



FIM FRAME: a method for assessing and improving emergency plans for floods

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Abstract. Over the past decade Europe has been hit by a number of severe flood events. Reviews of recent large flood events in England and France have indicated that there is room for improvement in the emergency planning for floods. Methods that can be used for the systematic assessment and improvement of emergency plans are extensively documented in readily available literature. However, those that do exist are often limited to appraising the content of the plans rather than the process that the plan should guide. This paper describes research to develop a systematic method for assessing and improving emergency plans, which is called the FIM FRAME method. The development of the method was informed by research carried out with stakeholders in France, the Netherlands and England, as well as an appraisal of available tools that can be used to develop and improve plans, and an analysis of a selection of flood emergency plans from the three countries. One of the fundamental requirements of the FIM FRAME method was that it should be able to be applied by the relevant stakeholders to a range of emergency plans that mainly focus on flooding. The method comprises a series of steps (known as Appraise, Tackle and Implement) that can assist stakeholders with assessing and improving emergency plans. The method was piloted in the three countries and then refined following feedback from end users. This paper describes the development of the FIM FRAME method and its application in three case studies affected by different types of floods.

1 Introduction

Post-event reviews of floods affecting Europe in the last decade have underlined the importance of advanced planning for emergencies, as well as the inadequacy of existing emergency response planning. In England and Wales widespread flooding that occurred between June and July 2007 caused the UK's "largest peacetime emergency since World War II" (Pitt, 2008). This event acted as a catalyst for the British government to commission an independent review of the response to this event. Amongst its conclusions the review found that the emergency response plans for floods in England and Wales needed more information and a better understanding of the hazard, and the possible consequences; it recommended improving emergency planning with better information sharing and engagement (Pitt, 2008).

France has also recently been affected by some severe floods. On 28 February 2010 a storm, known as "tempête" Xynthia, hit the French Atlantic coast, claiming the lives of 41 people (Lumbroso and Vinet, 2011). On 15 June 2010 extreme flash floods in the Var Department in the south-east of France resulted in 26 fatalities (Vinet et al., 2012). A report by the French Ministère de l'Écologie, du Développement Durable et de la Mer (MEEDDM) following these events indicated that emergency planning for the floods was not "fit for purpose" and should be improved (MEEDDM, 2011).

The Netherlands has historically focussed on structural measures to prevent flooding, primarily through the

development of flood defences such as coastal levees, dikes and tidal barrages. However, a recent study aiming to evaluate Dutch flood risk management policies revealed the unpreparedness of the Netherlands to events resulting from the failure of such infrastructure that would result in extensive flooding (Ten Brinke et al., 2008). The reports by Pitt (2008) and MEEDDM (2011) and a Dutch review (Ten Brinke et al., 2010) show the need and importance of improving emergency planning for floods in the three countries.

This research was carried out within the second ERA-NET CRUE funding initiative as part of the effort for improving flood emergency planning. The objective of the research was to develop a method to evaluate and improve flood emergency plans. This research was undertaken by a team, comprising partners from England, France and the Netherlands. This paper presents the final outcome of this research, comprising a method for assessing and improving emergency plans for floods, known as the FIM FRAME method. This FIM FRAME method was developed through

- an analysis of existing methods and tools for developing and assessing emergency plans,
- extensive consultation and research with emergency planners and responders,
- examination of current emergency plans for floods in the three countries.

These steps led to the development of the first draft method, which was further developed in consultation with stakeholders through a number of workshops. The feedback from these was then used to update the method. The scope of this research was not to develop recommendations or guidelines for emergency planning, but instead to provide the emergency planners with a tool to help them assess and improve their plans themselves.

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

This section of the paper provides a brief background of emergency plans for floods in the three countries. There is generally a “hierarchy” of emergency planning in each country. In England and Wales issues such as evacuation and humanitarian assistance are generally covered by generic plans. These plans are then referenced by Multi-Agency Flood Plans (MAFP), which include specific information on flooding. In England and Wales MAFPs are produced by the Local Resilience Forum. There are some 43 Local Resilience Forums covering England and Wales, based on police areas, which consider the flood risk across the whole area for which it is responsible.

France is made up of 100 départements that are grouped into 22 metropolitan and four overseas regions. These départements are further divided into 36 700 communes,

governed by municipal councils, which are the lowest level of administrative division in France. The mayor of the commune is legally accountable for the security of the citizens and the organisation of rescue operations. When an emergency extends over more than one commune or its consequences are too important to be managed by local rescue services, the first départemental state officer (préfet) takes charge of the emergency and a départemental operational centre is activated. At a communal level mayors have a responsibility to produce a plan communal de sauvegarde (PCS) (a local emergency management plan); these were created to help communes carry out local-scale emergency planning. Not all communes have to produce PCSs. PCSs are a legal obligation for communes where an approved risk prevention plan exists. It is estimated that approximately 5000 communes in France have already started or completed their PCSs, and that approximately 10 000 PCSs will be required in total. Given that more than 40 % of the 36 500 French communes are affected by floods and flooding is responsible for 80 % of the damage attributable to French natural disasters (Pottier et al., 2005), floods generally form the central focus of the PCS.

In the Netherlands safety is legally defined as a local responsibility with the main responsibility of preparing for flooding being taken by municipalities. This is regulated by the 2004 act “Improvements in the emergency management” (Wet Kwaliteitsbevordering Rampenbestrijding, (WKR)), Eerste Kamer der Staten-Generaal (2004). In 2006/2007 a government bill entitled the “Safety Region Bill” was submitted for the establishment of the 25 “safety regions”. The majority of these safety regions are at risk of floods and in 2010 they commenced with the production of emergency plans for floods.

3 Existing methods for developing and assessing emergency plans

The three countries in which this study was focussed have all recently implemented legislation requiring the development of emergency plans for flooding. An act of parliament approved in 2004 resulted in the formulation of specific emergency plans for flooding in England and Wales (Civil Contingency Act, 2004); whilst in the Netherlands a similar act prescribed the inclusion of flooding in the generic local emergency plans (Wet Kwaliteitsbevordering Rampenbestrijding, 2004). In France, an act passed in 2005 (Décret 1156, 2005), resulted in the production of the above mentioned local level emergency plans, the Plans Communal de Sauvegarde, including flooding.

In the three countries readily available methods to assess and quality-check the plans generally comprise only of guidelines for their development, except for England and Wales, where a checklist for assessing multi-agency flood plans has been developed and applied (Environment Agency

et al., 2010; Environment Agency, 2011a). Consultations carried out as part of research, the results of which are published in Lumbroso and Vinet (2012), showed that most of the emergency planners and responders were not aware of the specific tools for assessing and developing emergency plans, other than their national guidelines. It is also important to note that an extensive review of the existing flood emergency management plans developed by the three countries (Lumbroso et al., 2011) showed a general lack of homogeneity among the plans, not only between countries, but also among plans from the same country. This can act as a barrier for developing methods to assess and improve the plans that are applicable to different plans, covering different spatial extents (e.g. local, regional, national) and different types of floods.

Various guidelines for emergency planning have been developed worldwide including: US Federal Emergency Management Agency (FEMA) Reports 101 and 502 (FEMA, 2010a, b); New Zealand Ministry of Civil Defence and Emergency Management guidelines BPG1/03 (MCDEM, 2003); Emergency Management Australia (EMA), Manuals 43 (EMA, 2004); the “Augustus Method” (Galanti, 1995) adopted by the Italian Civil Protection Agency; and the Irish Guidance Documents 11 and 6 (MEM, 2011a, b), part of the National Framework from Managing Emergencies. Where they are included, the recommended methods for the assessment of the plans include checklists, post-event reviews, and exercises. However, many of these guidelines do not provide a systematic method both to evaluate *and* improve emergency management plans for floods.

Many researchers have proposed methods to evaluate plans through the assessment of their content by proposing criteria (Alexander, 2005), with an assessment of requirements (Lindell and Perry, 1980; Lindell and Perry, 2003), and with the development of indicators against which the plan can be scored (Olonilua and Ibitayo, 2011). All these methods focus on concepts, and consist of assessing whether specific features, procedures and protocols are included in the plans. However, the presence of such features, procedures and protocols does not imply that these are actually properly defined and effective.

Baer (1997) and Brody (2003) looked at the “outcomes” as indicators for assessing the plans, meaning carrying out a post-event appraisal and assessing the effectiveness of the plan based on its application during an emergency. Post-event reassessments of the plan are widely recognised by practitioners as being highly effective. However, the ever-evolving emergency management structure and the necessity of constantly assessing and updating the plans (Lindell and Perry, 2003) make this method alone insufficient to be applied in areas affected by infrequent events. This is particularly true for extreme floods that occur infrequently (e.g. once every 30 yr).

Alexander (2009) and Heath (1998) are among others who stress the importance of testing plans through field and tabletop exercises, as well as developing scenarios to include in

the plans. The importance of exercising the plans is fully recognised by many guidelines. However, exercises can be expensive. A recent large-scale flood exercise recently carried out in England and Wales, called Exercise Watermark, is estimated to have cost approximately £1.8 million (Environment Agency, 2011b). Furthermore, the effectiveness of emergency scenarios strictly depends on the quality and comprehensiveness of the scenarios that are used.

Some authors also underline the importance of assessing plans in their general context, i.e. evaluating a plan’s success in relation to the preparedness levels measured through socio-economic indicators (Kirshenbaum, 2002), or evaluating the plan through the lens of its acknowledgement among the community (Brody, 2003), assessing the actual coordination and communication among the organisations involved in planning and responding (Crews, 2001), and taking into account the main drivers and impediments, such as policies and resources (Alexander, 2009).

Each of the methods proposed in literature presents positive aspects. However, each of these methods, if applied on its own, presents some limitations. Checklists and conceptual evaluations have an advantage of being easy to apply and “rigorous” (although they are still subject to bias, owing to the possible subjectivity of the evaluator). On the other hand, such methods do not evaluate the process itself included in the plans; furthermore, they imply that a review can be carried out, in many cases, by one person. This does not provide a platform for discussion and engagement, which is one of the most beneficial aspects of the planning. Alexander (2009) noted that the importance of the plan mostly lies in the planning process rather than in the plan itself. Some of these methods and recommendations also appear rather theoretical, and are not translated into practical guidelines or do not provide an indication on how to use their outcomes to improve the plans in practice.

The consultation carried out as part of this research with emergency planners supported these conclusions. The effectiveness of a conceptual evaluation was recognised to be strongly dependent on the parameters used for the evaluation. For example, the MAFP checklist used in England was considered too prescriptive and detailed by some of the emergency planners consulted, whilst others considered it to be incomplete. However, a large majority of the stakeholders consulted agreed on the usefulness of having some metrics with which to judge a plan, because they considered them simple to apply. Another point that clearly emerged from the face-to-face consultations and workshops was the need for the plan to be assessed by the same planners who developed and have to implement the plan, a view shared by Baer (1997). The importance of exercising the plans was also underlined by the stakeholders during the consultations, as a means for testing the operability of the plan and also as a basis for discussion, ensuring ownership of the plan and enhancing the capability of the emergency responders to communicate and work as a team, especially in a context of a multi-agency

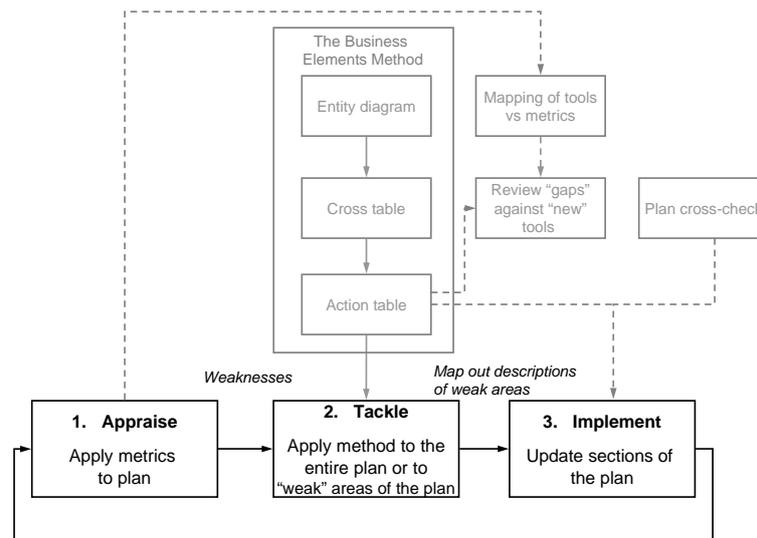


Fig. 1. Diagram of the FIM FRAME method.

response. Another aspect that emerged strongly from the research and the consultations is the lack of resources, which seems to be a common concern of emergency planners in the three countries.

4 Development of the FIM FRAME method to enable stakeholders to improve emergency plans for floods

The analysis described above provides an outline of the requirements that are needed to develop a method to help assess and improve emergency plans systematically. The key requirements are summarised below:

1. the ability to quickly assess the content and quality of a plan, which is simple and easily auditable;
2. the requirement for the method to be applicable by the stakeholders to assess their own plans;
3. the ability of the method to be applicable to different plans at different scales that are adapted to different needs;
4. the need for the method to effectively tackle the issues of the plans and to produce tangible outcomes, in the form of an actual enhancement of the plan.

As a result of these requirements, the FIM FRAME method was designed to include: a quick assessment phase; a more detailed analysis; and an implementation phase. It aimed to be simple, to be applicable without specific training by any emergency management team, to use very few resources; and to be adaptable by the user for their specific purposes. The FIM FRAME method was structured in three steps:

1. *Appraise* – applying the metrics to “flag up” general issues. This part was introduced to respond to the need for a quick and simple assessment and to take into account the possible issue of limited resources, thus identifying the aspects of the plan that need to be analysed in the most detail.
2. *Tackle* – structuring/de-structuring the process and identifying specific issues. This part was introduced to provide an effective in-depth assessment of the critical points, by means of a rigorous method to define and understand specific issues. This step also provides a platform for discussion to the stakeholders
3. *Implement* – taking actions forward and updating the plan. This part aims to ensure that the results of the first two steps are translated into actions and consequently into tangible outcomes.

Figure 1 shows a diagram of the developed framework.

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

4.1 Step 1 – “Appraise”: apply metrics to identify general issues or weaknesses

To appraise emergency plans for floods, 22 metrics were developed. The development of these is described in Lumbroso et al. (2011). It is important to note that these metrics were

developed specifically to look at emergency plans for flooding, whether these are separate plans (like the case of England and Wales) or included in generic plans (as is the case for France and the Netherlands). In developing these metrics, emergency managers, responders and experts in emergency planning were consulted to identify the various pieces of information that are considered fundamental for an emergency plan. These metrics, with the relative criteria for assigning the scores, are listed in Table 1.

To apply these metrics, an approach commonly used in literature (for example Alexander, 2003; Olonilua and Ibitayo, 2011) was adopted, i.e. the metrics were used to “score” the plan in a quantitative manner, according to the level of detail of each of the metrics. If a metric is not covered in an emergency plan for a flood but is included and covered in sufficient detail in a clearly referenced, complementary plan, then the metric would be “scored” as having a high level of detail. This appraisal achieves a rapid, initial understanding of how the plan is likely to perform and what the main obvious weaknesses of the plan are.

4.2 Step 2 – “Tackle”: structuring/de-structuring the process to identify specific issues

The following stage (“Tackle”) is designed to provide a thorough analysis of the plan (or a part of the plan) to analyse processes, identify specific issues by going beyond a simple content check, and understand their causes and implications. As no existing method has been specifically developed for emergency plans, research was carried out as to how processes are assessed in other disciplines.

After discussion with experts in process assessment, we selected a method used to assess information flow systems, the Business Elements Method (BEM). This method is a tried and tested guide for analysing any process (or event), developed by Mayon-White and Dyer (1997) to be applied to information flow systems, to assess data structures, information flow and process consistency and completeness. It was designed to look at information databases, but since then it has been applied to other processes, including enhancing the use of data for coastal management (Millard and Sayers, 2000) and as a framework for assessing and managing flood risk assessments for new developments in England and Wales (Udale-Clarke et al., 2005). This type of method enables all of the actors and actions involved in a system to be mapped and thereby to develop comprehensive and optimal procedures.

This BEM consists of examining a system in terms of five factors:

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

- Tools
- Audit

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

This step can be performed for the whole plan or just for particular aspects (e.g. for metrics that obtained a low score in the “Appraise” step). The “Tackle” step aims to go through specific processes (or components of the plan) and expand them into their constituent “items or entities”, each of these being analysed both individually and in combination with the other items they are linked to.

This analysis is based on an interpretation of the five factors of the Business Elements Method that have been adapted to comprise the following sub-steps.

4.2.1 Describe the process – the Entity diagram

The first sub-step consists of developing an entity diagram for the entire emergency process or for only a particular aspect of the process (e.g. evacuation 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 made up of 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, 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? (i.e. what is the process and who is responsible for the process?)
- What does this entity provide? (i.e. what information is produced?)
- Who does it inform? (i.e. who receives the information and who is responsible for passing this information?)
- Who makes sure that this is done? (i.e. who audits the process?)
- How this is done? (i.e. which tools are used/needed to produce the information or perform the process?)

Table 1. Diagram of the FIM FRAME method.

Metric	Level of detail		
	Low	Medium	High
Objectives, assumptions and target audience			
Aims and objectives of plan	Not detailed	Aims and objectives included but could be clarified further	Clearly stated aims and objectives including the area covered, types and sources of flooding
Target audience and updating of the plan	Not detailed	Audience defined and plan dated	Audience defined and how they will be notified of updates and modifications to the plan included
Assumptions made by the plan	Not detailed	Covers some aspects	Covers all aspects including flood warning lead time, method by which rescue will be undertaken, implications of the failure of critical infrastructure
Organisation and responsibilities			
Actions, roles and responsibilities	Not detailed	Brief details of the roles and responsibilities related to the activation of the plan provided	Details of the roles and responsibilities related to the activation of the plan provided including health and safety and environmental considerations
Recovery	Not detailed	Brief details of how the recovery is managed	Details of how the recovery is managed including clean up, waste disposal, repairs to public assets, humanitarian assistance
Training and exercises	Not detailed	Brief details of training and exercise requirements	Internal and external (with other organisations) training and exercises outlined
Plan activation	Not detailed	Brief description of the thresholds or levels used to activate plan	Description of the thresholds or levels used to activate plan together with flow chart
Communication			
Communication with other agencies	Not detailed	Outlined in words	Detailed and the links shown diagrammatically
Communication with the public	Not detailed	Outlined in words	Detailed and shown the links shown diagrammatically
Management of the media	Not detailed	Outline media management strategy in place	Well defined media management strategy in place
Flood warning (if available)	Undefined	Levels of flood warning with details of the areas flooded at each level	Levels of flood warning with details of the areas flooded at each level and shown on a map
Relationship with other emergency plans	Not detailed	Outlined in words	Detailed and the links shown diagrammatically
Evacuation			
Evacuation routes	Not detailed	Evacuation routes shown on a map	Evacuation routes detailed together with roads likely to be closed and their accessibility for emergency vehicles and other vehicles
Shelters/Safe havens	Not detailed	Safe havens/shelters shown on a map	Safe havens/shelters shown on a map with their capacity and facilities
Flood hazard			
Flood hazard map	Not detailed	Flood hazard map(s) showing extent	Flood hazard map(s) showing water depth and velocity
Details of previous floods (if available)	Not detailed	Brief description of historical flood	Description of historical floods with the cause and a brief description of the risk in terms of people and properties affected
Flood risk to receptors			
Flood risk to people	Not detailed	Number of people potentially affected included	Potential injuries and loss of life included and mapped for a range of scenarios
Flood risk to vulnerable people (e.g. elderly or disabled)	Not detailed	Areas where elderly/sick people live mapped	Numbers of vulnerable people defined with a response strategy
Flood risk to residential property	Not detailed	Number of properties defined	Number of properties defined together with those at risk of collapsing during an extreme flood
Flood risk to businesses	Not detailed	Number of businesses defined	Number and type of businesses defined together with potential losses
Flood risk to critical infrastructure (e.g. water supply, gas, electricity)	Not detailed	Number of pieces of critical infrastructure shown on the flood map(s)	Number of pieces critical infrastructure shown on the flood map(s) and an assessment of their likelihood of failure during a flood
Potential for NaTech hazards at industrial sites	Not detailed	Potential NaTech sites shown on map	Potential NaTech sites shown on site and brief details of the response

Source: Lumbroso et al. (2011).

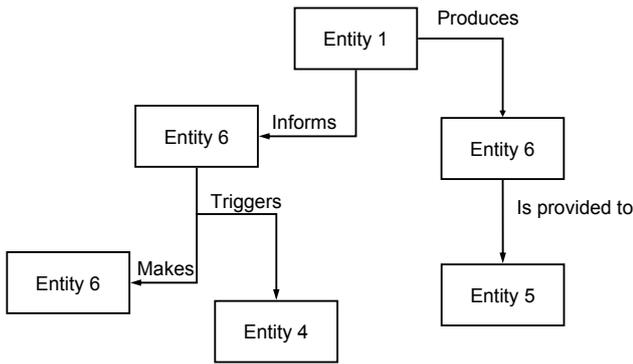


Fig. 2. An example of a generic entity diagram.

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 generic entity diagram is shown in Fig. 2.

4.2.2 Process/responsibilities/tools/information – the cross-table

The next step in the method considers each entity in the diagram. The outcome from sub-step (b) 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 Fig. 2.

To fill the action tables, it is necessary to identify a “quadrant” of the cross-table (e.g. processes and procedures), and then ask questions to describe this entity. The first question to ask would simply be “What does the entity do?”. The answer to this question is used to fill the quadrant with a short description of the process. Once this is done, the other parts of the table and the relative links should be completed by exploring the following:

- *Roles and responsibilities:* who is responsible for doing this process? Who checks that this has been done?
- *Information:* which data or information are needed for this process?
- *Tools:* what tools are needed/used for this process?

Once the links between “processes and procedures” and the other quadrants have been explored, another quadrant of the tables should be analysed, starting from, e.g. the information quadrant. The initial “information” listed can then be analysed and the following questions asked:

- *Roles and Responsibilities:* who uses this information? Who is responsible for providing this information? Who audits that this information is provided/disseminated?

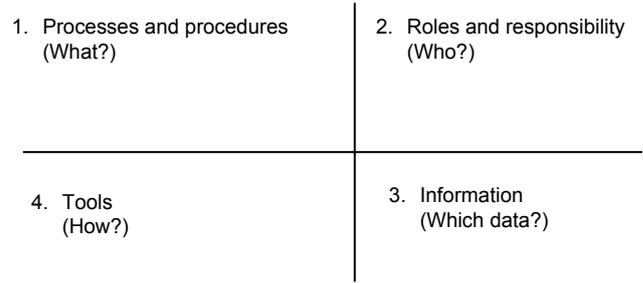


Fig. 3. Example of filling in the cross-table.

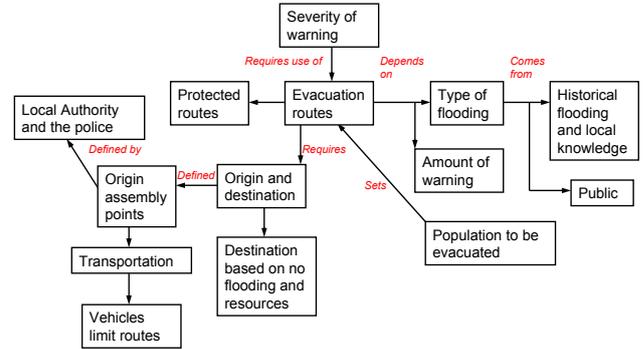


Fig. 4. Entity diagram for evacuation for Sheffield MAFP.

- *Tools:* how is this information produced? How is it communicated? Where/how is it stored?

This procedure is then repeated for each of the item listed in each quadrant and additional items and relative links are identified, as shown in Fig. 3.

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 then be discussed in detail in the next step.

4.2.3 Identify and tackle the issues – the action table

When completing the cross-table and identifying links between items, certain issues may arise, for example:

- identifying the links that are 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 a table, which is called the “action table”. For each of the identified issues, the user can

Table 2. Metrics used for the assessment of emergency plans for floods.

Action	Sub-action
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. Could a new tool be utilised?
Timeline	List of specific sub-actions with relative timelines
Plan to be updated?	The answer can simply be yes/no This column simply aims to capture any actions that should result in an update of the plan

Table 3. Flood hazards for the different case study locations.

Case study location	Type of flood
City of Sheffield, England	Surface water flooding and dam break
Tarascon, France	Fluvial flooding with dikes
City of Dordrecht, The Netherlands	Combined coastal and fluvial flooding

analyse how to address them by going through the questions proposed by the table, and filling the columns accordingly:

- *How to address it?* Define specific action(s) that is (are) needed to tackle the issue.
- *Who should bring it forward?* Identify who should be responsible for taking forward each of the specified actions.
- *What information is needed?* List 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.
- *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, step (c) 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 spotting possible issues, especially due to the links within different aspects that might not have

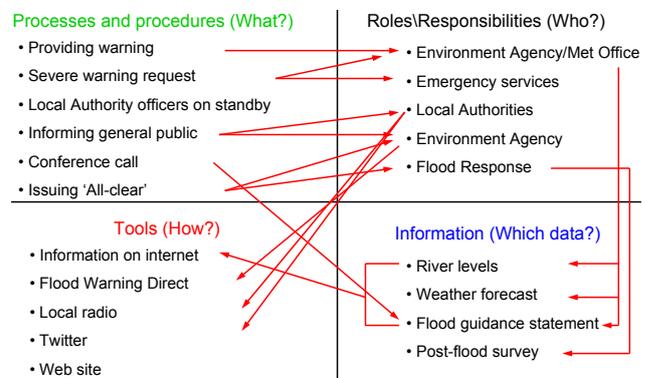


Fig. 5. Cross-table for evacuation for Sheffield developed during the workshop by the emergency managers of Sheffield.

been fully covered in an emergency plan, and therefore might cause possible “bottlenecks” to the process. Listing these items in a table can 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.

4.3 Step 3 “Implement”: taking actions forward

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

- a. a plan cross-check, to identify specific parts of the plans that cover (or should cover) the selected issue
- b. a review of potential tools that could be used to provide further information and insights into the selected issue
- c. an update of 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

Table 4. Action table for the evacuation of Sheffield.

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 the public	Media message	Environment Agency	River levels Fluvial forecast	River model	Tactical Control Group
	Flood Warning Direct	Environment Agency to Managing Agency	Request from Managing Agency partners		Tactical Control Group
	Door knocking	Local Authority/ Emergency Services	Preferred destinations	GIS system	Tactical Control Group
	Internet	Managing Authority	Preferred destinations		Tactical Control Group
	Signage	Local Authority	Preferred routes		Tactical Control Group
Where do they go?	Rest centres	Local Authority	Pluvial forecast	GIS/Local knowledge	Tactical Control Group
	Get address details	Local Authority/Police	Suitable locations	Co-operation	Local Authority

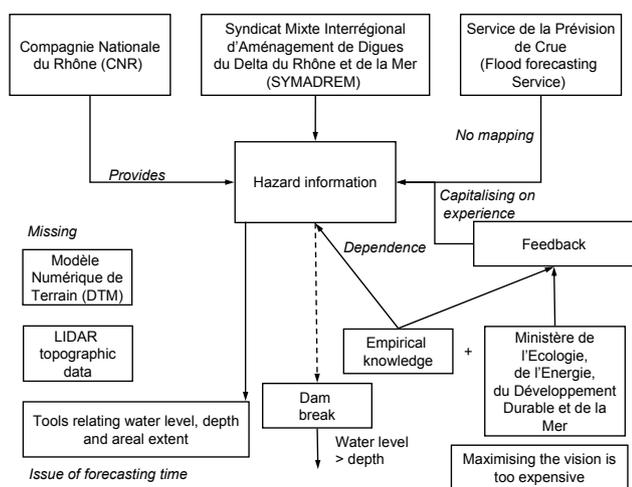


Fig. 6. Entity diagram for flood hazard mapping for the Tarascon PCS developed during the workshop.

- d. 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. Table 3 shows what needs to be specified for each of the identified actions.

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 implementa-

tion. 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 tackle the most important issues first,
- evidence for demonstrating the importance of the identified actions to those involved in the planning process, helping to engage with them and gaining a collaborative attitude.

The proposed method was tested in a workshop held with emergency planners and responders in England and Wales. It was then used in three other case studies in England, France and the Netherlands. The outcome of these workshops was used to refine the FIM FRAME method.

5 Application of the FIM FRAME method to case studies in England, France and the Netherlands

The FIM FRAME method was tested and applied to three case studies in England, France and the Netherlands as follows:

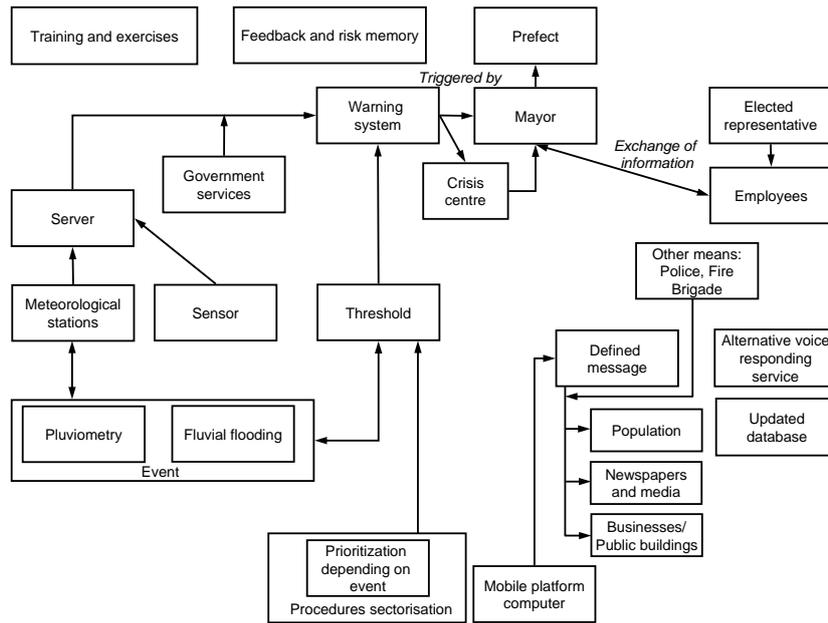


Fig. 7. Entity diagram for flood forecasting for the Tarascon PCS developed during the workshop.

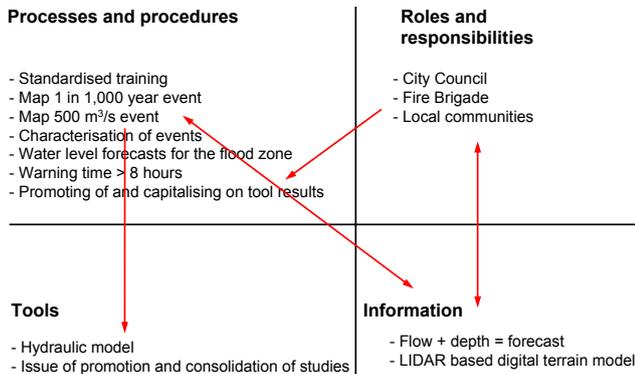


Fig. 8. Cross-table for “flood hazard map” for Tarascon, developed during the workshop.

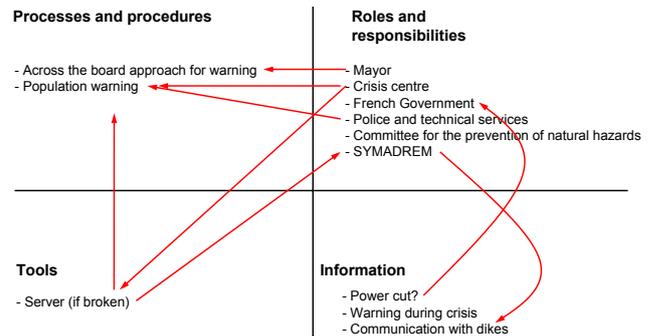


Fig. 9. Cross-table for “flood warning” for Tarascon, developed during the workshop.

- the city of Sheffield in Northern England;
- the town of Tarascon in southeast France;
- the city of Dordrecht in the Netherlands.

Each of these locations is subject to different types of flood hazards as detailed in Table 3.

5.1 Application of the FIM FRAME method to the city of Sheffield, England

The FIM FRAME method was applied to the Multi-Agency Flood Plan (MAFP) for the city of Sheffield in the North of England via a series of workshops. Representatives of the local multi-agency strategic emergency management team

(local authority, police, fire and rescue and environmental agency) took part in the workshop.

The first activity undertaken was to apply the 22 metrics to the plan via a group discussion (the “appraise” step). The majority of the metric scores fell in the average or high category, with the plan overall obtaining an “average” rating. The main weak areas were found to be:

- evacuation routes – no detail was provided, either on a map or in the text,
- detail is not provided on vulnerable people,
- critical infrastructure – although this was provided in a table, it is not included on a map,

- NaTech hazards – in common with the majority of plans analysed, this information was not provided (or even known).

Based on this assessment it was decided to consider “evacuation routes” during the remainder of the workshop. The first part of the “tackle” phase was to build an entity diagram, as shown in Fig. 4. It is important to note that this diagram does not need to be self-explanatory, as it was built during a “brainstorming” session and used as a mean to think of the sub-processes composing the item “evacuation routes”, to map the logical connections and start identify the actors, data and tools.

From the entity diagram, the various processes and procedures were identified, and a cross-table was developed by the stakeholders. 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 resulting table is shown in Fig. 5.

During this analysis, the participants were asked to note possible difficulties in identifying the links between the various items in the table. A lack of clarity or missing links was dealt with as “red lights” in the tackle process. Such items were 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 Table 4.

Overall, the feedback from end users was that, although the participants in the English case studies and workshops could see that the FIM FRAME method provides a set of useful tools and approaches for analysing and improving their emergency plans, there were concerns over the available resources, in terms of time and people, to be able to apply it fully. However, the FIM FRAME method has been formulated so that it can be applied to a small part of a plan. One other aspect was the time some users took to understand the production of entity diagrams. The entity diagram is a key component of the Business Elements Method and the FIM FRAME method. In order to address these concerns, a guidance document was produced using examples from various case studies, which details how the entity diagrams can be produced.

5.2 Application of the FIM FRAME method to Tarascon, France

The case study chosen for France was the city of Tarascon and the lower part of the Rhône catchment. The downstream part of the biggest French river is prone to three kinds of floods: fluvial floods from the Rhône and its tributaries, 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). The Rhône River is bordered

by a system of dikes, which is currently being reinforced after numerous failures over the last 12 yr. The Syndicat Mixte Interrégional d’Aménagement des Dignes du Delta du Rhône et de la Mer (SYMADREM) is the authority that is in charge of the maintenance of the dikes; however, this authority does not have any responsibility for emergency management of floods, apart from monitoring of the dikes.

There are no emergency plans that cover a flood event over the whole Rhône Delta. The Rhône Delta is divided into numerous administrative entities including more than 30 municipalities (i.e. communes), three départements and two regions (i.e. Languedoc-Roussillon and Provence-Alpes-Cote-d’Azur (PACA)). After 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 since 2006. The latest version was produced in 2009. The municipality has developed a flood warning system that is recognized as being efficient. However, the application of the FIM FRAME method to the PCS highlighted some gaps, which the application of some tools could partly fill including:

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

Following the appraisal of the PCS, two metrics were chosen, because they were perceived to be problematic by the stakeholders in terms of emergency planning. These were flood hazard mapping and flood forecasting. The entity diagrams produced for these are shown in Figs. 6 and 7, respectively, followed by the associated cross-tables in Figs. 8 and 9.

After applying the FIM FRAME method, a plan of action was drawn up, by which the emergency plan could be improved. These actions were as follows:

- 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 need to be defined;
- there needs to be 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 $500 \text{ m}^3 \text{ s}^{-1}$ interval increases in the flood flow;

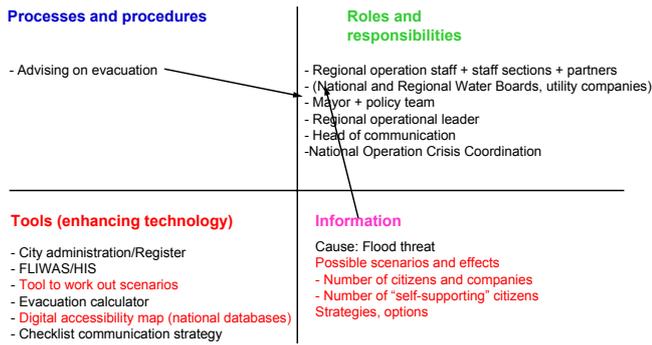


Fig. 11. Cross-table evaluating the process of “advising the mayor”.

Rhine. 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 1800 people in the region.

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. 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.

The scoring of the plans, which forms the “Appraise” step of the FIM FRAME method, was performed by the project team. The results were presented and discussed at a workshop in Dordrecht. 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 using 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.

During the workshop an entity diagram and cross-table were constructed to evaluate 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 Fig. 10. 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).

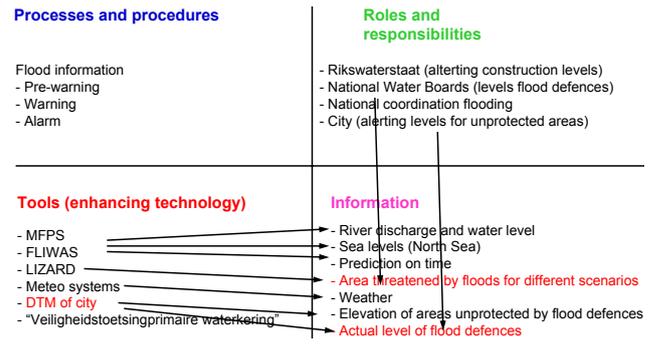


Fig. 12. Cross-table evaluating the process “flood information”.

The participants were asked to describe the ideal evacuation process and identify gaps with respect to the current organisation of the process. The starting point was describing and analysing the current evacuation procedures. 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 Figs. 11 and 12, respectively. The identified gaps are indicated in red.

The resulting cross-table shows 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 stakeholders emphasized the need for flood scenario-based information on flood risk (e.g. threatened areas, number of citizens and companies). The tools to develop this information require specialised expertise and knowledge. The application of the FIM FRAME method helped to identify the following issues:

- the importance of gaining insight into availability of evacuation routes;
- importance of having 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.

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 was 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 would be reduced by 50 %.

5.4 Feedback on the application of the FIM FRAME method

The stakeholders who attended the workshops in the three countries were asked to fill in a questionnaire in order to provide feedback on the application of the method. In all the countries they indicated that the FIM FRAME method responded to their requirements to have a method to assist them to develop new and assess existing emergency plans for floods, and was generally seen by the participants as logical and complete. The stakeholders also provided comments on specifics of the part of the frameworks, in particular:

(i) The “Appraise” step

The metrics were seen as a good way 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.

(ii) The “Tackle” step – the entity diagrams

The entity diagram proved to be a useful tool to “brainstorm” and to conceptualise ideas. The entity diagram provides a very “visual” representation that the stakeholders found useful. However, some attendees preferred the cross-table and pointed out that the entity diagram could be time-consuming to develop.

(iii) The “Tackle” step – cross-tables

The cross-table was considered to give a good overview of issues and provided a method to further develop a topic, bringing out a collective vision and facilitates the translation of the entity diagram into processes, “potential errors” and eventually gaps. The participants at the workshops found this step easier to implement and to understand than the entity diagram.

In general, the application of the FIM FRAME method generated a positive feedback, although in some cases it was considered to be too time-consuming. In other cases, it was considered complicated, especially with the production of the entity diagrams. However, it is important to note that the FIM FRAME method can be applied to an area where a plan is shown to be weak or to the whole plan, depending on the resources that are available and the objectives that the stakeholders wish to achieve.

From the feedback received from the stakeholders, the following improvements were made to the FIM FRAME method:

- to reduce the amount of time devoted to the application of the method, it is useful to have preliminary discussion

with the stakeholders concerning the level of detail of the analysis of the plan that is required.

- aim to produce entity diagrams that are simple and clear. This can be achieved by re-drawing diagrams that start to become too confusing.
- use actual case studies and concrete examples where possible.
- when analysing the plan and producing the diagrams, distinguish whether we are “analysing an actual emergency situation” (such as a specific scenario) or “looking at the general process included in the plan”, as the confusion between the two can create confusion in the outcomes.

6 Conclusions and recommendations

Feedback from stakeholders involved with the research indicated that the FIM FRAME method had the following benefits:

- it helps to identify gaps in and assumptions made by plans;
- it provides a logical method for analysing emergency plans;
- it allows the collection and collation of detailed information required for flood emergency plans, at the same time providing a gap analysis.

The stakeholders found that the FIM FRAME method was useful in analysing gaps in and improving emergency plans; however, the method needs to be “streamlined” in order to make it simpler to use. This was achieved by shortening and simplifying various material used in the case studies describing the method, and by providing examples of the entity diagram and cross-table to facilitate the workshop discussions and application of the method. It was also noted that the application of the FIM FRAME method was more effective when a “strong” member of the emergency management team would act as facilitator, to encourage the discussion and push the development of the entity diagram, the identification of the issues and encourage the undertaking of tangible implementation actions. The application of the proposed method was considered successful and can be repeated by other emergency management teams. As the FIM FRAME method is applied, it is flexible enough that it can be progressively updated and refined through the experience of other emergency planners.

One of the main advantages of the method is its applicability by emergency planners and responders, who can directly benefit from discussing and reflecting on the emergency process as a team. It needs to be noted that the application of the FIM FRAME method and the successful update of the

plan cannot ensure the actual success of the plan during an emergency. However, this method can help to at least identify issues and set out the actions required to tackle them, as it goes beyond a mere “content check”, providing an analysis of the processes and protocols described in the plans.

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