodplain that affect the chance of being exposed to the flood hazard. People are more vulnerable in areas of low rise, single-storey buildings, campsites and open floodplain areas than in areas of two-storey or high-rise buildings that can provide “safe refuge” above the maximum flood level.
- *People Vulnerability,* describes the characteristics of the people affected by flooding and their ability to respond to ensure their own safety and that of their dependants during a flood.

These are combined for each zone of the floodplain in order to estimate the number of fatalities and serious injuries as a result of the flood.

The variables considered in the model, listed for each model parameter, are:

Flood hazard represent by:

- Depth of flood water (m)
- Velocity of flood water (m/s)
- Debris factor (score)

Area vulnerability represented by:

- Flood warning: including % of at risk properties covered by the flood warning system; percentage of warnings meeting the two-hour target; and % of people taking effective action (score)
- Speed of onset of a flood (score)
- Nature of area: multi-storey apartments; typical residential/commercial/industrial properties; bungalows, mobile homes, campsites, schools etc (score)

People Vulnerability represented by:

- Percentage of residents aged 75 years or over.
- Percentage of residents suffering from long term illness.

Life Safety Model (LSM)

The Risk to People method to assess the “loss of life” from flooding described in the previous section is based on empirical analyses of fatalities and injuries from historical events. Empirically based loss-of-life models tend to apply one mortality rate to an area and do not model each individual person. To improve the accuracy of loss of life estimates the Life Safety Model (LSM) links the fate of each person with the local characteristics of the floodwater (e.g. velocity and depth), and also allows people to interact dynamically with it.

In order to obtain the emergent behaviour of people during floods the LSM has been developed as an agent-based model. An agent-based model is a computational model that simulates the interactions of autonomous receptors with a view to assessing their effects on the system as a whole. The Life Safety Model was originally developed for dam break risk assessment for small communities in Canada and has a long and well-validated history. It has now, however, been piloted in the UK and it is currently under development in order to allow its use in a European context and for different flood hazards.

Its potential function will be to compare different emergency plans, and help planners to select the most appropriate evacuation strategies.

The LSM needs the following inputs:

- The location of individual properties, vehicles and people;
- Flood depths and velocities from a two dimensional hydraulic model;
- The road network and other evacuation pathways.

These input data are processed and then handed to the "Life Safety Simulator", which is the effective core of the LSM; the Life Safety Simulator requires two inputs (obtained from the previous input data):

An initial state of the world (which describes modelling receptors such as people, buildings, cars, roads). This is developed from census and property data sets;
Details of how the velocity and depth of the floodwater changes as the event progresses. This is taken from the results of two dimensional hydraulic modelling.

The outputs of the simulation are an estimation of loss of life as well as a dynamic, computer-generated visualisation of the results. The LSM models the "fate" of a set of receptors, which are described by their position at each time step through the simulation. Each receptor can have a set of properties that describes its normal location/condition during a week, such as travel times, school/work hours, and weekend activities. Other time-varying properties include the ability of the receptor to withstand the effect of the flood wave, and how it would react to the approaching wave, with and without a formal evacuation warning.

The model uses a generalised event logic to determine the location of each receptor, whether it is aware of the flood wave, whether it is trying to find a safe haven, what happens if it encounters the flood, and whether the object survives or not. A loss function related to each receptor (e.g. people, buildings, and vehicles) specifies the ability of a receptor to resist the impact from the flood wave, in terms of depth and velocity, and how these can change during an event. There can be instantaneous loss when an individual encounters fast-flowing water, or a group who have sought safety in a building can suffer cumulative loss if the building collapses or a slow deterioration in health if they are exposed to the flood water for a significant length of time, as a result of hunger or cold.

As a flood event evolves, the interaction of receptors with the flood wave will impact the ultimate loss of life. The timing of the event and the decisions made by individuals can determine whether or not they can escape the flood wave. As the flood progresses, escape routes can be eliminated by rising water, and with advancing time roads can become congested with evacuees.

An interesting aspect is that the LSM is unique in that it allows dynamic interaction between the receptors (e.g. people, vehicles and buildings) and the flood hazard. For this very reason, the LSM requires a significant amount of data including:

- The location of individual properties, vehicles and people;
- Flood depths and velocities from a two dimensional hydraulic model;
- Details of the road network and other pathways.

Base data for study area

A key dataset for the hydrodynamic model and LSM is the ground elevation. A Digital Terrain Model (DTM) was obtained from the Environment Agency. For the 'risk to people' methodologies it is necessary to specify the location of the population and buildings for area of interest:

Information about the population has been retrieved from the 2001 Census; a GIS was used to locate the different census areas, also to provide the total number of inhabitants for each of them. Building location has been obtained from an Ordnance Survey map.

The total population considered in the simulation is 13,836 whilst the number of buildings is 7,420. It was been assumed that all the people are located inside the buildings, thus the population for each census area has been split equally between the buildings. Figure 3.7 displays the position of buildings, and the census areas marked with a different colour according to their inhabitants' density:

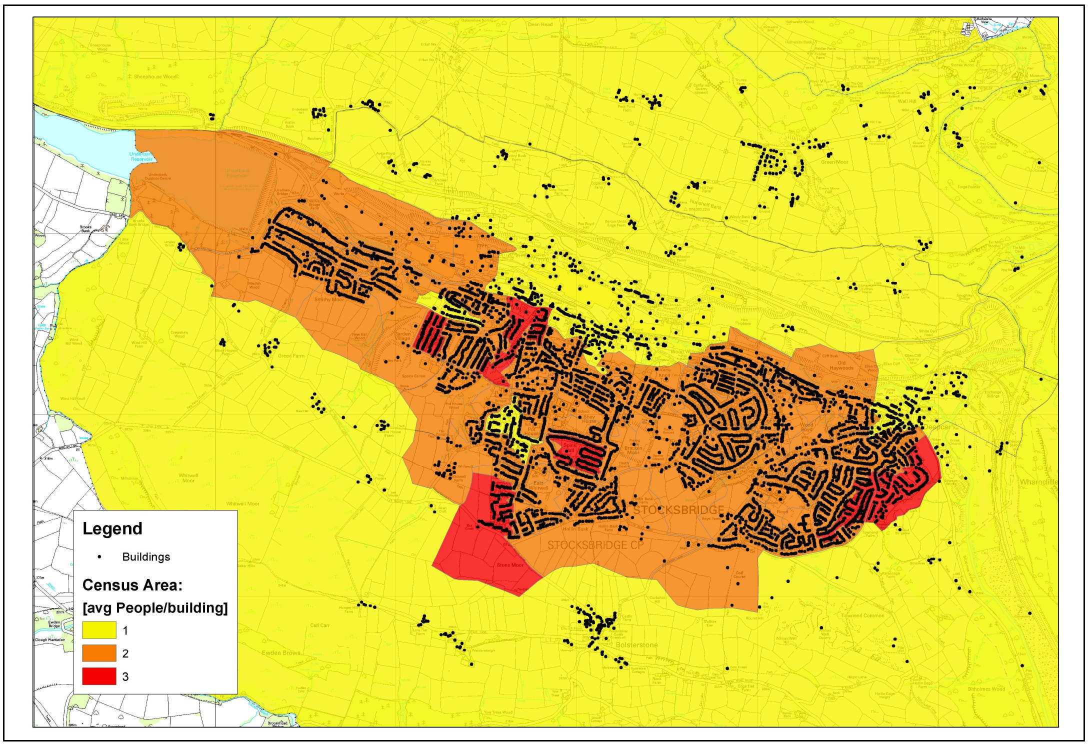


Figure 3.7 Buildings and census areas for the study area

Summary of results

(i) Flood hazard

From the hydrodynamic modelling it is possible to show the maximum depth and velocity of the flow; for simplicity the Figures 3.8 and 3.9 show only the initial stretch of the river below the dam.

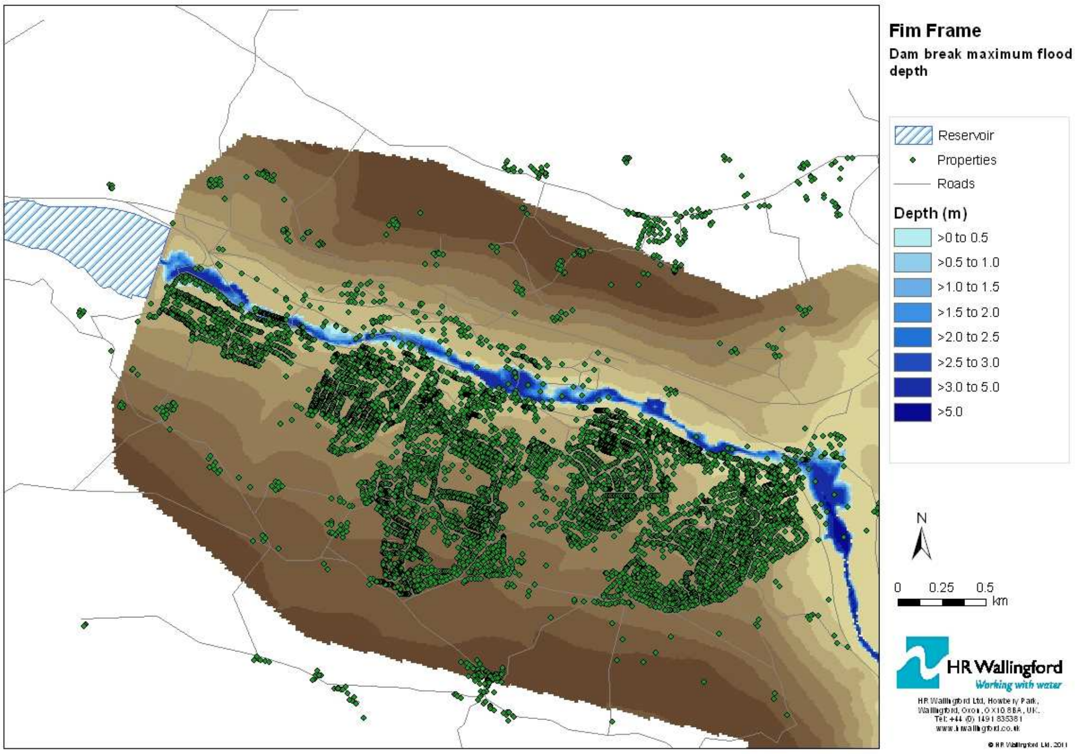


Figure 3.8 Maximum water depths

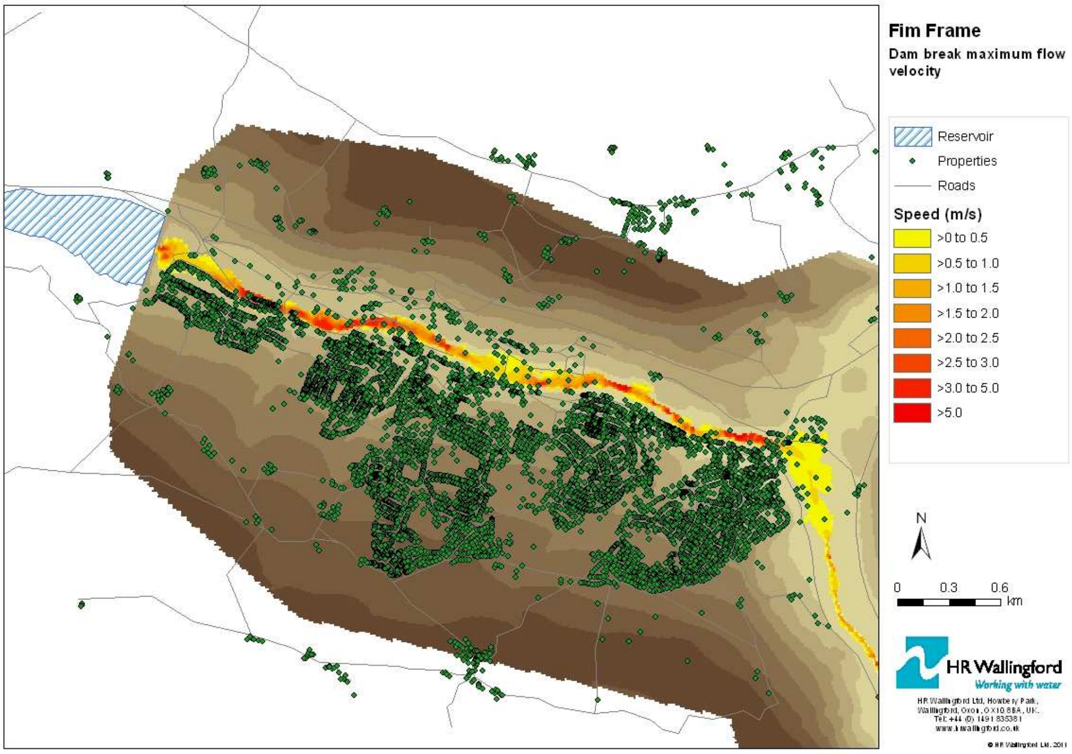


Figure 3.9 Maximum water velocities

It can be noted from Figures 3.8 and 3.9 that the maximum extent of the flooding and its characteristics:

- Given the topography of the area, which comprises a narrow and long valley, the flow is concentrated in the bottom of the valley.
- As a result of the topography, again, the water depths and velocities are very high, especially near the dam.

Another interesting aspect is the visualization of the flooding process from the moment in which the breach first occurs, considering a time-step of five minutes and taking into account the first 60 minutes.

Figure 3.10 shows the water propagation during the event. It is possible to locate the areas downstream the dam that are reached by the flood at different times. The flood wave appears to be very fast, covering a distance from the dam about 0.9 km after only 15 minutes, and 2 km after 30 minutes. Hence it could be highlighted the importance of this map with respect to flood protection and emergency planning, because it provides essential information regarding the different areas of the town reached by the flood wave at different times.

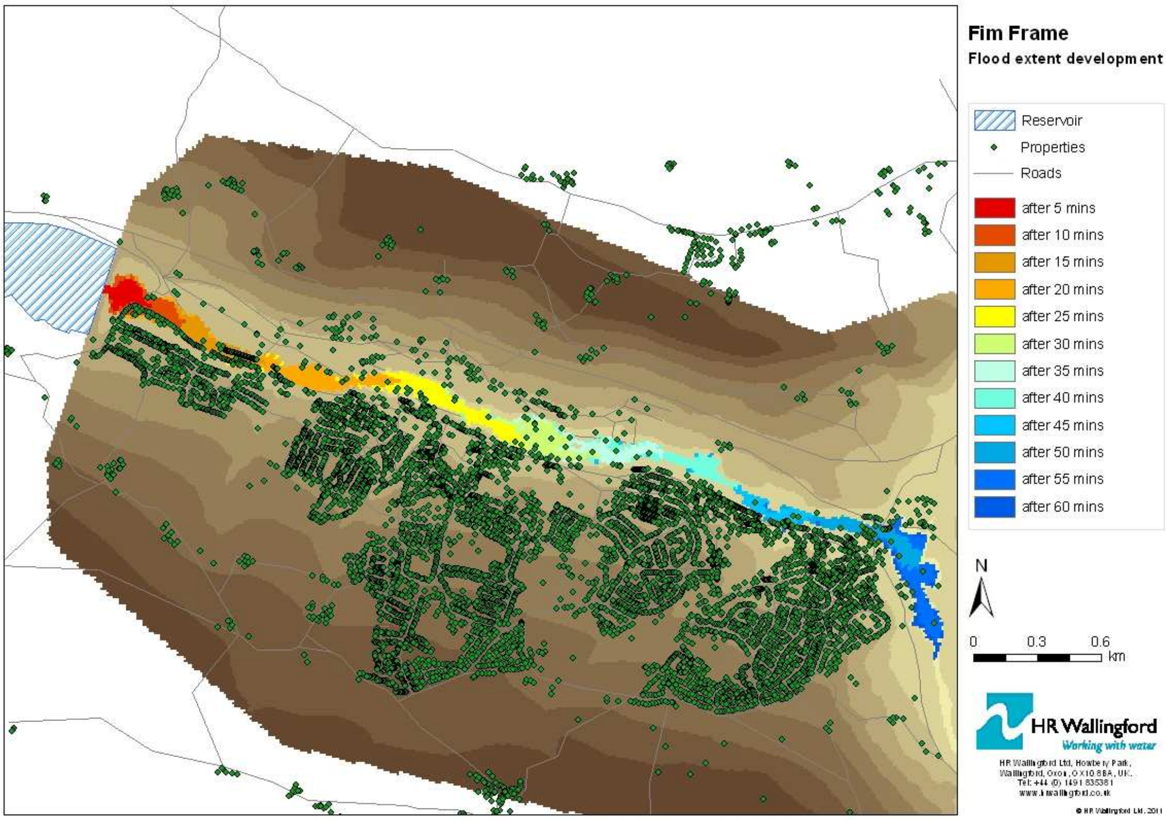


Figure 3.10 Flood extent development

Receptor impacts

The Flood Risk to People (FRP) and Life Safety Model (LSM) are among the best available currently for the purpose of loss of life estimation. The two models have a different framework and are based on different equations, but it is still possible to note the following similarities and differences:

The FRP takes into account the flood characteristics as their main input parameters, and return as output a fatality rate related to each different zone of the study area; therefore the number of fatalities can be obtained by multiplying the number of people within each zone by its corresponding fatality rate, applying the following general equation:

$$Fatalities_{TOTAL} = \sum_{i=1}^{n} (fr_i A_i)$$

where:

$Fatalities_{TOTAL}$ is the total number of fatalities
n is the total number of homogeneous zones
A_i is the i^{th} homogeneous zone
fr_i is the fatality rate concerning the i-th homogeneous zone

The LSM is an agent-based model, which simulates the interactions of autonomous receptors with a view to assessing their effects on the system as a whole. The LSM can simulate the flood effects in a better level of detail, modelling each individual person during the event, and allowing them to mutually interact. Table 3.4 summarises the comparison between the models' results.

Table 3.4 Results of the comparison between the models.

		Flood Risk to People		**Life Safety Model no warning**		**Life Safety Model with warning**	
Population		13,836		13,836		13,836	
Deaths	Total	8.5	0.1%*	240 (153)**	1.73% (1.11%)	35 (35)**	0.25% (0.25%)
	Drowning	-	-	150	1.08%	35	0.25%
	Exhaustion	-	-	3	0.02%	0	0.00%
	Building collapse	-	-	87	0.63%	0	0.00%
	Vehicles swept away	-	-	0	0.00%	0	0.00%
Injuries		64.2	0.5%				

*percentage evaluated on the total population
**in brackets, the total deaths and percentage if building collapse is not considered.

The LSM has been run with and without a warning centre that issues a warning as the dam is breached. The main effect of the warning is to allow people to move away from the area with the highest velocities and depths, which has the added benefit in removing the deaths caused by collapsing buildings. So an evacuation policy of moving to higher ground, rather than sheltering in buildings, is the preferred option.

Potential use of tools for improvement of emergency plan

In this case study we have only considered the impact of a dam failure on the town immediately downstream: however, the flooding impacts would be felt downstream within the city of Sheffield and therefore the total impacts would be higher than presented here. There will therefore be a need to consider the emergency arrangements for the town, as well as the wider emergency measures within the city, and to consider similar impacts from other reservoirs.

The results from the application of LSM were presented at the LRF workshop, and the animation of the flood wave and the movement of the population provided a very clear representation of where fatalities occurred and where the population needed to move to escape the floodwaters. Two key conclusions were reached:

1. The provision of an adequate warning of a breach at the dam was vital, and means to transmit this warning to the rest of the town should e considered
2. The narrow form of the valley means that fatalities only occur in the riparian zone, so if people move uphill, perpendicular to the river, this will afford the greatest safety.

The LRF needs to consider whether dedicated uphill escape need defining, or whether general advice can be given for people to simply move away from the river once the warning siren is heard. This also needs to consider whether specific shelter locations need to be defined. Some form of permanent signage could be used to remind people that a flood risk exists and where they should move.

Beyond this simple analysis, the LSM could be used to further investigate different warning rates and locations, plus the designation of shelters. This last option is probably not realistic as the linear nature of the town means that a large number of shelters would be needed if people were to get to high ground as quickly as possible. It is probably better to define the major roads to be used to get right away from the area, where people can be advised on where to proceed to. The results from the analysis can be used to improve the mapping of flood hazard and the location of any businesses or infrastructure that would be affected by the dam failure. To summarise the tools applied helped with the following:

- Planning evacuation routes
- Determining shelter and safe haven locations
- Defining warning arrangements

Conclusions and recommendations

An analytical framework for application to flood emergency management plans has been developed, based on the principles of the Business Elements Method (BEM), and been trialled in three workshops in the England. Generally the framework has been well-received, particularly application of the metrics, with various aspects considered to be useful to the emergency management process. The entity diagram, which is a key component of the BEM, was seen to be somewhat academic and there was concern that emergency planners would not have the time or understanding to apply this as part of their normal work. These key findings will be addressed in the production of the final guidance, which forms one of the FIM FRAME project outputs. It will be important to provide sufficient assistance and examples of how to construct an entity diagram, and why it remains a useful part of the whole framework.

The Sheffield LRF was keen to look at the flood risks and consequences arising from a potential dam failure upstream of the city. Several linked tools have been applied to investigate this issue, and some important findings have been produced. To date, it has only been possible to discuss these with the LRF in general terms. However, a further national meeting will provide an opportunity to discuss the use of tools to inform the content of MAFPs, and the developing assessment of flood risks associated with the UK's dams. Again, there is the issue that emergency planners, who have to cover all risks to society, do not have the resources to make much use of tools as part of their planning function. It is clear that there are many tools that could provide valuable insights into the flood risks across the country, and could be used to produce more robust emergency plans. However, this would require additional investment of finance and time.

3.3 Tarascon case study, France

3.3.1 Background to the area

The case study chosen for France was the city of Tarascon and the lower part of the Rhone catchment. The downstream part of the biggest French river is prone to three kinds of floods: fluvial floods of Rhone and its tributaries (i.e. the Gard and Durance River), the overtopping of canals such as the Viguerat canal which is an irrigation canal and the possibility of dam failure from structures located on the Durance River (e.g. the Sainte-Croix Dam and Serre-Ponçon Dam). An aerial view of Tarascon is shown in Figure 3.11.

The Rhone River is bordered by system of dikes which is currently being reinforced after numerous failures over the last 15 years. Syndicat Mixte Interrégional d'Aménagement des Digues du Delta du Rhône et de la Mer (SYMADREM) is the authority that is in charge with the maintenance of the dikes; however, this authority does not have any responsibility for emergency management of floods.

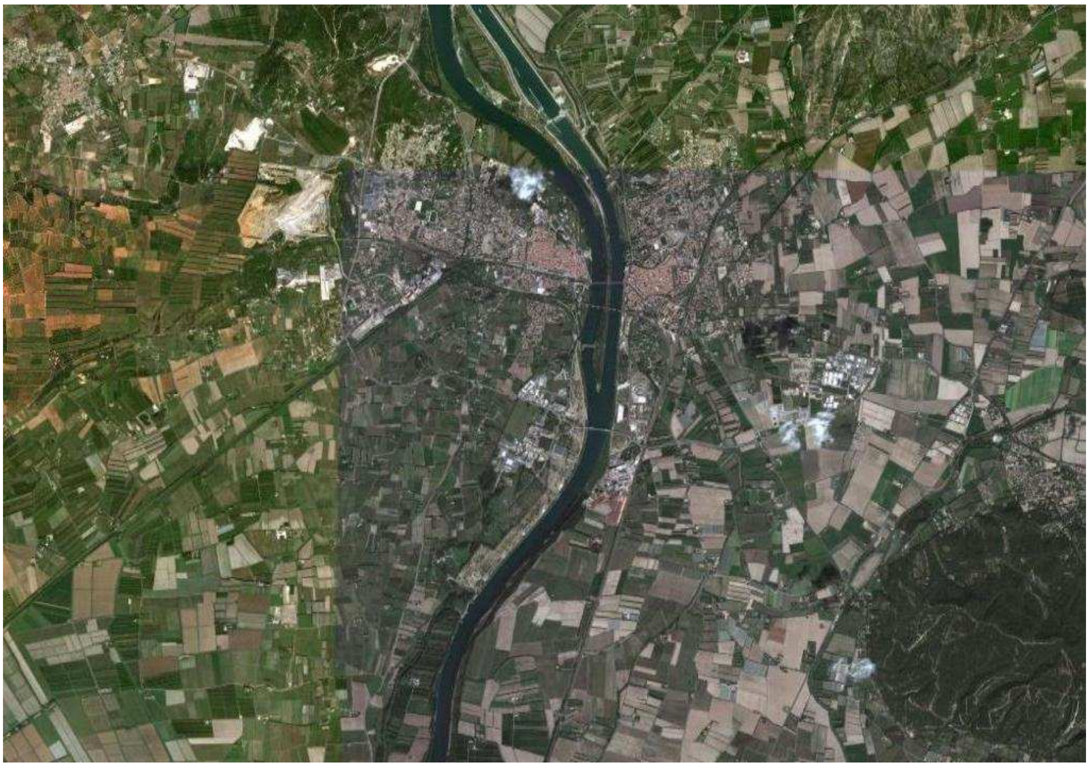


Figure 3.11 Aerial view of Tarascon, France

Two historical flood events have set the reference levels in terms of protection against floods. Before 2003 the “reference flood” was the flood of 1856 which devastated the Rhone valley and many other rivers in Europe. Many mitigation measures such as flood defence dikes were constructed or rebuilt following these floods. In 2003 the biggest floods since 1856 resulted in nine fatalities and caused more than one billion Euros worth of damage. Dikes that had not been repaired and well maintained failed in many places.

There are no emergency plans that cover a flood event over the whole Rhone delta. The Rhone Delta is divided into numerous administrative entities including more than 30 municipalities (i.e. communes), three Departments and two Regions (i.e. Languedoc-Roussillon and Provence-Alpes-Cote-d'Azur (PACA)). After the assessing the flood emergency management plans in the area it was decided to focus on the commune of Tarascon.

A flood emergency management plan called a Plan Communal de Sauvegarde (PCS) has been in place in Tarascon for several years. The municipality has developed a flood warning system that is recognized as being efficient. Nevertheless, the application of the FIM FRAME method to the PCS highlighted some gaps that the application of some tools could partly fill. The application of tool addressed two key issues:

- How to reduce the residual risk of people living in the Segonnaux which is the area between the River Rhone and the dikes;
- The impact of an extreme event (0.1 % probability flood) including breaches in the dike system.

The team chose to test a flood risk to people model on the western part of the Rhone Delta in the Gard Department to assess the residual risk to the population living in the area. The situation in this area is representative of the situation in many of the River Rhone floodplains. Several scenarios were tested using the flood risk to people model.

3.3.2 Application of the FIM FRAME method to Tarascon – Step 1 - Appraise

The FIM FRAME method to assist with assessing and improving flood emergency planswas applied to Tarascon's Plan Communal de Sauvegarde (PCS). The scoring of the PCS plans was performed by the University of Montpelier III. The results were presented and discussed at a workshop hold in Tarascon on the 4 January 2011. The aims of the workshop were:

- To launch a discussion on the shortcomings of the PCS of the city of Tarascon.
- To provide a basis for discussion on emergency planning issues that might lead to potential actions to implement and how they could be addressed.
- To gain feedback on the FIM FRAME method and recommendations for improving it

At the workshop an introduction to the FIM FRAME method was given as well as a presentation of the results of the scoring of the PCS using the developed metrics. Ten people responsible involved for emergency planning attended the workshop. They were from the:

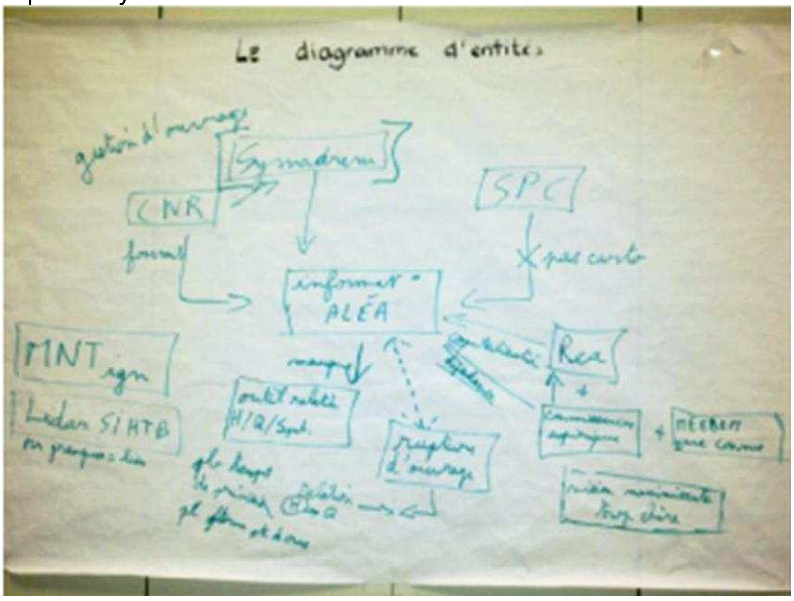
- City of Tarascon local authority
- Police
- Fire brigade

3.3.3 Case study application: Step 2 Tackle

The second part of the workshop was dedicated to applying the FIM FRAME to two areas chosen by the attendees. These were:

- Flood hazards maps
- Flood forecasting and warning

The above two metrics were chosen because they were perceived to be problematic by the stakeholders in terms of emergency planning. Two groups worked on each of these areas using the FIM FRAME method that involved producing an entity diagram, cross table and action table. The entity diagrams produced for flood hazard maps and warning systems are shown in Figures 3.12 and 3.13 respectively.



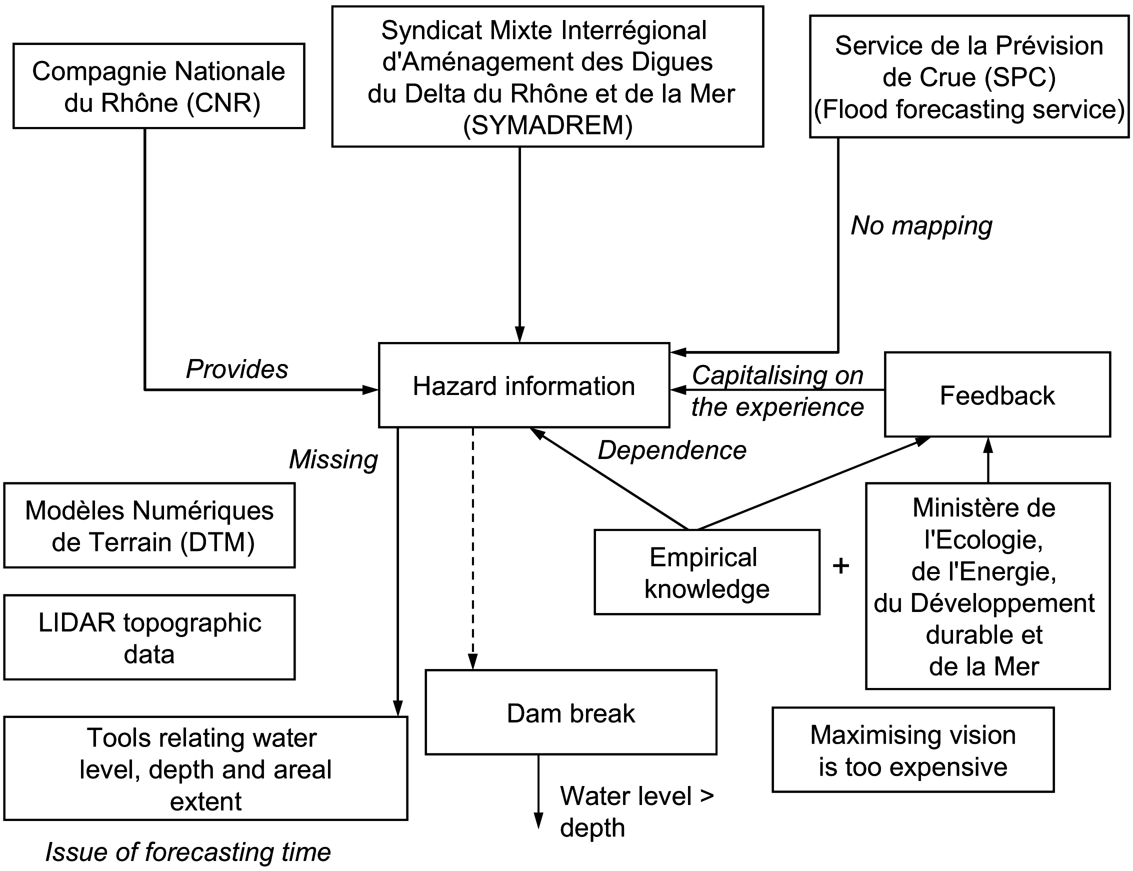


Figure 3.12 Entity diagram for flood hazard mapping

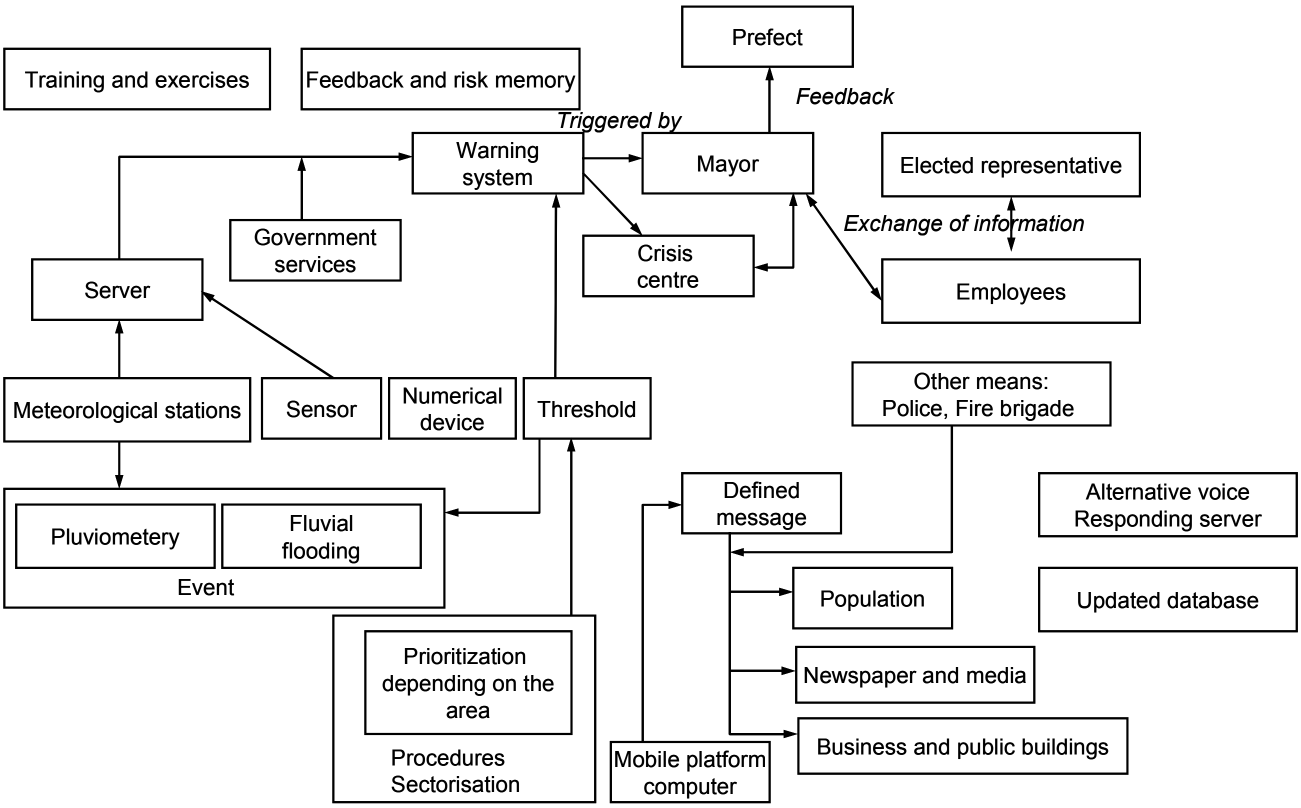
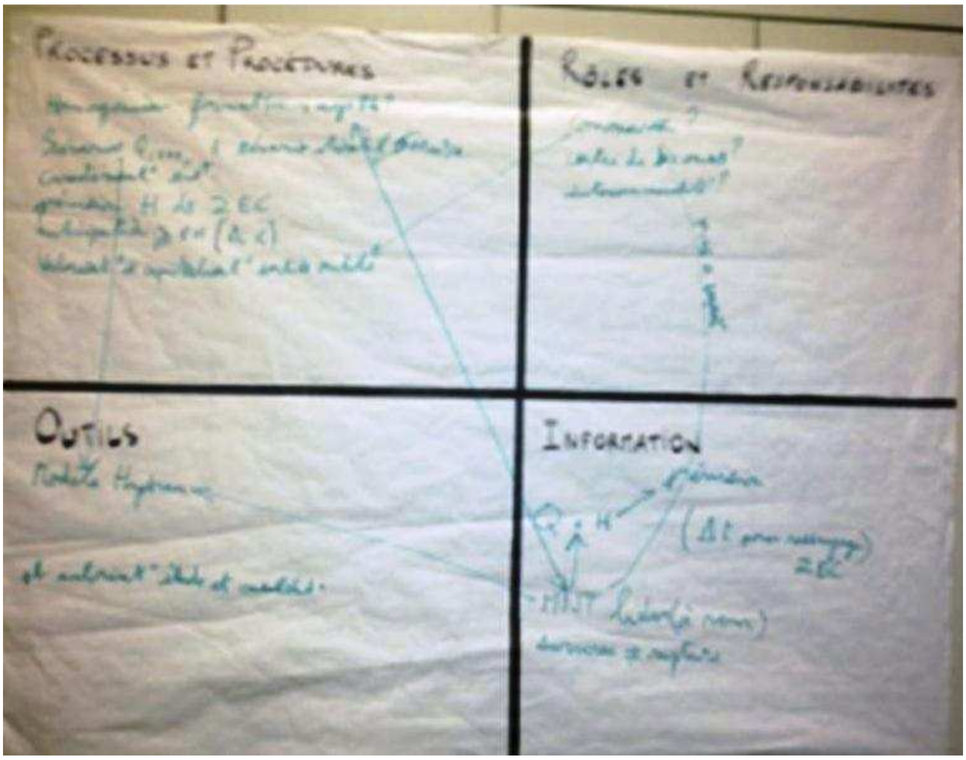


Figure 3.13 Entity diagram for flood forecasting and warning

The first breakout at the workshop gave rise to several debates among the attendees. It was the opportunity for the facilitators to understand better the local crisis management context and especially to have an overall view of the situation and to map the different processes that characterizes the PCS. For the flood hazard mapping the workshop highlighted the existence of considerable information concerning the flood hazard. However, this information is held by a number of different organisations and is not well disseminated. It was found that the stakeholders' knowledge of flooding was often based on previous large historical events. The fire service stated that they required hazard maps of more potential flood scenarios and also more extreme events (e.g. the 1 in 1,000 year annual probability event). Mitigations measures, although some times costly, for this extreme events need to be considered. New information is needed to assess the potential consequences of inundation as the result of the breaching of dikes.

From the entity diagram, the various processes and procedures were identified, and inserted in the first quadrant. These were then assessed on the basis of who was responsible for them, what information was required, and whether any tools or other technology was used or needed. The resultant tables are presented in Figures 3.14 and 3.15 respectively.

This step of the FIM FRAME method was the opportunity for the attendees to clarify the different issues observed in the previous step. Regarding the metric "Flood hazard map", the first issue was to emerge was the funding and the future enhancement of the hydraulic studies already carried out on the watercourses that affect Tarascon. Several studies have been carried out by various organisations on that have not always been relevant to the stakeholders' requirements. It was noted that the warning thresholds were not appropriate. It appeared that Tarascon council has a need for flood hazard mapping at different flows, possibly at an interval of 500 m^3/s with the different water levels and inundated areas shown for each flow. Currently such hydraulic modelling results are not available. Many stakeholders mentioned the need to have a more extreme flood event mapped (e.g. the 1 in 1,000 annual probability event). Trascon council currently uses the 2003 flood, which has a return period of less than 1 in 100 years, as their "benchmark" for crisis management strategies.



Processes and procedures

- Standardize training
- Map in 1 in 1,000 year event and scenario for 500 m^3/s flow
- Characterization of events
- Water level forecasts for the flood zone
- Warning time > 8 hours
- Promoting of and capitalising on tool outcomes

Roles and responsibilities

- City council
- Fire Brigade
- Local communities

Tools

- Hydraulic model
- Issue of promotion and consolidation of the studies

Information

- Flow + depth = Forecast
- LIDAR based digital terrain model

Figure 3.14 Cross Table for 'Flood Hazard Map'

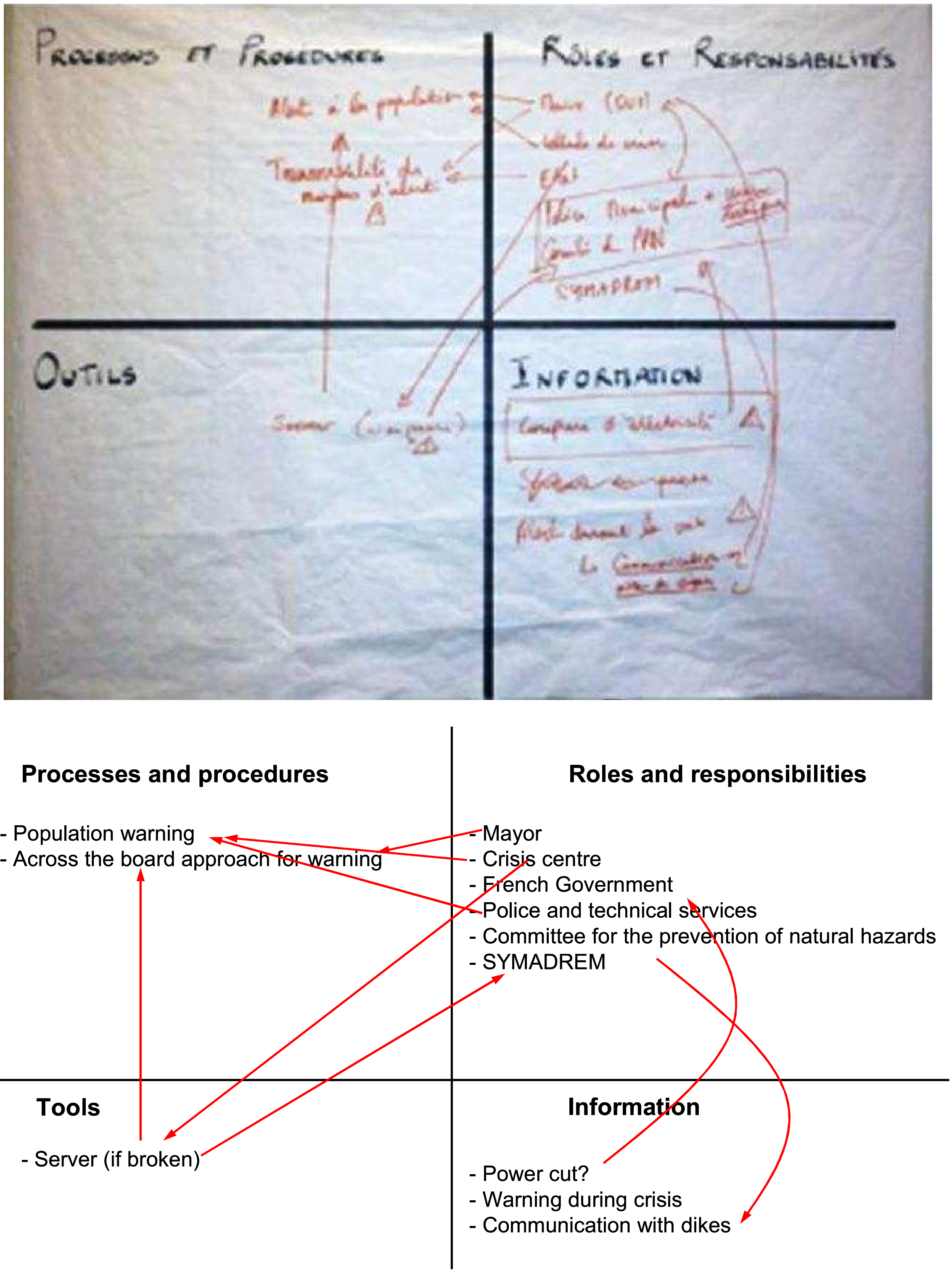


Figure 3.15 Cross Table for 'Flood Warning'

3.3.4 Stakeholders' feedback on the FIM FRAME method

The application of FIM FRAME method helped to facilitate useful discussions concerning the issue of emergency planning in Tarascon. The table of metrics was recognized as a good "check list" for an initial assessment of the PCS plan. The attendees did not contest the first appraisal of the PCS plan. The entity diagram was found useful by the stakeholders because it structured the ideas around a specific issue. The analysis of the metrics using the entity diagram and cross-tables was relatively straight forward for professional emergency managers such as firemen, but some times more difficult for "non-specialists" such as policy makers. The attendees indicated that the FIM FRAME method would be used mainly for assessing existing plans. The workshops did not test the use of the FIM FRAME method for development of a new plan. It was found that owing to time constraints it was best to use the method to analyse the "weakest" metrics rather than all 22 metrics.

3.3.5 The gaps in the plan found using the FIM FRAME method

Tarascon municipality is heavily involved in emergency management. The municipality and firemen services have invested in human and material resources to protect them from floods from the Rhône River. It is clear that flood risk management is at the heart of concerns in the municipality, not only because of its exposure to risk, but also because the municipality wants to promote the demographic and economic development of Tarascon by opening up some areas to development that are currently at risk of flooding. Tarascon has six people (i.e. elected representatives and firemen) that are aware of the flood risk and have significant experience of previous emergencies such as the 2003 flood event. By choosing to invest in several advanced tools the municipality has increased its capacity to respond and to manage future flood events. However, there remain some shortcomings and gaps in the municipality's emergency planning for floods as demonstrated by the metrics that were investigated as part of the workshop.

The Table 3.5 shows the initial scores of the Tarascon emergency plan and indicates the possible actions to improve the score of each metric among those which were considered during the workshop. The scores of each metric have been revised considering the objectives of the workshop and scoring the metrics according the criteria defined in WP1 of this research.

3.3.6 Potential actions that could improve the plan

After applying the FIM FRAME a plan of action was drawn up via which the emergency plan could be improved. These are summarised below:

- Improve the knowledge of the elements at risk and the vulnerabilities of flood prone areas via the creation of new mapping
- Improve the definition of the trigger levels i.e. the actions to be taken at specific levels or flows in various rivers needs to be defined
- There needs to a compilation and standardisation of the existing hydraulic studies and models that have been carried out
- The inundated areas and water depth need to be related to the flow in the river. For example, it would be useful to have flood hazard maps produced at 500 m^3/s interval increases in the flood flow
- Extreme flood scenarios such as the 1 in 1,000 year annual probability flood need to be mapped
- In terms of the warning system there were a number of actions that need to be carried out. These include:

Table 3.5 Potential actions to implement for each metric and improved score of the plan

Metrics	Initial Score			Initial Scoring	Potential action	Potential score
	Room for improvement	Accept-able	good			
Aims and objectives of plans			X	3	Not addressed	3
Target audience and updating			X	3	Not addressed	3
Details of previous floods	X →	**X**		1	Reports to share the knowledge of previous floods	2
Flood hazard map	X →	→	**X**	1	Flood hazard and potential aftermaths mapping of a flooding for each critical level oft he Rhône river (every 500 m3.s-1)	3
Flood Warning		X →	**X**	2	To link water depths to a flood trend with maps of affected zones	2.5
Risk to people	X →	**X**		1	Maps of people living in flood prone zones (ségonnaux)	2
Risk to vulnerable people	X →	**X**		1	To improve the registering of vulnerable people	2
Flood risk to residential properties		X		2	Not addressed	2
Flood risk to business	X →	**X**		1	To strenghten relationship between prevention and crisis management i.e. plans to protect businesses	2
Flood risk to critical infrastructure	X			1	Not addressed	1
Potential for NaTech hazards	X			1	Not addressed	1
Evacuation routes		X →	**X**	2	New maps for crisis management	3
Shelters/Safe havens			X	3	Not addressed	3
Relationship with complementary			**X**	2	Enhance exchanges	3

emergency plans		X →			between stakeholders (compatibility of data)	
Communication with other agencies		X →	X	2	Enhance the cross-knowledge of procedures, needs and objectives among stakeholders	2.5
Communication with the public		X →	X	2	Updating of the calling list	2.5
Management of the media			X	3	Not addressed	3
Assumptions made by the plan	X			1	Not addressed	1
Plan activation			X	3	Triggering levels to confirm by relation depth/affected areas (see metric : flood hazard)	3
Actions, roles and responsibilities			X	3	Improve cross competencies in emergency management teams	3
Recovery		X →	X	2	To help farmers to resume activity after disasters by helping them pumping and gathering cattle… A census of materials available is needed	2.5
Training and exercises	X			1	Not addressed	1
TOTAL	**Initial score**			**1.78**	**Potentiel score**	**2.21**

3.3.7 Application of tools to address gaps and issues

In order to address the gaps two tools were applied:

- The application of LIDAR digital terrain model which offers more accurate topographic data in the vicinity of Tarascon
- The application of the Flood Risk To People method to assess the potential impacts of extreme events.

Application of the LIDAR data

A LIDAR based digital terrain model (DTM) was available in the unprotected floodplains in the vicinity of Tarascon. This DTM allowed the services responsible for emergency management to have a better knowledge of the topography and which areas should be to evacuated first and which areas can be used as shelters. An analysis of the evacuation routes in the area to be made.

Application of the Risk To People method

The Flood Risk to People method was also applied as part of the case study to get an idea of the number of injuries and fatalities that may occur during a large flood. In December 2003 there was a flood event in which one person died. When the Flood Risk People method was applied to this flood the number of fatalities is estimated to be between one and two people with 31 people injured.

The Flood Risk to People method was also applied to the 0.1% annual probability flood event, including a dike breach. The hydraulic conditions are not deeply modified according the return period considered. The sensitivity of the Flood Risk to People method to changes in the demographic data was tested. This was done by simulating a doubling in the number of people aged over 75 and a doubling of the number disabled people by 2050. The Flood Risk to People method appeared to be more sensitive to the socio-economic variables than to hydrological variables. The number of fatalities rose from 5 to 10 with demographics changes. Table 3.6 shows the results of the Flood Risk to People method for the 2003 flood event and the 0.1% annual probability flood

Table 3.6 Results of the Flood Risk to People method for three flood scenarios of the Rhone floodplains in the vicinity of Tarascon

Scenario	Injured people	Fatalities
2003 event	34 to 35	1 to 2
0.1% annual probability flood with the present day population	77 to 78	4 to 5
0.1% annual probability flood event with 2050 demographics with a doubling in the number of disabled people an people aged over 75	154 to 155	9 to 10

Figure 3.16 shows the geographical distribution of fatalities for the 0.1% annual probability flood with the 2050 demographics as outlined above.

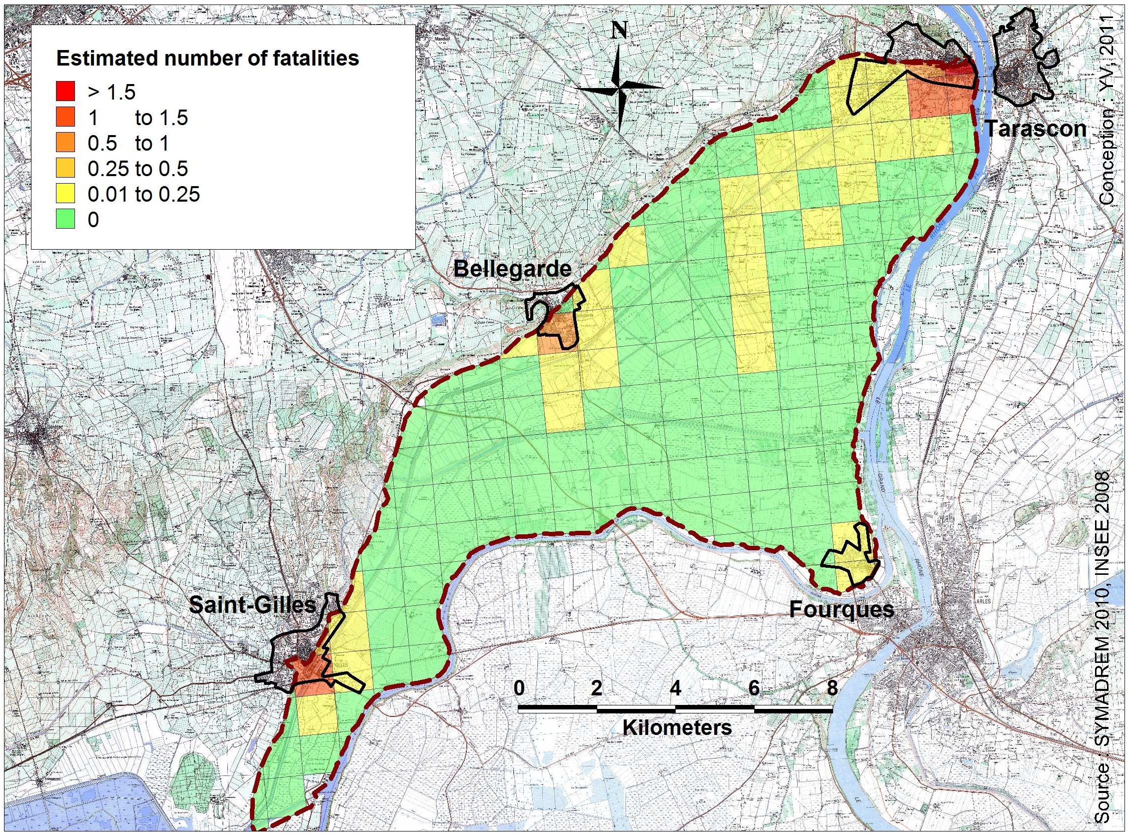


Figure 3.16 Outputs from the Flood Risk to People in the vicinity of Tarascon

3.4 Dordrecht case study, the Netherlands

3.4.1 Background to the case study area

The city of Dordrecht has a population of around 120,000. The city is located on a 90 km^2 island which is at risk of flooding from the tidal reaches of the Rivers Meuse and Rhine shown in Figure 3.17. Part of the city is situated in flood prone areas, not protected by dikes. Flooding is caused by a combination of high river discharges and sea levels, although flooding has not occurred since the night of 1 February 1953 when the South-West of the Netherlands was struck by a large flood killing around 1,800 people in the region

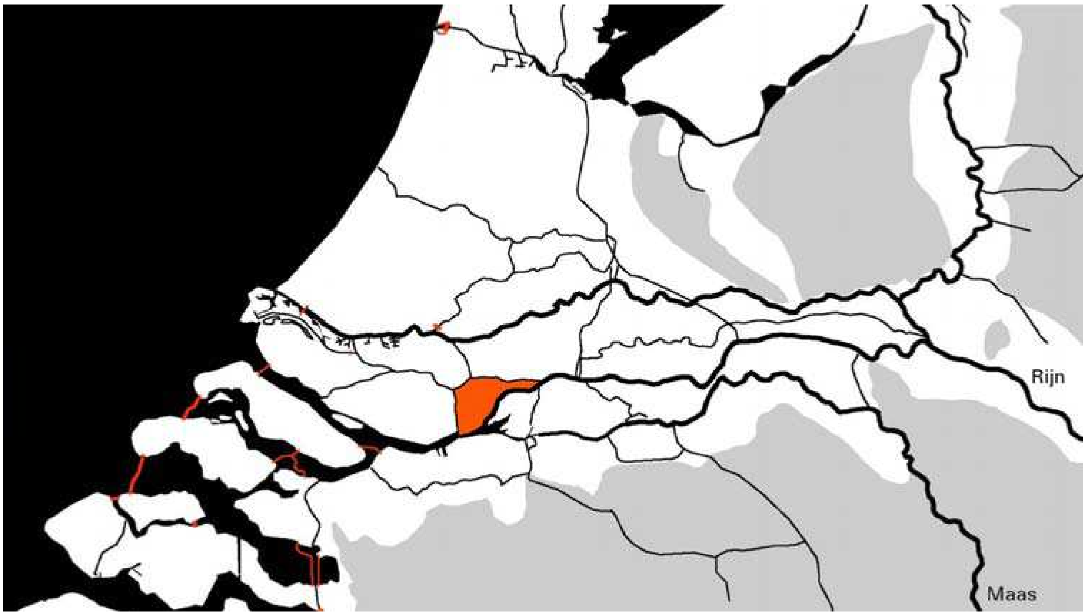


Figure 3.17 Location of the city of Dordrecht in the Netherlands

This island lies east of Rotterdam and is surrounded by several rivers. This island houses the city of Dordrecht. The island is mostly protected by dikes. The ring of dikes and flood defences protecting the largest part of the City of Dordrecht as is illustrated in Figure 3.17.

If the dikes in the vicinity of Dordrecht fail because of an extreme water level event, the island will become flooded quite rapidly and large water depths are expected. For 13 representative breach locations, the consequence of flooding has been evaluated. The maximum water depths on the Island would reach up to 4 m. The major part of the island would be under 2 m to 3 m of water. This is shown in Figure 3.18.

Owing to the limited exit points from the island, evacuation is complicated and the risk of casualties is high in the event of a flood. Figure 3.19 shows the exit points by road from the island. Evacuation possibilities will be further limited because the surrounding areas will also be in the process of evacuation, increasing the pressure on the main roads out of the flood threatened area. An early study on risk of casualties under changing climate conditions (Klijn et al, 2007) calculated the number of expected casualties for the current situation assuming that 10% to 40% of the inhabitants remained on the Island. The number of expected casualties was estimated at approximately 400.

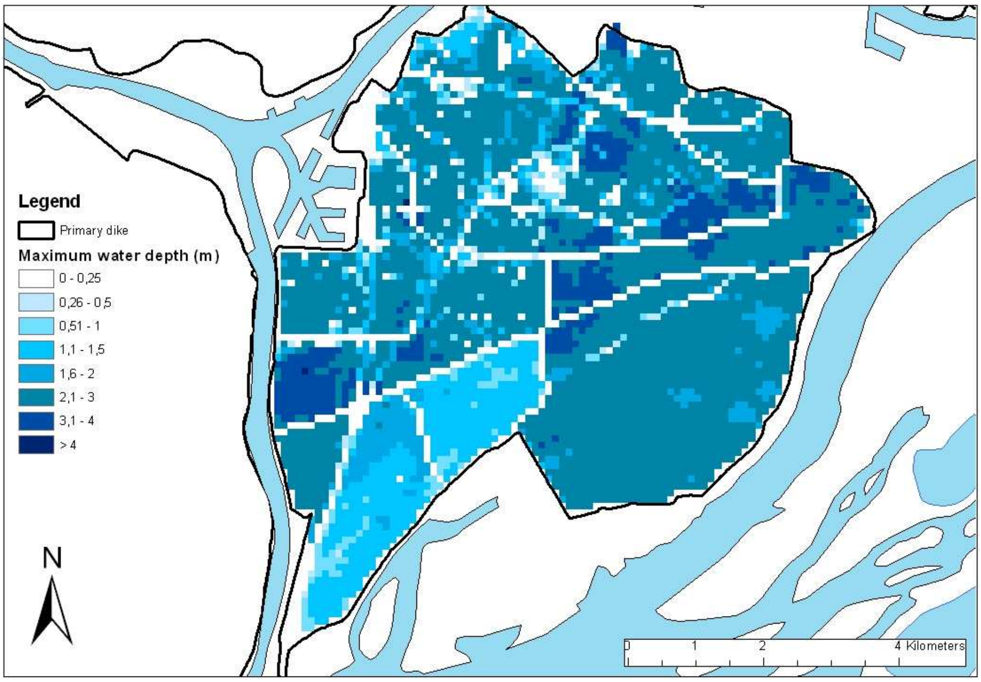


Figure 3.18 Compilation of maximum water depths for Dordrecht evaluated for 13 breach locations

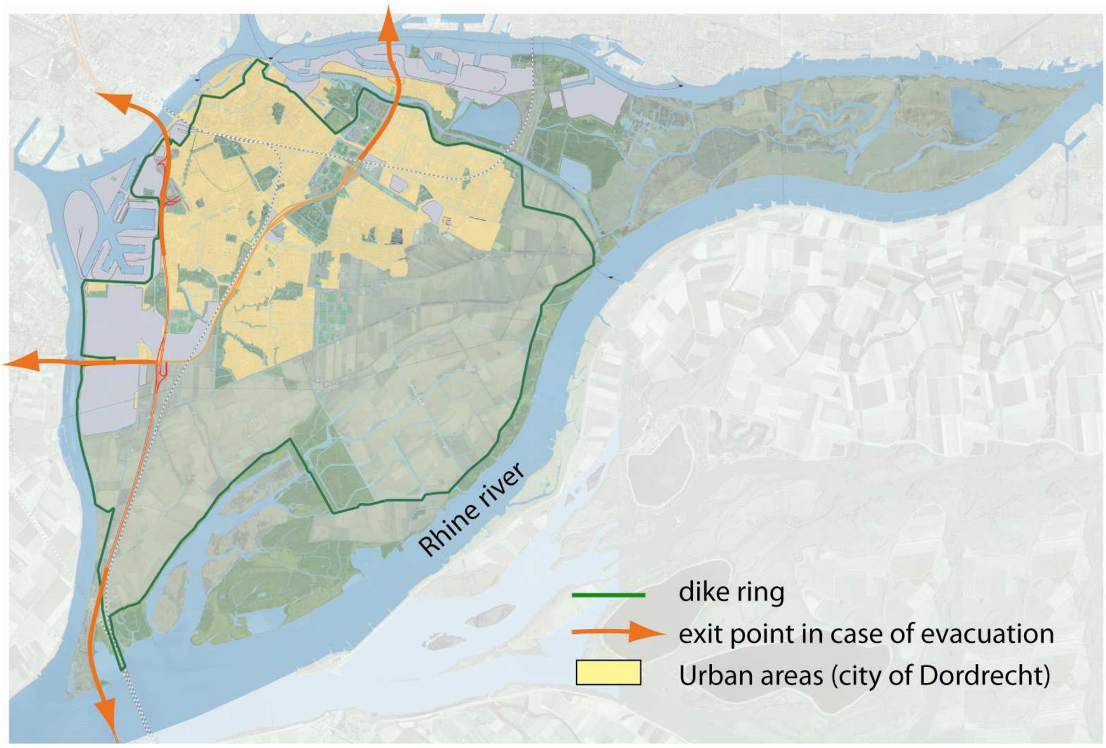


Figure 3.19 The Island and city of Dordrecht and the exit points in case of evacuation

If confronted with such a scenario, the regional police and fire departments would be involved in the so-called “veiligheidsregio (Safety Region) Zuid- Holland zuid”. Breaches in the flood defence system will cause the island to fill up rapidly with water, because the inner dike area is below river level and large water depths are possible. Preparing for an evacuation is an important issue for this area. The emergency plan assumes a total evacuation of the island. Experts and emergency planners expect this to be an impossible task, owing to the number of people and time it would take to evacuate them.

Three flood event management plans cover the Island of Dordrecht:

- *Regionaal Basisplan Overstromingen Zuid Holland Zuid, algemeen deel (RBO), v2.8*
  General flood emergency plan (FEMP) for the region in which Dordrecht lies. The plan was developed by the Safety Region.
- *Regionaal Basisplan Overstromingen Zuid-Holland Zuid, specifiek deel dijkring 22, Eiland van Dordrecht, v2.7*
  This plan is in addition to the general FEMP and focuses on the Island of Dordrecht. The plan was developed by the Safety Region.
- *Hoogwaterbestrijdingsplan gemeente Dordrecht januari 2010*
  This plan focuses on the areas unprotected by flood defences.

3.4.2 Application of the FIM FRAME method to Dordrecht – Step 1 - Appraise

The scoring of the plans, which forms Step 1 of the FIM FRAME method know as “Appraise” was performed by the project team. The results were presented and discussed at a workshop held in the Safety Region. The aims of the workshop were to:

- Provide feedback on the FIM FRAME method and ways it could be improved
- Provide a basis for discussion on emergency planning issues for the Island of Dordrecht that might lead to potential actions to tackle some of the identified issues

At the workshop an introduction to the FIM FRAME method was given as well as a presentation of the results of the scoring of the emergency plan with use of the metrics for the region of ZHZ. The second part of the workshop was dedicated to applying the FIM FRAME method with an emphasis on Step 2 known as “Tackle”. The workshop was held at the Safety Region’s main office in Dordrecht. There were seven people involved in emergency planning who attended the workshop. They were from the:

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

The workshop acted as a starting point for the case study, so the focus was on the topics related to evacuation for the area of the Island of Dordrecht. The following topics were selected by the attendees for further analysis with use of the FIM FRAME method:

- Evacuation of the people in the areas unprotected by flood defences towards the areas protected by flood defences
- Evacuation of the people in the areas protected by flood defences to areas outside of the island

There were two groups each worked on different metrics drawing up the entity diagrams, cross tables and action tables as outlined in the FIM FRAME method.

The two plans were scored complementary to each other with use of the metrics. The results for the Island of Dordrecht plan are shown in Table 3.7. The project team compared the lower scoring metrics to the requirements for a high score as defined in Step 1 of the FIM FRAME method. The last column in Table *** indicates possible actions to improve the scoring of the specific metric to meet the requirements for a high score. These actions were discussed with the Safety Region. It is seen that for several metrics the scoring can be improved by adding information that is also readily available e.g. target audience and updating. Several metrics require that maps are included where information is now only available through text or tables e.g. risk to people. This requires simple GIS actions. For some metrics the process needs further evaluation, e.g. recovery. Here step 2 in the FIM FRAME method can help. The project team indicated where the use of advanced tools could have more insight and more useful information e.g. for evacuation. Four types of actions have been listed in Table **** as follows:

- Blue: Add information that is already available to the plan.
- Green: show information that is already available on a map and add to the plan (GIS action)
- Red: further research is required (e.g. use of advanced tools, Step 3 in the FIM FRAME process).
- *Process needs to be analysed in more detail (Step 2 and 3 in the FIM FRAME method).

Table 3.7 Scoring of the flood emergency plans for the Island of Dordrecht

Metric	Room for improvement	Acceptable	Good	Score	Improvement of scores
Objectives, assumptions and target audience					
Aims and objectives of plans			●	3	
Target audience and updating		●		1.5	- Include updating procedure in the plan including notification of target audience. - Plan has a version number. Add the date of the plan.
Assumptions made by the plan			●	3	
Organisation and responsibilities					
Actions, roles and responsibilities			●	3	
Recovery	●			1	- * Develop an overview of the required recovery activities and how recovery should be managed. - Gain insight into draining time for the Island of Dordrecht for the different flooding scenarios. Use can be made of 2D flooding simulation tools.

Metric	Room for improvement	Acceptable	Good	Score	Improvement of scores
Training and exercises	●			1	A training and exercise program already exists. Uptake the requirements and procedure into the plan or uptake clear link to the plan.
Plan activation			●	3	
Communication					
Communication with other agencies			●	3	
Communication with the public	●			1	Event communication is described in a separate communication plan . This plan addresses the processes and responsibilities, but does not specify communication strategies, messages e.g. - Include clear links to the communication plan. - * Check if the communication plan is sufficient for a flood situation. E.g. is the warning coupled to the threshold levels of activation of the plan.
Management of the media	●			1	Same as for communication with the public.
Flood Warning	●			1	Flood Warning is linked to the plan activation stages which are linked to the river and sea water levels. Flood warning during actual flooding is not addressed in the plan. * Add levels of flood warning with details of the areas flooded at each level and shown on a map.
Relationship with complementary emergency plans		●		2	Add schematic overview of the relationship with complementary plans. This should include the communication plan mentioned earlier.
Evacuation					

Metric	Room for improvement	Acceptable	Good	Score	Improvement of scores
Evacuation routes	●			1	- * Evaluate different evacuation strategies. - * Define evacuation routes. Include which roads likely to be closed and accessibility in time for vehicles. - Map the location and the elevation of the routes in combination with the water depth maps.
Shelters/Safe havens	●			1	- Locate existing buildings which can be used as shelters both on the island as outside of the island. - Evaluate if sufficient shelter locations are available. - Include in plan the location, capacity and facilities of the shelters.
Flood hazard					
Flood hazard map			●	2,5	Add map showing flood velocities.
Details of previous floods	●			1	Not relevant to this emergency plan because no recent enough previous floods have occurred.
Flood risk to receptors					
Risk to people		●		2	A list of number of people per postal area is already available. - Show these numbers on a map and combine with the water depth map. - Casualty risk maps have been developed. Add these to the plan.
Risk to vulnerable people	●			1	A list of number of vulnerable people is available per postal area. - Show locations where vulnerable people are concentrated on a map and combine with the water depth map. - Show the number of vulnerable people per postal code on a map and combine with the water depth map. - * Add response strategy

Metric	Room for improvement	Acceptable	Good	Score	Improvement of scores
Flood risk to residential properties	•			1	- Show the residential areas on a map and combine with the water depth map. - Map number of properties in combination with water depth maps.
Flood risk to business	•			1	- Show location of businesses, types of businesses on a map an combine with water depth maps. - Potential damage maps are already available. Add these to the plan.
Flood risk to critical infrastructure	•			1	The plan already includes a list of vulnerable objects. - Add to this list and show on a map in combination with the water depth maps. - Analysis of impact of failure of critical infrastructure.
Potential for NaTech hazards	•			1	The plan already includes a list of environmentally hazardous businesses. - Show these on a map in combination with water depth maps. - * Add response strategy
Average score				**1.6**	**Room for improvement**

It is seen that especially aspects of the topics 'Communication', 'Evacuation' and 'Flood risk to receptors' have low scores. The attendees noted that the topic 'Communication' is addressed in a related plan specifically on communication. This plan is about processes and procedures and is not specifically focused on flood hazards. This plan was not available to the facilitators for scoring.

3.4.3 *Case study application: Step 2 Tackle*

During the workshop an entity diagram and cross table were constructed to evaluating the topic relating to the evacuation of people from the Island of Dordrecht to safe areas outside the island. In addition a start was made for the action table.

The resulting entity diagram is illustrated in Figure 3.20. The gaps are indicated with a dotted line. Four colours were applied to indicate a process (blue), people/organization (green), tool (red) or information (pink).

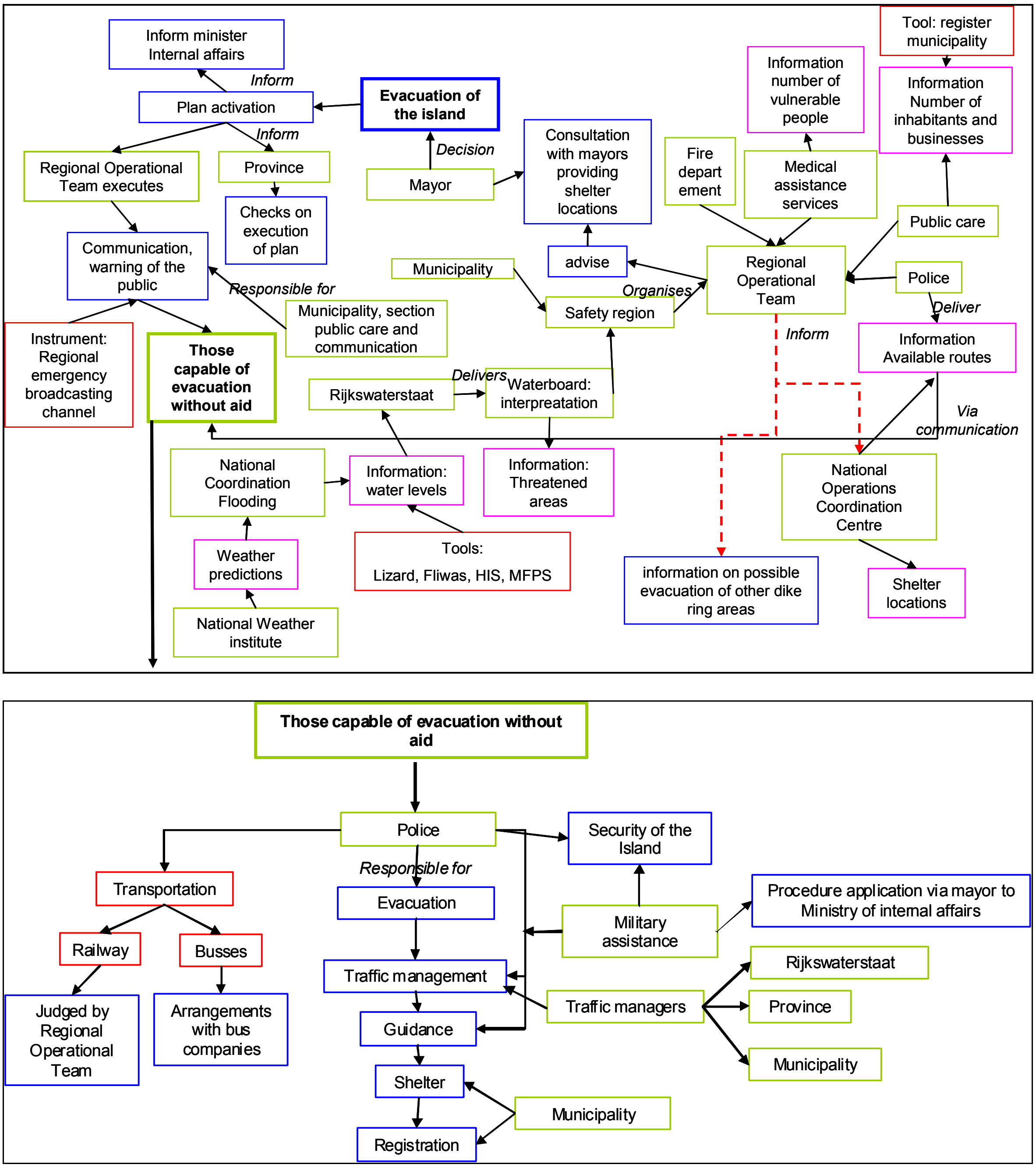


Figure 3.20 Entity diagram evaluating the topic relating to the evacuation of people from the Island of Dordrecht

The participants were asked to describe the perfect evacuation process and identify gaps with respect to the current organisation of the evacuation process. The starting point was describing and analysing the current organisation. From the entity diagram the only identified gap was the communication from the regional to national operations. The focus was mainly on the process (blue) and organisations and their responsibilities (green). The identified tools give an insight into the flood threat, required resources and instruments. No tools to improve the plans have been identified in this stage yet. The next step was the development of two cross tables shown in Figures 3.21 and 3.22 respectively. The identified gaps are indicated in red.

Processes & procedures	**Roles & responsibilities**
Advising on evacuation	Regional Operational Staf + staf sections + partners (National water board, Regional water board, Utility companies Mayor (receiver) + policy team Regional operational leader GBT (head of communication) National Operation Crisis Coordination
Tools (enhancing technology)	**Information**
City administration/register FLIWAS/HIS Tool to work out scenario's Evacuation calculator Digital accessibility map (national databases) Checklist communication strategy	Cause: flood threat Possible scenario's and effects • info number of citizens and companies • info number of self-supporting citizens Strategies, options

Figure 3.21 Cross table evaluating the process of 'advising the mayor'.

Processes & procedures	**Roles & responsibilities**
Flood information: • Pre-warning • Warning • Alarming	Rijkswaterstaat (alertering levels constructions) National Water boards (alerting levels for the areas protected by flood defences) National Coordination Flooding City (alerting levels for areas unprotected by flood defences)
Tools (enhancing technology)	**Information**
MFPS FLIWAS LIZARD Meteo systems DEM city 'Veiligheidstoetsing primaire waterkering'	Rivier dicharge and water levels Sea levels North sea, coast Prediction in time Area threated by flood for different scenarios Weather (storm) Elevation areas unprotected by flood defences Actual level flood defences

Figure 3.22 Cross table evaluating the process 'flood information'.

The cross table results show that processes and procedures as well as roles and responsibilities are well covered by the plans, but that the supporting information needs further elaboration. The attendees emphasized the need for flood scenario based information on flood risk (e.g. threatened area, number of citizens and companies). This kind of information is developed by research and engineering companies for the national government. In addition, the tools to develop this information require specialised expertise and knowledge. The Safety Region is therefore dependant on these organisations.

The attendees were asked to note the issues (red lights) which were identified from the cross table onto the action table. The action table was discussed, but due to time not further developed. The following issues were identified:

- Gaining insight into availability of evacuation routes
- Information on demographic numbers; vulnerable groups and to evacuate people, location of vulnerable people
- Being able to connect the different automated systems used by the different parties involved in emergency planning

3.4.4 Application of tools to address gaps and issues

Background

From the geographical location of the Island of Dordrecht means that evacuation of the island is not be feasible and that improving the evacuation and shelter possibilities could aid in reducing the flood risk for the Island. The application of the FIM FRAME method identified the issue of evacuation as a gap in the emergency plan for the island. The case study evaluated an alternative evacuation strategy making use of shelters on the island in which a number of people could find refuge and encouraging the remaining inhabitants to seek shelter in their own homes or tall buildings on the island. The currently strategy followed by the Safety Region is to attempt to evacuate everyone from the island.

The case study demonstrates the use of advanced casualty calculations and evacuation tools and methods to evaluate the different evacuation strategies. The results from this case can assist in improving the understanding of the evacuation process during a flood threat which in turn can be used to address the evacuation issues in the flood emergency plan for the island of Dordrecht. The calculations on the flood risks were executed by the Technical University of Delft within the context of the MARE project (Hoss et al, 2011). An analysis of the research with regards to the use of tools and the results was undertaken. In addition an interview was conducted with the Safety Region to assess to what extent the application of the tools and the outcome of the calculations could aid in improving the Flood Emergency Plan.

Application of tools

As part of the case study two evacuation strategies, the current evacuation strategy and the alternative strategy were evaluated with respect to their effectiveness. For the current situation it is estimated with use of the EvacuAid tool that it would be feasible to evacuate 15% of the people to safety. This percentage was determined in earlier studies (Maaskant et al, 2009). For the remaining people no measures are taken. For the alternative strategy it was estimated with use of the EvacuAid tool that owing to improved warning a higher percentage of 28% could be evacuated to safety. In addition it has been assumed that due to the system of shelter and improved communication, the mortality rate will reduce by 50%.

Sobek 1D2D

Sobek 1D2D is a flood hazard mapping tool and is used to simulate a flood event. It calculates flood characteristics such as the flood extent, water depths, water velocity, rate of rise and arrival time for a specific scenario. Figure 3.23 gives an example of a water depth map for a dike breach location on the east side of the Island of Dordrecht.

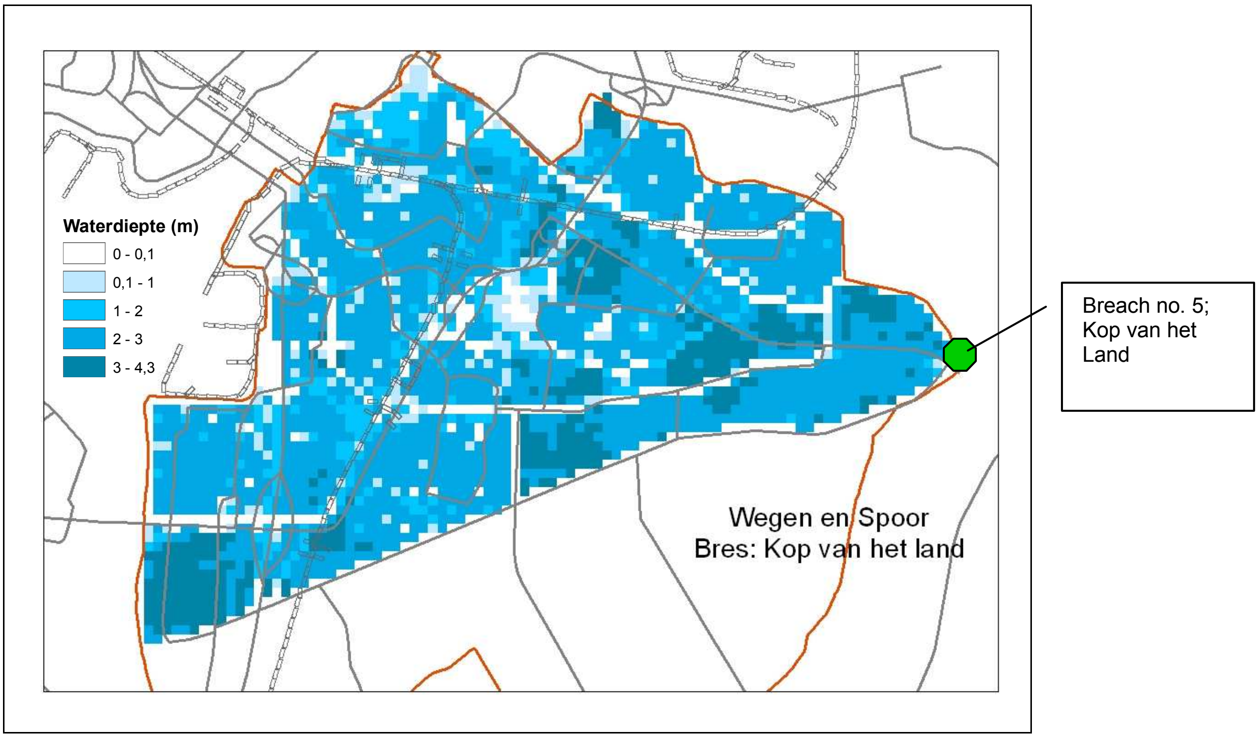


Figure 3.23 Water depth map for breach location no. 5; 'Kop van het Land

HIS-SSM

HIS-SSM stands for 'High Water Information System – Damage and Casualties Module'. The HIS-SSM is used to calculate direct and indirect damages and number of expected casualties for a flood scenario.

Evacuaid

EvacuAid determines through a probabilistic approach the expected value of the number of evacuated people for a certain evacuation strategy. It takes into account sources of uncertainty such as the type of threat (expected versus unexpected), behaviour of people, the chosen evacuation strategy and the effectiveness of use of infrastructure (Kolen et al, 2010). The average percentages of people evacuated for the alternative strategy, was determined using the EvacuAid tool.

RiskTool

The effectiveness of the two strategies is determined by the number of expected casualties and the flood risk to people. The flood risk is determined by the flood probability and the consequence of the flood. RiskTool combines the risks for different flood scenarios and determines the overall flood risk for a dike ring area (Thonus, 2008). It calculates the flood risk, the local risk (individual risk) and the group risk.

Summary of the results

Table3.8 shows the results for the expected annual number of casualties for the evaluated strategies. The alternative strategy using shelters shows a decrease of annual casualties of 66%.

Table 3.8 Expected annual number of casualties (EANC) for the evaluated evacuation strategies

Strategy	Expected annual number of casualties	Reduction of risk of casualties (%)
Current strategy	0.42	-
Alternative strategy	0.14	66

The Local individual risk also improved considerable as is illustrated in Figure 3.24.

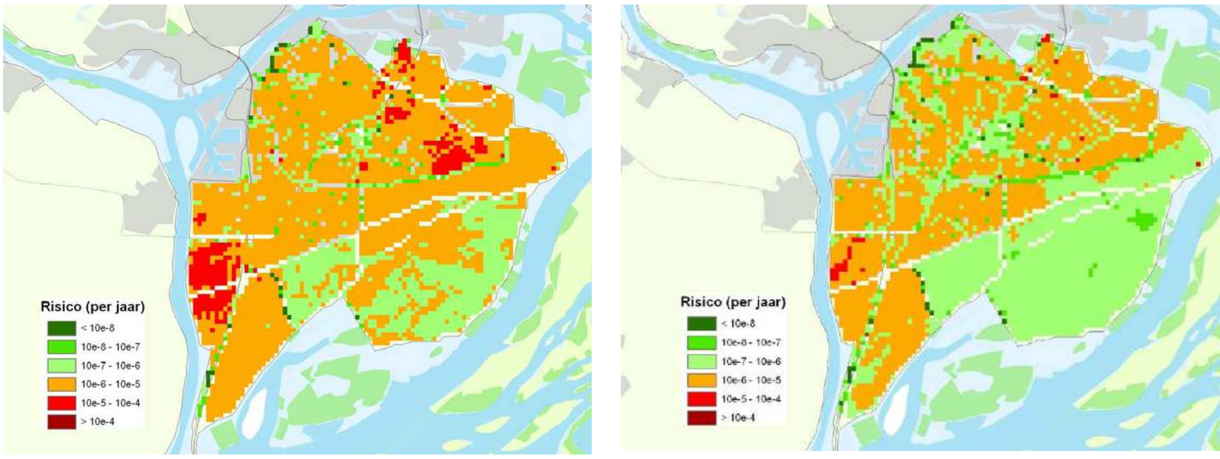


Figure 3.24 Local individual risk for current strategy (left) and alternative strategy

The results show that preparing for floods by assigning shelters can aid in reducing the number of casualties by 66%.

Potential use for improvement of the emergency plans

In recent years the research on evacuation calculation has improved and the tools and new insights can aid emergency planning considerable. The case illustrates the use of tools for evaluating the effectiveness of different evacuation and shelter strategies. These strategies need to be worked out in more detail e.g. by assessing which buildings are feasible to use as an emergency shelter during a flood and by assessing the required capacity of the shelters and resources needed to supply and staff the shelters. In addition evacuation routes to the shelters can be mapped out and evaluated on their accessibility during a flood.

An interview was conducted at the Safety Region to assess the applicability of the case results for improvement of the Regional Flood Emergency Plan. The results were seen as useful, but need to be elaborated further. The risk assessment was performed only for the island of Dordrecht. The emergency plans currently developed by the Safety Region are for the area for which the Safety Region is responsible. This includes a large part of the surrounding areas of the island as well. Similar calculations will therefore need to be performed for the region as a whole.

The alternative strategy is a progressive way of thinking. It is expected that time is needed for people to become accustomed with alternative strategies. The results from the case can act as an example and aid in getting commitment for the application of alternative strategies.

The interview also made clear that the people responsible for the development of the plans, are interested in the results and outcomes from studies and tools, but do not have the knowledge and people available to work with the tools themselves. Access to the results is therefore essential for improving emergency plans, but access to and use of the actual tools will not be required by the

Safety Region. The gap in knowledge and tools availability can be overcome by facilitating information availability e.g. through centralised information storage or by bringing parties together.

As final remark it was noted that for correct use of results and outcomes of tools and studies, the end-user requires knowing which underlying assumptions were made and what the corresponding uncertainty is.

4 Summary of the outcomes of the workshops in England, France and the Netherlands

4.1 Workshop agenda

Each workshop held in the case study area followed approximately the same agenda. The various steps of the FIM FRAME method were introduced to the attendees including the expected outputs and the level of detail of the analysis. The model agenda used in the workshops is shown in Table 4.1.

4.2 Selection of the metrics to be discussed

The first discussion involved looked at the metrics that were developed as part of the research and the scores that the project team assigned to the plans after they had been assessed. In general the discussion and the choice of the metrics to analyse were made in a plenary session. The assessment of the plans using the metrics allowed their weak points to be identified and also provided criteria as to which metrics to focus on.

As part of the workshops possible actions were developed to allow the score of the chosen metric to be improved in the future. The metrics chosen in each workshop in the three countries are given in Table 4.2. These metrics were briefly considered by reviewing the relevant part of the plan (provided in a hand-out) and the given score was discussed. In the Netherlands, the issue of evacuation was seen as important by the stakeholders, whilst in France the attendees favoured issues concerning warning and flood hazard mapping. In England and Wales the metric discussed was “evacuation routes”.

In all the countries, discussion were held regarding what exactly the metrics covered. Before implementing the FIM FRAME method it was important that the stakeholders agreed on coverage of the selected metric. For example in Netherlands, the focus was on the topics related to evacuation for the area of the Island of Dordrecht. The following topics were selected by the attendees for further analysis:

- Evacuation of people in the areas unprotected by flood defences to the areas protected by flood defences;
- Evacuation of people in the areas protected by flood defences to areas outside the island.

Table 4.1 Typical workshop agenda

Time	Item
10:00	Welcome, introduction and scene setting The objectives of this workshop are: • To present an overview of the project and the draft framework • To gain feedback on the framework and possible ways forward • To provide the basis for discussion on emergency planning issues that might lead to potential actions to tackle some of the identified issues
	Background to FIM-FRAME project in general and the framework *Presentation*
	Breakout 1: Appraise. Identify an aspect(s) of the plan on which to concentrate during the workshop *Breakout session*
11:00	Coffee break
	Breakout 2. Tackle, part 1. Describing the identified aspect of the plan (entity diagram) *Breakout session*
	Breakout 3. Tackle, part 2. Identify potential issues (cross table) *Breakout session*
12:30	Lunch
	Enabling guidance and technology to aid emergency planning in UK and Worldwide *Presentation*
	Breakout 4. Tackle, part 3. Identify potential resolving actions: envisaged barriers, use of specific tools and other implementation issues. (action table) *Breakout session*
	Breakout 5. Implement. Drafting a possible implementation plan.(implementation table) *Breakout followed by plenary discussion*
14:15	Coffee break
	Feedback on the framework: identification of 3 good and 3 bad points of the framework and discussion *Individual work followed by plenary discussion*
	Conclusion and next steps Wrap up of the day and presentation of the next steps of the project
15:00	Close

However, the attendees chose not to consider the topic of shelters e.g. the identification of possible shelters within existing locations or the identification of a few large central shelters.

4.3 Breakout sessions and outcomes

Following the selection of the metrics FIM FRAME method was completed via applying the entity diagram and the cross table. The stakeholders experienced some difficulty in applying the entity diagrams. This is discussed later in this report. The final step in the process was to identify the problems that required be to solve in emergency planning regarding the elected metric and the actions and tools to implement to make those improvement. As part of the FIM FRAME method these issues are dealt with as ‘Red Lights’. Attendees were asked to report them in the first column of the “Red Light”\Action table. The attendees were asked to note the “red light” issues that were identified from the cross table onto the action table. The action table was discussed; however, owing to a lack of time not developed further in all the countries. However, there was sufficient time to agree with the stakeholders on what tools were possible to implement to improve the emergency plans that were assessed.

4.4 Gaps identified in the flood emergency plans via the FIM FRAME method

At the conclusion of the workshops, gaps where identified in general in plenary session taking in account the “Red Lights” and action table. The discussion with facilitators brought out the possibility of implementing some tools to fill those gaps. Table 4.2 sums up the gaps identified and the tools proposed as a response in the three countries. Numerous gaps in the plans were identified. Table 4.2 illustrates the main gaps and their associated actions that were identified as part of the workshops.

Table 4.2 Typical workshop agenda

Case study	Gaps identified	Actions and tools to implement
Sheffield	• Gaps in the evacuation process • Dissemination of evacuation message (media, web, door-knocking, signage…) • Places to go (safe havens) and routes to take in case of evacuation	Models addressing evacuation
Dordrecht	• Availability of evacuation routes • Information on demographic numbers; vulnerable groups and to evacuate people • Location of vulnerable people	To test an alternative strategy of sheltering and evacuation using the Evacuaid and RiskTool.
Tarascon	• Lack of flood hazard maps for high frequency floods (3% to 10 % probability floods i.e. discharge < 10500 m^3/s) • Lack of knowledge of potential impacts of extreme events (0.1% floods)	- LIDAR –topographic data - Flood Risk to People model

5 Feedback on the FIM FRAME method and improvements

The chapter deals with how the FIM FRAME method could be improved following the workshops. Improvements to the FIM FRAME method were based on the comments of the attendees collected in plenary session of the workshops and also through a questionnaire distributed to the stakeholders at each workshop. The goal was to help the research team have anonymous feedback on the method developed during the project in order to improve it and to publish a well-tested method in the guidance document.

5.1 Reaction of the attendees to the FIM FRAME framework

The stakeholders who attended the workshops in all three countries indicated that the FIM FRAME method responds to their needs to have a method to assist them to develop new and assess existing emergency plans for floods. The FIM FRAME method provides a method to audit and review plans in an “objective” way. The FIM FRAME method has been applied in different contexts for different types of floods (e.g. coastal, fluvial, flash floods and dam breaks).

The FIM FRAME method was seen by the participants as logical and complete. It ensures that there are no “gaps or omissions between organisations“. In general, there was insufficient time to fully applied the method during a one day workshop e.g. to fill completely the action table and the implementation table. Nevertheless the facilitators intended to focus and developed the implementation on some actions related to the metrics. The following points summarises the findings of the works:

(i) Metrics

The metrics were seen as a good instrument to assess flood emergency plans objectively. In addition the attendees noted that the metrics could be used as a checklist to assess the completeness of the plans. The list of metric has been disseminated through a paper (Lumbroso et al, 2011) and via a number of workshops and conferences. Organisations such as the police and fire brigade who are in charge with emergency planning in the three countries asked for a list of the metrics The list has been disseminated to help organisations evaluate local emergency plans. The list of metrics can be adapted according to the plan that is being evaluated and the local situation. An attendee at the Dordrecht workshop suggests that each country should have an agreement on a list of the metrics to be considered for evaluating and developing flood emergency plans.

(ii) Entity diagrams

The entity diagram proved to be a useful tool to brainstorm and to conceptualization ideas. The entity diagram provides a very “visual“ representation that the stakeholders found useful. However, some attendees preferred the cross-table owing to the “spaghetti” design of the entity diagram. Some stakeholders pointed out the entity diagram appeared to be rather academic. It also was noted in the three countries that this step was time-consuming. A familiarity with the development of the entity diagram means that after applying it several times process becomes more efficient. It is found that it was important to explain and to illustrate the entity diagram with examples and cases studies showing how to construct it.

(iii) Cross tables

The cross-table gave a good overview of issues and provided a method to further develop a topic. The cross-table brings out a collective vision and facilitates the translation of the entity diagram into processes, "potential errors" and eventually gaps. The cross-table is an important step to convert the process to assess the gaps in a plan. The participants at the workshops found this step easier to implement and to understand than entity diagram.

5.2 Facilitators feedback on the application of the FIM FRAME method

The facilitators noted that the framework had been welcomed and quickly appropriated by the stakeholders who attended the workshops. It was interesting to note that the attendees at the workshops did not contest the scoring of the plans, assuming that there was a real need for updating or enhancing them. The following issues were noted by the facilitators of the workshop.

(i) The choice of metric to discuss

Facilitators noted that is important to orientate the discussion and the choice of the metrics to assess during the workshops. There was a question related to the degree of freedom the facilitators let the discussion follow. Generally it was agreed that it was important to discuss the metrics with the lowest scores in order to establish how the emergency plans could be improved.

(ii) The use of the FIM FRAME method to develop a new emergency plan for floods

The framework was used to assess existing flood emergency plans. The workshops held in the three countries did not apply the framework to develop a new plan. It is therefore recommended that in future when stakeholders are developing a new emergency plan for floods that they apply the FIM FRAME method.

(iii) The duration of the workshops required to apply the FIM FRAME framework

The objective and the strength of the framework are to identify shortcomings within an emergency plan which can be tackled with use of available tools and information. In the workshop, the framework provided an excellent method to identify these shortcomings. However, it does take some skill and time to identify these gaps. It is important to encourage the participants to think "out-of-the-box" and in terms of "the ideal situation". This tendency of the stakeholders can be summarised by the following sentence find in an attendees questionnaire in England: *"It is something that can be adopted by those new to the field in the development of new plans or within the first review they do, but those who have been doing this for a while usually know where their gaps are".* Facilitators noted that in Netherlands and France owing to a lack of time, it was sometimes difficult to implement the "implement" stage. The action table takes time to implement as there are many issues to address and actions to tackle. It thus could be recommended to separate the workshops into two days in order to dedicate one day to assessing the plan and one to identifying the gaps and one day to establishing solutions and to drawing up an implementation plan of measures to enhance the plan.

(iv) Focusing on the flood emergency plan

Facilitators noted that it was easier for attendees to refer to an particular situations that they were familiar with. Stakeholders tended to focus and assess details that they were familiar with rather than concentrating on the plan itself. It is important that the facilitators of the workshop focus the discussion on the plan.

5.3 Differences between the three countries

The FIM FRAME method was implemented successfully in the England, France and the Netherlands there were some difference in how the method was applied. Those differences are summarised below.

(i) List of metrics

The list of the metrics needs to be adapted to the particular needs of each country. For instance, in the Netherlands the metric "details of previous floods" was not seen as being relevant because the country is well defended and there have been no significant floods in the country since 1953. For the Dutch evacuation was a key question and may merit more than two metrics. An attendee in Dutch Workshop suggested that in each country there is an agreement on the list of metrics to be adopted for developing and assessing emergency plans for floods.

(ii) Type of flood

In the three countries the FIM FRAME method was piloted in areas where there are a wide range of different floods i.e. fluvial, coastal, flash, surface water and dam break. It was found that the FIM FRAME method was not limited by the type of flood.

(iii) Involvement of national level stakeholders

In both France and in Netherlands there was a lack of involvement in the research by the relevant national level organisations. In England and Wales the Environment Agency appeared to be more engaged with the development of the method. The reasons for this are partly to do with the spatial scale at which the plans are applied in the three countries and the institutional/organisational set up. In all three countries local authorities are generally responsible for the development of emergency plans for floods. The following is often the case with these organisations:

- They often have no financial means to implement tools to improve emergency plans
- There is some times political oppositions to the dissemination of the outcomes of tools (e.g. such as potential loss of life, risks to buildings)

(iv) Spatial scale of emergency plans

In France there are approximately 36,700 communes of which some 10,000 have to produce emergency plans to cover the natural hazards that occur in their communes. In France the lack of an overview of the regional flood risk can be problematic for developing an effective emergency plan. For example in France the flooding of the Rhone valley would hit more than 30 communes. However, there is no coordination of the crisis management at the upper level of the low Rhone valley. The spatial extent of emergency plans in France means that it may be better apply the FIM FRAME method at a river basin scale by producing one emergency plan for an agglomeration of communes.

(v) Workshop participants

The participants at the FIM FRAME workshop determined, to a certain degree, the success of the application of the FIM FRAME method. In England and the Netherlands, the people who attended the workshops were professionals and specialists with a strong involvement in flood emergency management. In France the workshops brought together specialists and policy makers local authority staff whose core competencies are not in emergency planning and who are mobilised only in case of crisis. For participants such as mayors or authorities, flood emergency planning is just one problem amongst many others. In France it was felt that the FIM FRAME method would be best used by the fire service who are the main point of contact for the technical aspects of emergencies and .

In Netherlands, people who attended the two workshops were emergency management professionals. They worked for the police, fire department and municipality and are representatives for their organisation within the Safety Region. They were involved in the development of the flood emergency management plan for their region. That explains why the level of technical discussion and the comprehension of the framework seemed to be higher in Netherlands than in France.

(vi) The application of tools

The flooding is a national concern in the Netherlands especially ongoing sea level rise. Many of the tools that were investigated as part of the research are very useful for the project. In France, the application of the FIM FRAME method to local emergency plans was found to be useful as as the plans assessed (i.e. the Plans Communaux de Sauvegarde (PCSs)) are a relatively new legal requirement. However, PCSs are in general multi-risk plans looking at a range of hazards. In this respect there are some tools that were found to be more useful than others.

5.4 Improvements to the FIM FRAME method

The stakeholders who attended the workshop and the facilitators recommended improving the framework as follows:

- To define the level of detail of the discussion in advance of any workshop
- To list the processes linked to the chosen metric analysed at the workshop in advance of the workshop.
- To make the entity diagrams more simple and more efficient
- To use actual case studies and concrete examples in the workshop
- To put more emphasis on “improving” flood emergency management plans through the better use of available tools and information
- To distinguish between and making the step from “analysing an actual crisis situation” to “defining what needs to be done to improve the plan”.

6 Conclusions

This report describes the implementation of the FIM FRAME Method in the case studies in England, France and the Netherlands. In total seven workshops were held three in England, two in the Netherlands and two in France between July 2010 and April 2011. The application of the FIM FRAME method and is described in the guidance document that has been produced as part of this research.

The workshops in the three countries showed that there was a demand for simple method to appraise and improve emergency plans as well as to develop new plans. The main conclusions reached by the case studies were as follows:

- There is a demand amongst emergency planners for a simple method to assess existing flood emergency plans as the number of such plans is
- The FIM FRAME method was found by the attendees of the workshops to be a good method to assess their emergency plans.
- The FIM FRAME method helps to facilitate discussions between stakeholders, policy makers and emergency planners. It can bring out both existing problems as well as those that are sometimes ignored
- The workshops allowed gaps in plans to be identified and tools that could help “fill” these the gaps to be identified

The list of the metrics was found to be a good “checklist” with which to assess emergency plans for floods. This list has already been disseminated through papers and applied in a number of other case studies. The workshops often lasted a whole day (i.e. between six and eight hours) in order to complete all the steps contained in the FIM FRAME method.

Problems associated with the implementation of the FIM FRAME method were identified and addressed via the workshops. Issues with the FIM FRAME method were found to be the following:

- Definition of the aim of the method at the workshops - It was found that it was important to explain fully the method before commencing the workshop
- The discussion needed to be adapted depending on the type of stakeholders who attended the workshops
- There was often found to be insufficient time to complete the last steps of the FIM FRAME method (i.e. the implementation table and potential actions)

The FIM FRAME method was applied successfully to different kinds of floods (e.g. dams and dike failures, fluvial flooding, surface water flooding and flash floods) and different kinds of plans (i.e. local and regional level plans) In terms of future work it would be interesting to address the following questions:

- How can the FIM FRAME method be adapted so that it can be applied to multi-risk plans and or to other types of risk (e.g. natural or technological hazards)?
- The possibility of developing a more concise and simpler version of the FIM FRAME method for use by small local authorities covering relatively small areas where resources are limited.

The final aim of the FIM FRAME method is to identify the gaps in emergency plans and to provide stakeholders methods via which the gaps can be filled by using tools (e.g. checklists, guidance documents, technical method and software). In all three countries the outputs of the tools were welcomed by the emergency planners and the research showed that they matched to existing needs. The case studies also allowed extreme scenarios that had never been looked at to be considered in terms of the emergency plan. Tools to estimate the risks to people posed by floods have been used in the three countries either to test directly the potential consequences of different scenarios in terms of mortality rates or to test the effectiveness of different evacuation strategies.

It was found that there were some differences between the three countries. The implementation of the FIM FRAME method and tools should take into account the cultural and political features of each country. For example in some case studies ther was some reluctance to disseminate the results of some of the modelling of flood impacts unless emergency planners and policy makers agreed with the outputs of the models. It was noted that policy makers often hesitate to publish the results of the application of tools as this can trigger questions or cause anxiety amongst the population at risk. The dissemination of potential loss of life caused by extreme flood events can worry authorities because it can raise questions such as: What can we do? And how can the search and rescue practices be improved?

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Acknowledgments

We would like to acknowledge the support of the Royal Academy of Engineers (RAEng) who provided a Global Research award to Darren Lumbroso to assist him in undertaking some of this work whilst on a secondment at Laboratoire Cenrtral des Ponts et Chaussées. We wish to extend our thanks to the RAEng for their support. We would also like to acknowledge the main funders of the research who included: Department for Environment, Food and Rural Affairs (Defra)/Environment Agency Flood And Coastal Erosion Risk Management (FCERM) Research and Development Programme, England and Wales, Ministère de l'Ecologie, de l'Energie, du Développement durable et de la Mer, en charge des Technologies vertes et des Négociations sur le climat (MEEDDM), France and HR Wallingford Ltd.

Piolenc, France

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: The last major floods occurred in 1993/1994 (both on the Rhône and tributaries) and in September 2002 (flash floods) and in 2003 on the Rhône river and tributaries
Environmental setting: Piolenc is prone to the flash floods from the Rieu de Foyro and the Aygues as well as fluvial flooding of the Rhône River. The Rhone River floods are slow rising flood but they spread over a large low plain and can trigger significant damage especially relating to industrial and nuclear plants. The Aygues and Rieu du Foyro trigger flash floods in the autumn.

Flood of sept 2002 in the centre of Piolenc

Level of stakeholder involvement

- Municipality authority involved in the preparation and the participation in a December 2010 workshop
- Fire services at local and Départemental levels participated in the workshop

CRUE Activities

The flood emergency plan for the Pilonec commune had the worst score using the developed metrics of all the plans that were evaluated as part of the research in France. This plan provided a good opportunity to test the framework that was developed as part of the project and to use it for enhancing the emergency plan. A workshop was held with stakeholders in December 2010. Ways in which the current flood emergency plan can be improved have been agreed by the stakeholders. One of these measures was the setting up of a flood warning system in the commune. However, the existing data coupled with financial meant that the commune was not in a position to implement all the measures that were identified as part of the workshop.

Specific outcomes

- Case study reports have been disseminated to all the stakeholders.
- A warning system is about to be set up on the Rieu de Foyro basin.

Lessons learnt

The workshop used the framework developed as part of the research was useful. It highlighted the shortcomings and "bottlenecks" relating to emergency management in the commune when it faces a large event. The debate created by the stakeholders is likely to be useful in many other communes where the emergency plan for floods comprises a paper report that has been put together to meet legal or regulatory requirements but is not necessarily "operational efficiency".

CRUE Project

Flood Incident Management – A Framework for improvement (FIM FRAME) Funded from 1 September 2009 to 31 August 2011 within the 2nd CRUE Funding initiative "Flood resilient Communities".

Partners

HR Wallingford, England

Laboratoire Central des Ponts et Chaussées, France

University of Montpellier III, France

Deltares, The Netherlands

Funders

Department for Environment, Food and Rural Affairs/Environment Agency, England and Wales

Ministère de l'Ecologie, de l'Energie, du Développement Durable et de la Mer, France

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Project website: www.fimframe.net

Integrate, Consolidate and Disseminate

European Flood Risk Management Research

Tarascon, France

Main characteristics

Major type of flood: Fluvial and flash floods
Size of catchment area: 90,000 km²
Past flood events: Tarascon suffered from severe floods in December 2003 that affected a major part of its territory.
Environmental setting: Tarascon is located in the floodplains of the Rhone but is protected by flood defences. The dikes have failed in the past leading to flooding.

Socio-economic setting: Tarascon is a town in the south of France with a population of 14,000 people. Many industrial plants have been built in the floodplains. In spite of the flood hazard, the municipality wants to attract new inhabitants to this area.

Tarascon during the 2003 floods.

Level of stakeholder involvement

- Municipality of Tarascon: The municipality participated in a workshop hold in January 2011. They hosted a researcher from March to June 2011
- Fire services: They participated in the workshop held in January 2011. The fire services have been closely linked with the research. The researcher seconded to the municipality has assisted the fire service in drawing up flood maps for emergency planning management and to look at other flood scenarios including previous historical events.

CRUE Activities

- The city of Tarascon was identified because it has a well established flood emergency planning. The work carried out with the municipality and local firemen service 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 using local available data. Currently, stakeholders base their response to emergencies on previous floods events. 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.

Specific outcomes

- The research helped to improve the flood maps used in emergency plans for Tarascon.
- A training exercise on crisis management in Tarascon was carried out in January 2011

Lessons learnt

The application of the developed framework under the FIM FRAME project has led to an improved dialogue between stakeholders at a local level. The assessment of the plan using the developed metrics and framework shows that local emergency planners are too confident in their knowledge of the flood characteristics. They are often reliant on their knowledge of previous floods without addressing other scenarios.

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Integrate, Consolidate
and Disseminate
European Flood Risk

City of Sheffield, England and Wales

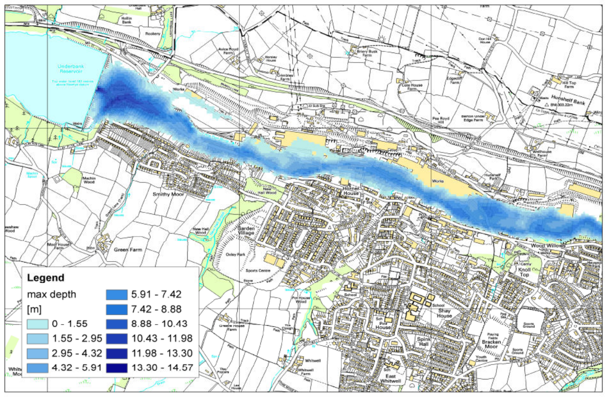
Main characteristics

Major type of flood: Surface water floods and dam failure

Past flood events: In 1864 collapse of the Dale Dyke Dam killed 270 people in Sheffield. In 2007 there was extensive flooding from the River Don and pluvial sources.

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 is has a population of approximately 547,000.



Simulated flood depths for the dam breach

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 were engaged with via a number of meetings and workshops.

CRUE Activities

The framework to assist with developing and improving flood emergency plans was applied to the Multi-Agency Flood Plan that had been developed for Sheffield in conjunction with the key stakeholders. The MAFP was scored using the metrics that were developed as part of the plan. The case study was used to refine the framework. As part of the case study a breach scenario was created for reservoir in the area. This helped raise awareness of the use of tools to improve emergency plans.

Specific outcomes

- Development and improvement of a framework to help improve emergency plans of floods
- Demonstration of tools that can improve emergency plans

Lessons learnt

The framework was implemented and improved via a number of workshops and found to be a useful tool to assist with the development and improvement of emergency plans for floods.

CRUE Project

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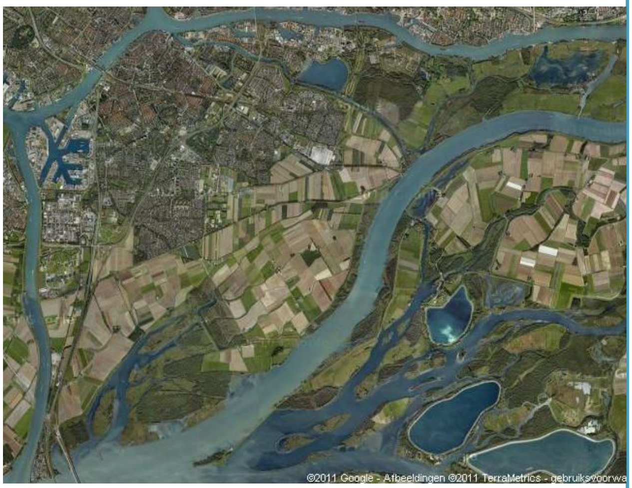
The city of Dordrecht, The Netherlands

Main characteristics

Major type of flood: Flooding is caused by a combination of high river discharges and sea levels
Past flood events: The 1 February 1953 flood killed approximately 1,800 people in the South-West of the Netherlands
Environmental setting: The city of Dordrecht is located on an island in the Rhine estuary. The Island of Dordrecht lies in the Rhine catchment (185.000 km^2). The Island has an area of 90 km²
Socio-economic setting: Dordrecht is a city in the Dutch province of South Holland, the Netherlands. It has approximately 118,000 inhabitants.



Level of stakeholder involvement

Stakeholders make up the Safety Region who were involved in the development of the Flood Event Management Plan. The following were engaged as part of the case study:

- City of Dordrecht
- Province of South Holland
- Police
- Fire brigade
- Water Board Hollandse Delta
- These were engaged through an internet survey and a workshop.

CRUE Activities

Breaching of the dike protecting the Island of Dordrecht would cause a rapid flood with significant water depths. Owing to the limited number of exit points from the Island, risks of casualties are high in the event of a flood. The framework to assist with developing and improving flood emergency plans was applied to the Flood Emergency Plan for the Island of Dordrecht. The focus was on the improvement of the evacuation strategy of the plan. Results from the workshop were used to improve the framework. In addition the evaluation of alternative evacuation strategies demonstrate the use of evacuation tools as a useful source to improve emergency plans.

Specific outcomes

- Report on the results from the workshop
- Case study report including demonstration of tools that can improve emergency plans

Lessons learnt

The framework proved to be a useful aid in analysing flood emergency plans and identifying actions to improve the plans.

CRUE Project

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