Logistics aspects of emergency preparedness in flood disaster prevention

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Abstract

Purpose – This paper aims to develop and verify a framework of logistics aspects for flood emergency planning.

Design/methodology/approach – Provides a topical review of academic literature, illustrative case study and structured interviews in practice.

Findings – Creates and details a framework for logistics flood emergency planning on four aspects: demand management, supply management, inventory management and resource management.

Research limitations/implications – The paper is empirical in nature and based on an investigation within one country (the Netherlands) that is considered an expert in this area; the framework requires international testing.

Practical implications –. The framework presented provides practitioners with a tool for logistics flood emergency planning and highlights essential elements of these plans.

Originality/value –The field of humanitarian logistics so far has received limited attention by logistics academics and there is a strong need for empirical research in this area. This paper provides the results of an empirical investigation into a highly relevant area of humanitarian logistics: the logistics preparedness against flood disasters.

Keywords Logistics emergency planning, Flood disaster prevention

Paper type Research paper

Introduction

Natural disasters are unpredictable in every respect. It is never known when, where and in which size disasters will happen and which responses are required. Only one thing is for sure: new natural disasters will occur. Natural disasters are triggered by, for example, droughts, floods, earthquakes, volcanic eruptions, or hurricanes; they can be sudden-onset such as an earthquake or slow-onset such as drought (Van Wassenhove 2006). Between 1994 and 2003, floods and storms caused approximately 55% of all worldwide disasters (EM-DAT 2005).

Managing disasters effectively requires a continuous chain of activities that includes hazard prevention, preparedness, emergency response, relief and recovery (Wisner & Adams 2003). Disaster relief agencies acknowledge that 80% of their efforts in these supply chains concern "humanitarian logistics operations" (Van Wassenhove 2006). Humanitarian Logistics can be defined as the process of planning, implementing and controlling the efficient, cost-effective flow and storage of goods and materials, as well as related information, from the point of origin to the point of consumption for the purpose of alleviating the suffering of vulnerable people (Thomas & Kopczak 2005). Preparing these logistics activities is crucial to successful disaster response. It has been acknowledged that the government needs to play a key role in preparing for effective disaster response (Moe & Pathranarakul 2006).

Compared with for example earthquakes, flood disasters can be more easily predicted and prevented; they can generally be characterised as relatively slow-onset (Wisner & Adams 2003). Four phases can be distinguished (see also figure 1): 1) planning and preparation (under normal conditions); 2) extreme conditions (occurrence of a high water level); 3) actual flooding; 4) recovery. In this research, we focus on the first two phases (i.e. planning and preparation and occurrence of extreme conditions). Emergency plans are made during the first phase and put into action in the second phase. We focus on these two phases in this article (see figure 1).

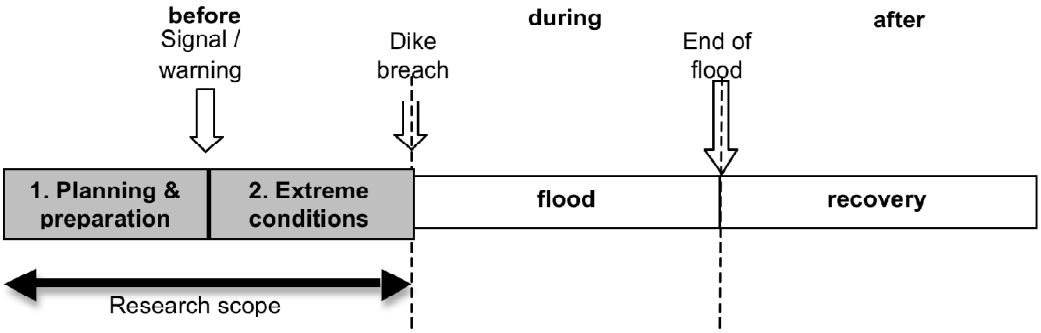

Figure 1: General timeline and phases associated with flooding, and research scope

Emergency preparedness plans often lack insight in humanitarian logistics (Chaikin 2003). In general, planning of flood emergency logistics has received little attention in literature (Chang et al. 2007). The objective of this research is therefore to develop a framework of logistics aspects that need to be accounted for in plans that are set up to prevent flood disasters. Activities that are incorporated in such plans may comprise close monitoring of dike conditions but also filling sand bags to reinforce dikes. We do not consider the technological defence against floods through dikes. As the Netherlands has a long experience with flood risk management and is prone to high flood risks, the Dutch situation will be used as a reference. Results of a case study and a survey amongst agencies in The Netherlands responsible for flood management (i.e. Water Boards) are used as a basis. The framework is also expected to be applicable to flood disaster prevention in other countries and to other similar hazard types as we focus on generic logistics aspects of emergency preparedness plans and not on the specific role of the government.

The next section develops an initial framework for logistics emergency planning based on literature. Thereafter, we focus on the structure of flood risk management in the Netherlands. The consecutive section illustrates the logistics issues of Water Boards by means of a brief case study. We then verify and expand our framework by means of interviews with Dutch Water Boards. The last section provides a discussion, conclusions and recommendations.

Towards a framework for logistics emergency planning

Good logistics planning to ensure availability of the right materials and capacity is crucial in order to be prepared for a flood disaster. Being prepared is crucial for an efficient response (Van Wassenhove 2006). A body of research is developing on

proactive planning for catastrophies in commercial supply chains (Knemeyer et al. 2008). However, there is no standard in emergency planning for floods and other types of disasters in the humanitarian area (Alexander 2005). In general, emergency planning is perceived as not adequate enough (Kovacs & Spens 2007). We therefore detail a framework that can be used in preparing for logistics activities that need to be performed to prevent flood disasters (phases 1 and 2 in Figure 1). We base our frameworks on models developed for the immediate response phase (phase 3 and 4 in Figure 1) as frameworks that cover these preparation phases are lacking to our knowledge. Kovacs and Spens (2007) discriminate immediate disaster response into demand management, supply management and fulfilment management. Özdamar et al. (2004) use a distinction between capacity aspect and material issues in emergency logistics planning during actual response. This is used to point out that emergency logistics planning involves dispatching both items (such as relief medication or other products) and capacities (such as rescue equipment, rescue teams) into affected areas. They furthermore also argue that a logistics plan for immediate response during emergencies involves demand and supply aspects.

In the remainder of this section, we will describe the logistics aspects covered in disaster planning related literature for each of these four planning elements. We use this information to develop a framework containing logistics decision problems for each of the four elements.

1. Demand management

Disasters are unpredictable in many respects. Many therefore argue that some form of demand management is necessary to generate early warnings and therefore to be prepared (Kovacs & Spens 2007; Perry 2007). Several authors (for example Beamon 2004; Kovacs & Spens 2007) mainly consider demand management as a process of making an inventory of requests for products and capacities after a disaster has struck. To ensure preparedness, it is necessary to make predictions of needs before a disaster strikes in order to ensure timely availability of materials and capacities. Though disasters are unpredictable, so-called slow-onset disasters such as floods do have a degree of predictability. There is for example a 3-5 days lead-time before a river flood hits the country and a 48-hour period for storms, which gives some leeway to take precautions (Moe & Patrhanarakul 2006). Many commercial business environments make a discrimination between long, medium and short term forecasts each using

different methods and sources of information (McCarthy et al. 2006). Disaster relief also necessitates such discrimination. In the short run, some form of early warning system can directly help in determining potential locations of a disaster that is coming, for example a hurricane or tsunami, enabling the early shipment of prepositioned stock a specific area or making sure resources are ready to act. Several efforts have been undertaken to improve forecasting of disasters, particularly after the tsunami of 2004. Countries such as Indonesia have installed early warning systems for tsunamis' (Telford et al. 2006); other systems are, for example, described by Gonzales et al. (1998). Wei et al (2002) discuss a method to predict flood disasters using neural networks that they apply to Chinese situations. However, early warning systems are not easy to establish: data may not be available, causes are difficult to establish and there may be political opposition as countries may feel 'being watched' (Schmeidl & Jenkins 1998). On a longer term, demand management is difficult. One of course needs to take account of the fact that some regions are more prone to specific disasters than others (Kovacs & Spens 2007). Even then, the probability of occurrence of disasters in a region is typically very low. These days in the Netherlands, for example, dikes are designed in such a way that the probability of a dike failure is considered to be once in roughly a 10000 years (Wesselink 2007). However, the impact of such a disaster is enormous. Databases with historical disaster information exist to develop probabilities of occurrence– such as the EM-DAT database (Altay & Green 2006). Based on such information and taking e.g. the number of inhabitants of a region and local conditions in a region into account, it is possible to make estimates of logistics needs once a disaster is about to occur. Chang et al. (2007) use Taiwanese floodwater estimations to determine rescue demand points, based on which they develop their plans. Physical conditions need to be known as well as they may differ strongly and impact equipment needs (Van Wassenhove 2006).

2. Supply management

The management of procurement and associated suppliers is crucial to maintain high emergency response levels. First of all it needs to be decided what activities to keep in-house and what to outsource; this is a challenge that also relates to humanitarian operations. Cottam et al. (2004) show for example that transport outsourcing during emergency relief may be beneficial, in particular if sudden surges of demand occur, but there are mixed results with the effectiveness of it. Just like in commercial supply

chain management, good preparation of supply would mean having for example alternative suppliers (Van Wassenhove 2006) as many items are needed frequently. It therefore also makes sense to make long-term agreements with suppliers (Kovacs & Spens 2007; Thomas 2003a).

Coordination of supply between agencies involved in disaster relief is challenging (Beamon 2004) and also required during the aftermath of a disaster as Quarantelli (1997) points out, However, it is of highest relevance between disasters as few links exist between organisations between disasters. This could result in redundancies in preparation of logistics activities such as setting up warehouses (Thomas & Kopczak 2007). The preparation phase typically is the time to develop collaborative platforms (Kovacs & Spens 2007). Other aspects relevant in ensuring proper supply when disasters strike are mutual aid agreements and memorandums of understanding between agencies about who does what, setting up information systems and acquiring emergency equipment (Altay & Green 2006).

3. Inventory management of materials

Some items are required so often that it makes sense to preposition these (Altay & Green 2006; Thomas 2003b). Whybark (2007) argues that disaster planning is centered around disaster inventories and therefore acquisition, storage and distribution of products are key. However, little research is available on inventory management in humanitarian disaster related environments (Ozbay & Ozguven 2007). Organisations have to make a distinction between goods that are needed in any kind of disaster, such as drinking water and medicines (response-generated needs) vs goods which are only needed with a specific kind of disaster, such as sandbags, called agent-generated needs (Quarantelli 1997). The difference between these two types of needs is that the response-generated needs can be kept in stock (e.g. sand bags), because they are needed with every (flood) emergency activity. Ozbay & Ozguven (2007) have developed a stochastic model for safety stock levels of these commodities. The agent-generated needs are so specific for each disaster that it is much more difficult to determine which to keep in stock and how much. Balcik et al. (2008) discriminate between two types of items along similar lines: type 1 consist of critical items where demand usually occurs at the beginning of the disaster. Examples given are tents, jerry cans and tarpaulins. Type 1 item demand is generally very large at the

beginning. Type 2 items are consumed regularly and demand reoccurs, e.g. food or hygiene kits.

4. Resource management

In order to manage disaster response, a large pool of resources is needed for a variety of tasks. They need to operate under complex conditions (Van Wassenhove 2006). Most of the literature on emergency logistics planning emphasizes how to distribute items into an area after a disaster has struck (Chang et al. 2007). Both Özdamar et al. (2004) and Yi et al (2007) for example describe an operational model focused on vehicle routing in disaster response to ensure shortest delivery times possible within a planning horizon considered and Balcik et al. (2008) discuss the last mile problem during disaster response. Chang et al (2007) are one of the few to develop a flood preparation planning tool. They describe an approach to develop an infrastructure for distribution of rescue resources during disaster response, including location of rescue resource warehouses, allocation of resources over these warehouses and the distribution of these resources.

Good resource management requires well thought through recruitment of personnel. Relief organizations will have to select people who are capable of cooperating in a relief organization, and they have to be trained (Van Wassenhove 2006). For this training, special programmes have to be developed (Paton & Jackson 2002) in which the people learn to cooperate and to coordinate with each other and other agencies in order to be prepared for a disaster. Community volunteer groups are essential elements of preparedness (Altay & Green 2006). Public education and disaster excercises (Altay & Green 2006) play an essential role in getting people accustomed to providing aid.

Based on the literature overview, we can establish the first part of our framework. Table 1 provides a framework with relevant logistics decision problems that should be addressed in emergency preparedness to prevent flood disasters from happening. For each of the four categories discussed, we present an overview of relevant decision problems. So far, this is mainly based on literature. The next section first provides a view on flood risk management in the Netherlands. Thereafter, commonly used solution methods in practice as well as remaining challenges will be discussed.

Aspect	Decision Problems
Demand Management	• Forecasting of disaster moment and conditions (e.g. weather) and affected location(s) • Forecasting local situation (e.g. accessibility) • Forecasting and identifying (logistics) needs of affected people
Supply Management	• Deciding on outsourcing or managing own activities and selecting suppliers • Effective and efficient procurement of materials and resources • Coordination between agencies in procurement decisions
Inventory Management	• Selecting products keep in stock • Deciding on inventory levels during disaster preparation for each of the selected products • Selecting storage locations
Resource Management	• Planning of distribution • Selection and training of people with necessary skills • Planning of resources required in disaster preparation • Cooperation with other agencies and organisations during preparation to be prepared for disaster response

Table 1. logistics decision elements of emergency plans

Flood risk management in the Netherlands

Floods account for a significant portion of natural disasters worldwide. A country that is in almost constant threat of floods is The Netherlands (Olsthoorn & Tol 2001). As almost half of the country is situated below sea level or below high levels in rivers and lakes, there has been a ongoing struggle against the water for centuries (Wesselink 2007).

The necessity of structured action against water in the Netherlands was shown by the flood of February 1953, when the dikes in the southwest of the Netherlands breached due to an unfortunate combination of a weak condition of the dikes, a strong hurricane and spring tide, and more than 1800 people drowned (Olsthoorn & Tol 2001). After this drama, the Dutch government decided to start building the Delta-works that were

finished in the late 1990s (Wesselink 2007). The Dutch are prone to several causes of dike breaches: storm surges in the coastal areas in western part of the country and rivers in the eastern part.

The management of flood risks is a task of several government parties that include the national and local government. The so-called Water Boards play a key role (Olsthoorn & Tol 2001). In total, there are 28 of these Water Boards in the Netherlands, of which 6 are located next to the sea. These Boards have three main responsibilities; 1) ensuring the quality of the water, 2) management tasks related to the drainage and irrigation systems and 3) management of the flood protection system that can consist of dams, dikes, sand dunes and hydraulic structures. As part of the third task during a flood situation (e.g. a high river discharge) water boards are responsible for the surveillance of the flood defence system and the logistical preparation of emergency management activities that have the objective to prevent a catastrophic failure of the flood defence system. Evacuation is not a task of a Water Board and will therefore not be considered.

In this context being logistically prepared is a key task of the Water Boards as they are responsible for the availability of materials to aid in disaster response (such as sand bags) and the availability of resources to respond to disasters (e.g., warehouses to store materials or personnel to fill sand bags).

Since long, the Dutch flood defence strategy has mainly consisted of prevention of flooding by means of flood defence structures (Wesselink 2007). A different approach is to rely on prediction and mediation of the effects once a disaster has happened, as common in for example the USA (Bijker 2007). Disaster experience throughout the world has shown that flood hazard mitigation needs to shift from a disaster response driven system to a more pro-active system based on risk analysis and pre-disaster activities (Billa et al. 2006). The flooding of New Orleans due to hurricane Katrina in the year 2005 has shown how catastrophic the (human) consequences of a flood disaster in a densely populated area can be. Due to these developments, more attention is given in the Netherlands to strategies aiming at the reduction of consequences and is suggested that a complete flood defence strategy should cover measures in all parts of the so-called safety chain (ten Brinke et al. 2008). More specifically, the Dutch government has initiated a program to improve the emergency preparedness and response for flood situations.

The Dutch situation, in which low-lying and densely populated areas are threatened by flooding, can also be found in other delta areas around in the world, e.g. in the Mississippi delta (USA) and the Yangtze Delta (China). Findings that are presented here are therefore expected to be also relevant to other flood prone areas. In this research we focus on the role of the Water Boards in the Netherlands as they have an important role in logistics preparation. In other countries similar government agencies exist that will also have a similar task in the development of emergency management plans. Before discussing the results of the interview round, we will first further detail the role of a Water Board in the next section by means of a brief case study.

The role of a Water Board in logistics emergency planning: Water Board "Rivierenland"

The Water Board "Rivierenland" is one of the larger water boards in the Netherlands and is situated in the middle of the Netherlands. This Water Board is prone to both flood risks from the sea and from inland rivers. Due to its size and diversity of challenges it provides a good illustration of the role of a Water Board in emergency planning for flood prevention. This Water Board is responsible for an area with 550 kilometer of dikes. The area is prone to both risks from the inland rivers and the sea. The dikes in this area form different enclosed defense systems (so-called dike rings). Some dike rings are relatively small (5 kilometers length) and others are relatively long (up to 168 kilometers). The Water Board is responsible for the quality of in total 10 of these dike rings. The location of these flood defense systems is partly historically determined and partly geographically. There is a depot close to each of the larger dike rings. There are 6 such locations spread over the region. Each depot contains an inventory of emergency materials required in preventing the dikes from breaching. Materials stored there are for example sand bags that are needed to prevent water from coming into an area once filled and stacked; dike canvas, which is a cloth layer that is put on top of a dike to prevent further erosion once the natural erosion prevention (grass) has been washed away; beams specifically designed to close the cuts in dikes where e.g. paths or roads run through dikes. These depots are co-located with facilities where Water Board equipment can be maintained and other tasks of the Water Board can be performed as well (e.g. water sanity control). managed by the water board Rivierenland. These locations have been selected in such a way that no

bridges need to be crossed in the process of distributing these materials, as bridges are particularly sensitive to calamities.

The region of responsibility of a Water Board may run across provincial borders. Provincial government regulation sometimes requires that additional items need to be stored in a depot as well. For example, one of the provinces in which the region Rivierenland is located in requires depot storage of southwesters (a type of rain cap), rain clothing, shovels, and storm lamps. Another province in the Rivierenland region does not require such materials.

Once there is a threatening flood, dikes are monitored more closely by dike watches than normal and information is frequently sent to the Water Board coordination center. These dike watches are often volunteers appointed by the Water Board, and are specially trained in executing this task. The Water Board also monitors the weather forecasts closely to determine whether and what types of actions are required. Once it is necessary to take precautions because there is a flooding danger, contractors are notified to perform activities such as filling sand bags and enforcing dikes. These contractors have been selected and appointed per dike segment. This is necessary to ensure that contractors have good knowledge of an area they are responsible for and travel distances are limited in case of calamities. Furthermore, contractors are appointed in such a way that there is no need for them to cross bridges in case of calamities. Bridges are often weak points in case of floods.

Empirical evidence

There is a lack of empirical research in the area of logistics aspects of emergency preparedness (Kovacs & Spens 2007). The remainder of this article is focused on developing an empirical understanding of the logistics aspects that need to be incorporated in flood emergency plans as well as the challenges faced in logistics aspects of flood emergency planning.

Our goal is not to provide empirical support for (quantitative) relationships but rather to understand the types of relationships that may exist and to understand which relationships may be valid research objects. We provide an overview of current and potential solutions to the decision problems posed in Table 1, As such, an exploratory research approach seems appropriate (Eisenhardt 1989; Johnston et al. 1999; Yin 2003).

We focus our empirical investigation on the logistics aspects of emergency preparation plans of the Dutch Water Boards as Water Boards play a pivotal role in flood emergency preparedness and have the overview over the complete preparedness process. Of the 28 water boards that exist in the Netherlands, one does not have emergency preparation plans, as there are no inhabitants in the area managed by this Water Board. We have therefore left out this Water Board in our investigation. We have identified the people responsible for logistics within the Water Boards and approached them to participate, either through existing networks or through the switchboard of the particular Water Board. Typically, this was a logistics manager with an executive role in the Water Board. All potential respondents were asked by phone if they wanted to participate in the research. If their answer was positive, a date was set to interview the respondents by telephone. Of the 27 Water Boards that we approached, 21 participated (78% response rate; see Appendix 1 for an interview list). We used a semi-structured interview approach whereby the people interviewed received Table 1. They were asked to comment on how each of the aspects mentioned in the table is covered in emergency plans. If an aspect was not covered, it was discussed why not. Furthermore, participants were asked which aspects they deemed critical in logistics preparation of emergency relief but were not yet discussed.

The results of the interviews are used to complete and detail our framework and are summarised in Table 2 (demand and supply elements) and Table 3 (inventory and resources elements). The results are discussed below, first for the demand and supply aspects and thereafter for inventory and the resource aspects.

Aspect	Decision Problems	Solution methods in practice	Challenges and problems
Demand	Forecasting of disaster moment and affected location(s)	• External organisations provide agencies with information on weather conditions. • Agencies monitor flood risk • Practice how to deal with unforeseen conditions	• Agencies need to rely to a large extent on external organisations in forecasting flood disasters. There are several uncertainties associated with the predictions.
	Forecasting local situation (e.g. accessibility)	• Plans indicate possible routes to access affected areas • Dike monitoring used to provide frequent feedback on local conditions	
	Forecasting and identifying (logistics) needs of affected people	-	• So far hardly any attention is given to identifying expected logistics needs from affected people.
Supply	Deciding on outsourcing or managing own inventory and selecting suppliers	• Agreements exist with contractors to make equipment and staff available when required. • Agencies keep their own inventories • Overview available of contractors such that direct action can be taken in case of a distaster response	
	Effective and efficient procurement of materials and resources	-	• Efficiency and effectiveness of procurement is acknowledged to be an opportunity for improvement
	Coordination between agencies in procurement decisions	-	• Coordination is lacking on scarce resources • Coordination is lacking between agencies • There is a need for prioritizing in assigning available resources and materials

Table 2. Demand and supply elements in emergency plans of Water Boards

All Water Boards use weather forecast input obtained from external sources. The focus of Water Boards is on monitoring potential flood risks based on amongst others those forecasts. Some Boards mentioned they had agreements with weather forecasting agencies to provide input, which feeds into their own systems. Based on this information, alarm phases may be announced. For each of the alarm phases

certain actions are required. Local dike conditions are furthermore guarded by dike watches. They provide frequent feedback on the local situation of dikes to Water Boards. This information is used to decide on where to put additional support to dikes by means of e.g. dike canvas or sand bags, and how much to put there. Actions are also triggered if river discharge exceeds a certain threshold or if rainfall is extremely heavy and enduring.

Several Water Boards have thought about how to reach an area once floods are about to occur and have e.g. a traffic protocol, but most have not; local improvisation remains required as not all circumstances can be foreseen. Some Water Boards therefore practice unforeseen circumstances in training sessions (e.g. what to do if trees block road access).

The procurement of materials and equipment is set up per Water Board. The Water Boards indicate that a mere focus on procurement price is not a relevant consideration, it is more important to have materials in stock and agreements with responsive suppliers in place. In general, Water Boards note that procurement is not an explicit part of their emergency plans. Each Water Board makes agreements with contractors and other suppliers for materials such as sand and resources such as equipment. Only in selected occasions the Boards cooperate. For example, three Water Boards together outsourced the training activities for their personnel to one supplier. They also indicate that coordination of potentially scarce resources (such as pumps or personnel) is therefore lacking. One Water Board mentioned that there is less need to coordinate, as there is always a possibility to involve the army.

Inventory	Selecting products	• List with products available and will be updated yearly. • Main components of list are agent-generated products as sand bags, stones and sand.	• Lists hardly contain any response-generated products.
	Deciding on inventory levels during disaster preparation and response	-	• No specific plans exist for planning inventory and fine-tuning for different phases during the disaster yet. Inventory levels are not based on actual quantitative assessments of the needs.
	Selecting storage locations	• Regional storage locations (higher	

		grounds)	
Resource	Planning of distribution		• Planning of distribution into the areas that may be affected is left to contractors
	Selection and training of people with necessary skills	• Some level of training and practice available; plans for joint training sessions across Water Boards	• No sharing of evaluation results of preparedness and response
	Planning of resources required in disaster preparation	• Overview available of staff who can be called. • Volunteers are trained to perform monitoring tasks and sometimes specific prevention tasks	• Scenario planning and risk analysis could be used more • Needs will vary during disaster phases
	Cooperation with other agencies and organisations in assigning duties to resources during preparation and disaster response	-	• Coordination is lacking between organisations. • Difficult to exchange resources between organisations due to a lack of standard in plans. • Coordination is lacking in case that multiple floods occur at the same time

Table 3. Inventory and resource elements in emergency plans of Water Boards

Water Boards all perceive the management of stock as a highly important issue and keep a list of materials to be stocked which they update on a yearly basis (see case description Water Board Rivierenland). Stocks are located in regional depots; usually each Water Board is further divided in regions and each region has 1 depot for storage of materials and equipment. Some Water Boards use special distribution centers located at higher levels so that these cannot flood. The Water Boards have not set stock norms for their materials nor for obsolescence, nor do they have an overview of stock available in depots of other Water Boards. Selected products stored deteriorate over time (e.g. sand bags) and therefore require replacement. This implies that the levels of stocks are not based on a (quantitative) assessment of needs.

Water Boards all have made agreements with contractors to provide equipment and resources in emergency situations. The contact details of these contractors are provided in the emergency plans. Training plans differs per Water Board. Some practice frequently, also with third parties involved; the usefulness of training is not univocally recognised.

The use of volunteers as a resource for providing aid is limited on purpose. Water Boards agree that volunteers are only helpful for relatively simple tasks as most of the

work requires extensive training. In the northern areas of the country Water Boards use volunteers to monitor the dikes. Furthermore, one Water Board has a so-called "high water brigade" consisting of volunteers with a very specific task. In these regions, several houses are part of the dike infrastructure and it is the task of this brigade to close specific dike cuts in and around those houses once there is a certain flood danger.

Responsibilities of parties to involve in emergencies are often described in the emergency plans but the effectiveness of this is doubted. One Water Board indicated: "we have not incorporated the capacity requirements for different situations; reality is always different anyway"

Conclusions and recommendations

Disaster experiences throughout the world have shown a need for a shift of emergency management towards a more proactive approach based on pre-disaster analysis (Billa et al. 2006). However, there is a lack of empirical research in the area of logistics aspects of such a preparedness approach (Kovacs & Spens 2007). In this article, we have made an overview of the emergency planning of logistics aspects to prevent flood disasters on four main issues: demand management, supply management, inventory management and resource management.

Our results confirm that an effective flood emergency planning model needs to contain a rigorous, well-informed and pro-active approach (Ahrens & Rudolph 2006). Although the quality of forecasts of floods has increased considerably over the last decades (Sorensen 2000) it is particularly the variability of local conditions that require attention to be able to attune capacity and material needs to these local conditions. One challenging aspect during a threatening flood situation concerns the logistics aspects of transporting the materials from the storage to the location where they are used for flood fighting. During a threatening situation the weather could be severe (rain, wind) and the accessibility of the most critical locations could be limited. Geographical Information Systems together with Global Positioning Systems have proven effective tools to provide the required geographical information for this (Billa et al. 2006).

Supply management needs to be an integral element of emergency plans. Responsiveness of suppliers is key in the selection of suppliers. In this selection process, the physical location of suppliers is a crucial consideration as the amount of obstructions to reach areas struck need to be as limited as possible. Furthermore, suppliers should be well aware of local conditions (including infrastructure such as bridges). Though local knowledge of suppliers is essential, collaborative procurement agreements to share contractor capacity and leverage capabilities should be strived for.

Our findings confirm that stock management is essential in disaster preparation (Altay & Green 2006; Thomas 2003a; Whybark 2007). Response capabilities of agencies could be enhanced further if local agencies have insight and access to inventory levels of depots outside their immediate region of responsibility.

As in any disaster, a large pool of resources is needed who need to operate in complex conditions (Van Wassenhove 2006). In case of flood emergency preparation, it is generally preferred to use skilled people as much as possible and to use volunteers only to a limited extent. Professionals are trained in their activities and even though volunteers may be highly willing to provide aid, they are only helpful for relatively straightforward tasks or tasks that can be standardised such as dike monitoring. More generally speaking, although citizens are found to be a great resource for life-saving operations after disaster has struck, research shows that little can be done about preparedness of citizens (Helsloot & Ruitenberg 2004). Particularly in circumstances where one does not have much experience – as with flood disasters given their low probability of occurrence – it is worthwhile to study alternative scenarios in depth to obtain as much about potential consequences as possible (Jenkins 2000). Practicing emergency responses is thus a fruitful method to prepare both citizens and professionals involved in flood disaster prevention.

In general, we can conclude that there is more and more attention for logistics emergency preparedness for flood disaster prevention. A more proactive government approach is generally perceived as necessary to prepare for flood emergencies (Moe & Patrhanarakul 2006). An issue of course is that the practical experience on a local level with floods is limited. This calls for a collaborative approach based on scenario planning as well as practical training in order to be prepared for the unexpected. Such

an approach necessitates an integrated planning approach to all four aspects of demand, supply, inventory and resource management.

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Appendix 1. Water Boards interviewed (names in Dutch)

Name Board	Name Board
Vallei & Eem	Regge & Dinkel
Rivierenland	De Stichtse Rijnlanden
Veluwe	Hollands Noorderkwartier
Hollandse Delta	Delfland
Schieland & de Krim	Zeeuws Vlaanderen
Noorderzijlvest	Groot Salland
Rijn & Ijssel	Hunze & Aa
Fryslan	Zuiderzeeland
Zeeuwse Eilanden	Peel & Maasvallei
De Dommel	AGV?Waternet
Reest & Wieden	