Achieving Agility in Evacuation Operations: An Evidence-Based Framework

There is an agreement among European countries about the need to achieve efficient, effective and responsive evacuations as part of disaster management. Evacuations face uncertain and dynamic conditions, which often challenge the expectations at the planning stage. This research looks at the adoption of agility in evacuation operations. Managers involved in disaster operations in three countries were interviewed to identify current practices and needs during evacuations. This article looks at the potential of beneficiary engagement, staff and information, cooperation, and fitness for change to incorporate agile practices at each one of the stages of evacuation planning. The purpose is to provide an Agile Evacuation Operations (AEO) evidence-based framework to inform theory and practice. The analysis provided shows that along with current practices it is important to engage the beneficiaries more closely, empower and train the staff to react to unexpected conditions, and take advantage of local knowledge to enhance operations.

Keywords: evacuation, humanitarian operations, agility

1. Introduction

Natural and man-made disasters have been continuously increasing globally. Every year around 500 disasters occur worldwide with an average of over 200 million people affected (Van Wassenhove 2006). Man-made disasters have a similar increasing trend per year with approximately 3,000 victims per year and USD 10 billion in economic losses (CRED 2017). These situations are expected to be even greater in the future as climatic change in relation to population growth and widespread poverty will be amplified (ADB 2015). The implications of disasters are not limited to people's deaths, but they also have significant economic losses and post-disaster impact on people's lives (i.e. injured, homelessness, in need of emergency assistance (CRED 2017). Europe is highly affected by disasters, with many of them being weather and climate related

incidents such as droughts, extreme temperatures, landslides, and storms (EM-DAT 2015). Unfortunately, the future seems to hold more disruptions in store for European countries. High temperature extremes, heavy precipitation events and droughts are expected to increase in the continent which will presumably lead to greater losses (EEA 2018).

Humanitarian operations have proven to be vital in averting human suffering in the event of disasters (Kovacs and Spence, 2007). Humanitarian operations are characterised as unpredictable, turbulent, and inflexible (Oloruntoba and Gray, 2006). Developing an appropriate logistics strategy for humanitarian operations management could create a prompt and effective response in disasters (Cozzolino et al, 2012). A core part of every humanitarian operation is evacuation. Evacuations involve the transportation of the vulnerable population to safe locations before or after the occurrence of disaster (AZDS 2018). Looking at evacuations is important because they involve the safety of people at risk. Nevertheless, this activity can become very convoluted because of the uncertainty of the conditions of the disaster and the human component involved. Therefore, evacuations often require swift changes and the capacity to adapt to dynamic conditions to reduce death and suffering. Improper management of mass evacuations could lead to collateral casualties due to evacuations not being coordinated in real-time, dynamic and situation-based way (Lujak and Ossowski, 2017). Thus, mass evacuations are a very important and sensitive aspect of humanitarian operations.

Due to the increased occurrence of natural and man-made disasters along with the high stakes involved, humanitarian operations need to be continuously improved. Agility is defined as "the adaptive capacity of an organisation as a whole to build strategic capabilities that support operational responsiveness and flexibility in order to

manage existing or arising risks, uncertainties, and opportunities in the logistics and supply chain environment" (L' Hermitte et al., 2015, p.221). Supply chain agility is a logistics strategy that aims to respond quickly to short-term changes in demand (or supply) and to smoothly handle external disruptions (Lee and Marc 2003), which can be a suitable approach to manage the complexity of humanitarian operations. Agile supply chains are flexible, responsive, and effective (Charles et al., 2010). According to Oloruntoba and Kovacs (2015) agile supply chains have the following characteristics: market sensitive by connecting to the end-users needs, virtual through information sharing across the supply chain, and orchestrators of networks by using the strengths of the network to gain flexibility. Based on recent experiences, it is clear that there is a need for agility to be incorporated in humanitarian operations due to the high unpredictability, and high complexity involved as well as the need for situation specific response (Charles et al., 2010; Wassenhove, 2006). This could bring significant benefits to humanitarian operations such as increased responsiveness to the changing needs of the end users and demand changes, and improved flexibility and efficiency (Chandra and Kumar 2001; Oloruntoba and Gray 2006; Nelan, Wachtendorf, and Penta 2018). Agility could improve mass evacuation in disasters by assuring high real-time reactivity to safety changes throughout the evacuation process for evacuees, increasing flexibility and efficiency of the processes through network collaboration, and information sharing across stakeholders (Oloruntoba and Kovacs, 2015; Lujak and Giordani 2018). Implementing agility in mass evacuations will develop operations and strategic level capabilities such as purposeful, action-focussed, collaborative, and learning oriented capabilities (L' Hermitte et al., 2015). Current research on agility in mass evacuations planning is focused on the transportation stage of the process (Lujak and Giordani

2018), but there is lack of research regarding agility in mass evacuations looking at each one of the evacuation stages and to the process as a whole.

Taking a holistic view of mass evacuations planning from the agility perspective will incorporate the benefits of agility across the different evacuation stages. This is particularly important for practice, as NGO's and governments plan and conduct mass evacuations considering the whole process of mass evacuation rather than the individual stages. The increase of disasters worldwide and their inherent uncertainty and unpredictability requires continuous improvements in mass evacuations to make them for efficient, responsive, and adaptable to the particular context. An agile mass evacuation could mean that more lives are rescued by adapting to the people's needs and the specific disaster conditions, which highlights the high societal impact of this research. Additionally, a comprehensive framework for agility in mass evacuations planning considering all the evacuation stages is missing from the literature. Hence, this research will bridge this gap in theory and practice by developing a comprehensive framework for agility in mass evacuations planning, i.e. Agile Evacuation Operations (AEO) framework, considering all the different evacuation stages. The research question is the following: How could agility be incorporated in the planning of the different mass evacuation stages?

The aim of this research is to study how agility concepts can be applied to evacuations to develop an evidence-based framework for improving mass evacuation planning in disasters through agility. This is the first study that considers agility across all the evacuation stages. Looking at the current outlook of potential disasters in Europe, interviews were conducted with disaster-related experts from Northern European countries. Having faced prior disasters, authorities in these countries provided insights about current practices and needs in evacuations. Their experiences and views are used

to build a framework for incorporating agility in mass evacuations in a context that could be exploited by other European countries with similar resources.

The paper is organised as follows: Section 2 presents the literature review, section 3 discusses the research methodology, section 4 presents the interview findings, and section 5 discusses the results. Section 6 draws conclusions and provides future research directions.

2. Literature review

2.1. Humanitarian logistics

Major crises have become a significant problem for authorities globally. The impact of recent disasters combined with poor management of operations (See Bogard 1988) have attracted the attention of several researchers lately. As a result of the implications of humanitarian situations for victim's wellbeing, it is important to develop efficient tools for effective management (Van Wassenhove 2006; Kovács and Spens 2007). The purpose of these contributions have been to develop strategies and solutions for humanitarian operations characterised by a dynamic environment (Drabek and McEntire 2003), high levels of uncertainty (Balcik and Beamon 2008; Whybark et al. 2010; Van Wassenhove 2006), and shifting priorities over time (Van Wassenhove 2006; Whybark et al. 2010).

Humanitarian logistics is a discipline arising from the need to support disaster victims in need of products and services in the face of a crisis. It can be defined as "the process of planning, implementing, and controlling the efficient and cost-effective flow and storage of goods and materials, as well as related information, from point of origin to point of consumption for the purpose of meeting the end beneficiary's requirements" (Thomas and Mizushima 2005). This field has two main areas of study: continuous aid

work and disaster relief. The former looks at slow-onset situations such a drought or famine, whereas the latter focuses on sudden disasters commonly caused by natural phenomena (Kovács and Spens 2007). In both cases, there are high stakes involved (Kovács and Spens 2007) which require the appropriate management of resources to account for the high cost of operations (Christopher and Tatham 2011).

Humanitarian logistics plays a prominent role across the different phases of emergency management, namely mitigation, preparedness, response and recovery (Drabek and Hoetmer 1991); but it is closely related to disaster preparedness and response. Preparedness involves planning and prevention, which can include early warning (Nagarajan, Shaw, and Albores 2012), preventive evacuation (Kolen et al. 2013), location of emergency facilities (Balcik and Beamon 2008) and stock pre-positioning (Rawls and Turnquist 2010). Emergency response refers to the activities just before, during and after the disaster strikes including relief distribution (Rodríguez-Espíndola, Albores, and Brewster 2018b), post-event evacuation (Apivatanagul, Davidson, and Nozick 2012) and inventory planning (Beamon and Kotleba 2006).

Caunhye, Nie, and Pokharel (2012) introduced a framework incorporating the most relevant activities involved in preparedness and response. These activities include: evacuation, stock pre-positioning, facility location, capacity planning, relief distribution, casualty transportation, and inventory planning. In real operations, all of these activities are challenging because they involve the participation of different organisations (Rodríguez-Espíndola, Albores, and Brewster 2018a), the appearance of self-initiated participants (Drabek and McEntire 2003; Whybark et al. 2010), and communication constraints (Drabek and McEntire 2003; Tatham and Spens 2011). Therefore, each one of the activities mentioned above requires approaches to ensure efficient and responsive operations to protect people.

Evacuation is one of the most important activities in humanitarian logistics because it can reduce the level of mortality caused by crises. The purpose of this activity is to transport people from a risky area to safer locations for temporal or permanent support, and it is a strategy widely used both at the preparedness and at the response stages (Bayram 2016). There are several articles focusing on evacuation from the point of view of operational research (Altay and Green 2006), but recent experiences show the necessity to look at evacuations using the perspective of operational excellence to improve humanitarian operations.

2.2. Evacuation Planning and Management

Evacuation has been defined as "the mass physical movement of people, of a temporary nature, that collectively emerges in coping with community threats, damages or disruptions" (Quarantelli 1980). The purpose of evacuation is to transport the vulnerable population to safe locations, either temporarily or permanently, in order to reduce deaths and injuries. This activity can be essential to protect vulnerable people because it allows to reduce the chance of the disaster reaching the population, but it involves several logistics decisions which have to be carefully managed.

Southworth (1991) adapted the traditional model for transportation planning into a five-step process for evacuations planning including *trip generation, trip departure time, trip distribution, network assignment, and the development of a user specified-plan*. Looking at the origin of the evacuation, trip generation involves the analysis of the point of departure of the evacuees (Bayram 2016) whereas trip departure time looks at the response timing of the evacuees (Southworth 1991). In any evacuation, it is key to understand the evacuation zone and the potential demand to create an evacuation plan (Shaw et al. 2011). Several factors can have a significant effect on the success of evacuation because of the effect of the context of the situation (e.g. time of the day, the

day of the week, externalities in the area, among others) and the behaviour of the people affected (Bayram 2016).

Trip distribution and network assignment focus on the selection of the most appropriate refuge facilities, and the mode of transportation and the path chosen to get there, respectively (Bayram 2016). The selection of the destination is a critical part of evacuations (Sherali, Carter, and Hobeika 1991), and it needs to be complemented by the right transportation decisions. These steps include the decisions about the most appropriate combination of options available to reduce risk and transportation time. Safety becomes of paramount importance both in-transit and at the destination. During these stages, there is a strong focus on the supply of resources provided by authorities (in the form of facilities, employees and vehicles) and their practices to transfer the victims from areas at risk to safer zones.

The user-specified plan refers to the analysis from the manager to test different strategies using traffic management controls (Murray-Tuite and Wolshon 2013). At this step, authorities consider the controls at their disposal such as signal times and road closures (Southworth 1991) that could enable them to implement the evacuation plan and enhance the operations.

All of the stages presented are essential to provide reliable and robust evacuation plans, very often with the support of different models. There is ample literature looking at the use of operational research (OR) formulations to provide evacuation plans to support decision-makers (Caunhye, Nie, and Pokharel 2012). However, some of the assumptions included in these models, such as considering no alterations during the execution of the plan, can be difficult to transfer to reality (Galindo and Batta 2013). In the field, there is a series of challenges which complicate operations. Beyond the infrastructure damages commonly found in crisis (Tatham and Spens 2011; Van

Wassenhove 2006), evacuation can be hindered by the absence of accurate and updated information (Drabek and McEntire 2003), the behaviour of the evacuees (Durage et al. 2014), and the effect of external traffic (Bayram 2016). These problems highlight the need to have more adaptable plans. Several studies have been looking at the effect of human behaviour on evacuation (Toledo et al. 2018; Li, Zhuang, and Shen 2017). Nevertheless, the wide range of behaviours, the appearance of improvisation, resource variability, and route changes (Toledo et al. 2018; Murray-Tuite and Wolshon 2013) make it important to introduce an approach that can flexibly adapt to dynamic conditions. That is the reason this paper is looking at lessons from the agile approach to improve evacuation planning and management.

2.3. Agile systems in humanitarian logistics

The agile approach has been treated as the evolution of lean, which can only handle a pre-determined number of variants and is better suited to situations with known demand and steady production (Potdar, Routroy, and Behera 2017). Agility is very useful in settings where speed is the priority (Soni and Kodali 2012), as it can be defined as the capacity to be flexible and responsive in order to manage risks and uncertainties (L'Hermitte et al. 2016; Ifandoudas and Chapman 2009; Lauras, Dupont, and Humez 2012). This concept has been clearly associated with different areas such as manufacturing (Soni and Kodali 2012), business (Loss and Crave 2011), project management (Mafakheri, Nasiri, and Mousavi 2008), supply chain management , among others. The reason is because the concept of agile considers dynamic environments and focuses on the customer (Potdar, Routroy, and Behera 2017; Bruce and Daly 2011; Mafakheri, Nasiri, and Mousavi 2008), which makes it valuable for multiple contexts. A prominent feature of agile is that it works at its best in circumstances which we cannot control, not only accommodating change but

welcoming it in order to thrive and prosper (Maskell 2001; Loss and Crave 2011).

Moreover, agility can be value in multi-disciplinary environments because it can boost the performance of participating organisations, reduce their weaknesses, create more synergy in the field (Loss and Crave 2011), and create more resilient organisations (Purvis et al. 2016).

Maskell (2001) postulates that the agile approach has four main aspects: customer prosperity, people and information, co-operation within and between firms, and fitting a company for change. Customer prosperity refers to the strong focus on the customer and their needs. Instead of looking at the processes and capabilities of the firm, this aspect is looking at the value generated by the product/service to the customer. To that end, this approach is looking to involve the customer from the design stage to improve the final outcome. People and information involve the interaction through the use of knowledge-based systems to achieve customer awareness. Also, it looks at the interaction of these systems with stakeholders. Cooperation on the other hand is looking at the synergy of capabilities across departments and organisations, which can be achieved through introducing more flexible structures to encourage joined operations. Fitness for change refers to the empowerment of the final links that interact with the customer through high levels of education, training, and alignment towards a clear objective. The purpose is to have assets that are able to reconfigure resources to serve different customers.

The unpredictable and turbulent nature of humanitarian supply chains highlights the need of adaptability and flexibility that could be achieved using agile principles (Oloruntoba and Gray 2006). In fact, agility can add a degree of resilience built-in the plans and the organisations (Purvis et al. 2016), which is the reason both concepts have been linked before (Altay et al. 2018). That is the reason several authors have hinted the

value of agility in humanitarian supply chains (Van Wassenhove 2006; Charles, Lauras, and Van Wassenhove 2010; Oloruntoba and Gray 2006). Among the articles looking at this area, L'Hermitte et al. (2016) show the value of agility in continuous relief operations based on the case of the World Food Programme (WFP), whereas Cozzolino, Rossi, and Conforti (2012) use the same context to analyse the role of lean and agile across different stages of the WFP. The relationship between lean and agile has been well established in the supply chain literature (Bruce and Daly 2011; Ifandoudas and Chapman 2009; Moyano-Fuentes, Bruque-Cámara, and Maqueira-Marín 2018), but in the context of emergency logistics, Lotfi and Saghiri (2017) link leanness and agility to resilience in order to show their impact in organisational performance, finding improvements in cost and responsiveness, among others. Baham et al. (2017) propose the use of agility for disaster recovery from the project management perspective to support businesses affected. Looking more towards monetary and material donations in cases of disaster, Nelan, Wachtendorf, and Penta (2018) postulates that agility is a suitable approach for the management of donations, especially to sort relief items. Looking at supply chain agility and resilience on performance, Altay et al. (2018) found that these elements have a significant effect on pre-disaster performance. The works presented so far show the potential of agile in humanitarian operations, but we believe that the implementation of agility in this context is still at an early stage.

Although most of the extant research is looking at relief fulfilment, the idea of agility in humanitarian operations can be transferred to other relevant activities. For instance, Lujak and Giordani (2018) address the area of evacuation specifically. In their work, the authors propose an algorithm to find agile evacuation routes which allows to change and reroute depending on the conditions under uncertain environments. A summary of the contributions can be seen in Table 1, which shows the interest paid to

the supply chain but highlights the lack of studies looking at agility in evacuation. In that sense, it is evident that Lujak and Giordani (2018) provided a valuable contribution to achieve more responsive evacuations, but based on the classification from Southworth (1991) it mostly addresses network assignment and disregards other stages. As a result, the value of agility to the different stages of evacuation is a gap in current literature. It is important to provide an analysis about the integration of agility across evacuation stages to tackle the challenges found in past disasters related to changing conditions and the need for re-evacuations (Santos-Reyes, Alvarado-Corona, and Olmos-Peña 2010).

Therefore, as table 1 above illustrates, this article is looking at the potential of agile practices for evacuation planning and management. Despite the number of articles suggesting the integration of agile practices in humanitarian logistics, there is a lack of research bridging the gap between this concept and current practices from managers in the field, especially for evacuations. Through the application of interviews with managers from different organisations in three different countries, this article is proposing a framework for the implementation of agile evacuation planning.

Table 1 - Taxonomy of the literature

Authors	Focus	Contribution	Application of agility in humanitarian logistics	Agility in evacuations	Approach
Van Wassenhove (2006)	Supply chain management in humanitarian logistics	Showing the importance of agility in different settings to support disaster response	Disaster response (Relief distribution)	Not explicitly mentioned	Theoretical discussion based on humanitarian logistics' cases
Oloruntoba and Gray (2006)	Agility in the humanitarian supply chain	Arguing the value of agility in disasters and proposing postponement as a suitable substitute to pre-positioning aiming to have an efficient flow through the supply chain	Disaster response (Stock pre-positioning and relief distribution)	Not explicitly mentioned	Theoretical discussion
Charles, Lauras, and Van Wassenhove (2010)	Supply chain agility	Discussion about supply chain agility and developing a model to assess the agile capabilities of humanitarian organisations	Disaster response (Relief distribution)	Not explicitly mentioned	Interviews and case studies
L'Hermitte et al. (2016)	Supply chain agility in protracted operations	Introducing the value of agility in humanitarian protracted operations	Disaster recovery (Relief distribution)	Not explicitly mentioned	Case study

Cozzolino, Rossi, and Conforti (2012)	Supply chain agility	Exploring the appropriate stages for the use of lean and agile principles in humanitarian logistics	Different stages of disaster management	Not explicitly mentioned	Interviews and case study
Baham et al. (2017)	Information management	Use of Kanban in a complex scenario	Disaster response and recovery	Not explicitly mentioned	Action research
Lotfi and Saghiri (2017)	Supply chain agility	Looking at the implementation of lean and agile to enhance resilience in disaster management	Disaster recovery	Not explicitly mentioned	Survey and statistical analysis
Nelan, Wachtendorf, and Penta (2018)	Supply chain agility	Analysing the effect of agility to reduce convergence in humanitarian operations	Disaster response (relief distribution)	Not explicitly mentioned	Interviews
(Altay et al. 2018)	Supply chain agility	Exploring the impact of supply chain agility and supply chain resilience on performance	Different stages of disaster management	Not explicitly mentioned	Survey and statistical analysis
Lujak and Giordani (2018)	Agile evacuation routes	Algorithm to find agile evacuation routes which allows to change and reroute	Disaster response (network assignment)	Explicitly mentioned	Modelling

		depending on the conditions under uncertain environments			
Present article	Agile practices in evacuation management	Development of a framework to plan evacuation considering the use of agile principles	Disaster response (Evacuation)	Explicitly mentioned	Interviews and case studies

3. Research Methodology

In order to prove the use of the concept of agility in evacuation, a framework was developed by combining Southworth's (1991) framework for evacuation with Maskell's (2001) dimensions of agility and data collected from emergency managers, civil protection officials, Non-governmental organisations (NGOs) and other relevant actors.

The research approach and methods used to collect data on evacuation and how the data were analysed are now discussed. This research is exploratory with the application of qualitative methods, involving a focused literature review, interviews and observations. The approach for this research was qualitative. Van-Maanen (1983) (cited in Easterby-Smith, Thorpe, and Jackson (2012)) defines qualitative methods as "an array of interpretive techniques which seek to describe, decode, translate and otherwise come to terms with the meaning not the frequency of certain more or less naturally occurring phenomena in the social world".

Semi-structured interviews were carried out in three countries (Belgium, Denmark and Iceland) with emergency managers. This approach was deemed suitable for the research as semi-structured interviews "involve prepared questioning guided by identified themes in a consistent and systematic manner interposed with probes designed to elicit more elaborate responses. The focus is on the interview guide incorporating a series of broad themes to be covered during the interview to help direct the conversation toward the topics and issues about which the interviewers want to learn" (Qu and Dumay 2011). The three countries were selected as case studies because the focus of their preparation includes different types of disasters. These countries have plans for a variety of disasters, but for this study, they focused on evacuations around nuclear plants, due to terrorism/flooding and caused by volcanic eruptions, respectively. They were chosen for the study because of this different focus on disasters. Whilst their

operating structures are similar and therefore allow comparison between the countries, they are headed by different entities (Ministry of the Interior, Police and Civil Protection), which helps the generalisability of the findings of the study. Therefore, the social similarities among these countries allows comparability, whereas the difference in their internal disaster management structure can help provide more robust results. These cases are treated as a holistic, multiple-case design (Yin 2011) in that the focus of the interviews was a single type of incident (e.g. volcanic eruption) for each country and therefore is considered as a single unit of analysis, but we are using three cases, following the replication logic proposed by Yin (2011). This replication logic intends to cover different types of disasters (natural and man-made, sudden and slow onset (Wassenhove 2006)) in order to see the way in which the authorities in these countries have faced prior disasters to provide insights about current practices and needs in the area of evacuations.

The qualitative data for the project was collected through practitioner interviews and observations of sites. The interviews took place over a period of six months. The sampling method used was purposeful sampling. Purposeful sampling was chosen because "The logic and power of purposeful sampling lie in selecting information-rich cases for study in depth. Information-rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the inquiry, thus the term purposeful sampling" (Patton 2002).

Of the 16 purposeful strategies proposed by Suri (2011), Operational Construct Sampling was deemed the most appropriate for this research since "one selects cases that represent 'real-world examples (i.e. operational examples) of the constructs in which one is interested'" (Patton 2002).

Interviews were carried out by teams of at least two researchers, to reduce bias. They were recorded and transcribed. A total of 24 interviews were conducted, comprising a total of 27:17 hours of recordings (See Table 22) and included the following actors: First responders (Police, Fire Service, Ambulance), emergency managers, civil protection officials, NGOs and other relevant organisations (e.g. port authorities, municipal transport). These actors were selected because of their role in the preparation, logistics and execution of evacuation plans.

Table 2. Data collection summary

Country	Interviews	Length of interviews
Belgium	11	11:40
Denmark	8	10:14
Iceland	5	05:23

All interviewees were fully informed about the purpose of the interviews and steps were taken to put the interviewees at ease during the interviews so that a two-way, open communications climate existed (Shaughnessy and Zechmeister 1985). All data collection and analysis conformed to the standards required by the University's Ethics Committee. While follow-up questions were used to get respondents to elaborate on ambiguous or incomplete answers, care was also taken to reduce bias through refraining as much as possible from asking leading questions (Miles and Huberman 1994).

Once the interviews were transcribed, data reduction was carried out and subsequently, the data analysis was done using a thematic analysis process (Boyatzis 1998) adopting a manual coding approach which allowed to explore similar dynamics and meanings across the interviewees (Mingers, Mutch, and Willcocks 2013; Yin 2011). A provisional list of codes covering mass evacuation operations was developed

from the review of extant literature on humanitarian logistics, evacuation and agile systems in humanitarian logistics. Cross referencing with the literature and informal discussions identified additional codes. Two researchers coded each interview. In order to draw conclusions from the coding, further analysis involved noting patterns and themes. These were clustered to enhance understanding, and then mapped onto the proposed framework. This resulted in an empirically validated framework for incorporating agility in mass evacuation operations considering a context that could be exploited by other European countries with similar resources.

4. Findings and Analysis

The findings sought to understand current practices affecting evacuation operations and the factors that would enable the adoption agility in these operations. Interviews were carried out with 24 managers representing both government and non-governmental organisations from three Northern European Countries namely, Belgium (BE), Iceland (IL) and Denmark (DK). The interviewees have been anonymised and categorised as follows:

- Central government organisations (CGO) – Foreign office, Public Transport Authority, Meteorological office
- Civil Defence (CD) – e.g. Military, Police
- Civil Protection (CP) – e.g. Emergency management centre, crisis centre
- Emergency services (ES) – e.g. Fire and health services
- Local government authorities (LGAs) – e.g. Local municipality, communication departments
- Non-government organisations (NGOs) – e.g. Red cross, charities
- Research institutions (RI) – e.g. Universities

Many of the practices (outlined below/ Table 3) considered during evacuation operations by the managers in the countries selected are covered by the existing literature, but findings also highlight additional factors such as local knowledge and support, organisational structure and command of decision making that need to be addressed to introduce agility in evacuation operation. The analysis was summarised using the following themes:

- communication and information sharing

- collaboration and coordination

- adaptability and flexibility

- evacuation drill and training

- local knowledge

- evacuation routes planning and shelter

Evidently, there are different practices among the organisations interviewed and different components driving their decisions. The codes extracted from the literature were analysed to find out the way in which organisations have approached those decisions and the effect of the different components in their practices. The analysis and findings are illustrated using extracts from the interviews. This section shows current practices undertaken by authorities and the dimensions which affect those practices, and the link of those dimensions to the implementation of agility in evacuation planning.

4.1. Collaboration and coordination

Multi-stakeholder *collaboration* and *coordination* was identified by all the interviewed organisations as a key practice that affects agility in evacuation operations. Authorities are aware of their responsibilities and the need to interact with other stakeholders. In

Denmark, it was the civil protection organisation taking this coordinated action and one of the interviewees from the emergency services highlighted that:

> "So if an incident happens, that and involves more than one agency, then you have a coordination task; and that coordination task within the law is laid upon the police. And so, the police steps in and coordinates, and that goes from very small like traffic incidents, traffic accidents to if a fire factory blows up, and even if flooding…" (ES, DK)

The above statement clearly indicates that the coordination of the evacuation operations was managed by an individual authority enabling to better respond to emergency scenarios. The coordination efforts in the examined countries were relatively adequate and there was consensus that effective disaster management and a speedier evacuation required efficient multiagency coordination and collaboration amongst public and private agencies and organisations on the local and national levels. An interesting finding of this quote is the trade-off between clear hierarchy and flexibility. Police takes the coordinating role regardless of the type of emergency, thereby establishing well-defined jurisdiction at the expense of flexibility, as every disaster is different and requires distinct resources. Unsurprisingly, *communication and information sharing* as part of an effective coordinated effort was also a key factor that was emphasised by almost all government organisations for evacuation operations. Interview findings highlighted that a well-prepared communication strategy that provides a coordinated message and a consistent and joint effort between organisations avoiding any confusing messages is key for agility in evacuation operations, as expected in centralised systems. One of the interviewees from the Central government organisation in Denmark highlighted that:

> "very important issue is to come up with the coordinated press release or a communication strategy. So what we also do is that, when we setup the National

Operational Staff, we have a national central communication staff, which consists of communications advisors an experts from the involved agencies. ….” (CGO, DK)

The above statement evidently indicates that the coordination with the media is essential to effective disaster management to disseminate accurate information in a consistent timely manner before, during and after disasters from experts is key in mass evacuation operations. In this context, development of a communication plan or strategy is regarded as an important exercise as part of information sharing and public reporting. Moreover, that statement shows the importance of making people aware of the circumstances and the decisions, as their behaviour can affect operations. Findings also highlight that the *complexity in decision making* in a collaborative and coordinated evacuation effort had a significant role to try to implement agility. The decision-making process of the responsible officer depending on the incidents adds to the delay in response time for the evacuation time. This centralised decision-making strategy has been criticised by its shortcomings such as lack of responsiveness, but it is still used widely. A civil defence respondent in Belgium highlighted the complexities involved in the decision-making process:

“When I speak - when I speak about mission, I must think about where, which are the limitation of my action. limitation, a question of time. If I [heard?] then we must evacuate a great building like this one. This evacuation will take a great time, to make a complete, total evacuation. Why must I evacuate this building? Maybe because a question of future explosion. The first thing I must know where, and what time we and the bomb explodes. Of the problem explodes. And then I take minimum, enough for our security, 30 minutes before I stop, I will stop my action. Then this limit for the mission, limit of time. Which are the security for my personnel and for the population. Security for 2. I must think and it is an alternative, another situation. If during [SPEAKS IN FRENCH] the passage of a toxic cloud. If the wind take another direction, I must think on that. Okay [this all?] ... I must have alternative…“ (CD, BE)

The statement above emphasises the importance of key decision points such as whether it is preferable or not to evacuate individuals from potentially affected areas and when to trigger the actions. It clearly underlines the importance of information in decision-making, which can be challenging in a chaotic environment. Depending on the emergency scenario, the decisions for evacuation operations are made within the various level of authorities. For instance, in some cases an evacuation order can simply be made by the civil protection officers on the ground but in certain cases, the decision needs to be escalated to a senior official with the civil protection authority which then might need the approval of a senior central government official. Thus, these layers and inconsistency in the decision making increases the response time in evacuation operations and in many cases reduces the decision-making power of staff. A civil defence respondent highlighted:

> "on the very very top we have the government security committee, these are the elected ministers; from the prime minister, the minister of economic and business affairs, the minister of foreign affairs, the minister of defence, and the minister of justice; they have the overall political responsibility regarding crisis management. And, they have senior official groups, which are the heads of departments from these ministries, and then they are supported by the two intelligence services; both the police and the military intelligence services. And then, they have the crisis management groups, which are the heads of offices for the same ministries, and then you will have the national police." (CD)

The above statement clearly indicated the various structural layers that are inherently required coupled with the complexity of decision making depending on the emergency scenario significant affects agility in evacuation operations. It hints the challenges with bureaucracy and responsiveness embedded in these disaster management systems. In some cases, decision on evacuation orders are made by emergency services experts in order to reduce the interference of political motivation in

emergency decisions and to reduce response time for evacuation operations adding to agility.

4.2. Adaptability and flexibility

It is important for organisations to be able to react to changing conditions swiftly. The interview findings highlight that adaptability and having enough flexibility in the system is a key element that is considered to be of importance for evacuation operations. Adaptability in preparedness and the response planning was found to be a common important practice related to agility in evacuations. Disaster response organisations were found to have a masterplan that can be used as a basis for responding in different types of disasters. This masterplan can be adjusted to different types of disasters, and disaster specific circumstances such as number of people affected. One of the interviewees from the Local Government Authority in evacuations plans in Belgium highlighted that:

> "No response plan is final. They are all kind of living documents and we have to change and make changes. It's not like there's only one thing that we have to prepare for, but what we look at, we look at it … we have to have kind of one plan that we can always use. Like this generic plan we can always use it, we can always adjust it to any hazards, but within these plans we have these specific plans that we have to work much … do much more work." (LGA, BE)

Models for evacuations are used a basis for responding to disasters. However, these models should be built in a way that could be adapted to the different emergency situations in real-time and they need to be situation specific. Thus, there is no single way for responding in mass evacuations, and flexibility of plans is essential. However, the way this flexibility is sought is not clearly defined. An expert from the Civil Protection in Belgium highlighted that:

"We have a great deal in models, in fact maybe this is a way to respond to your question, we often are confronted with people that ask to prepare a plan or a system to respond to an emergency within the organisation. They say, give us things like this and what do we need to do and there is not one single way, because if we have a broad response to anything that can occur and sometimes we train people in a call centre who say "do tell us what the right sentences are" and the situation is so complex." (CP, BE)

The abovementioned statement by the civil protection officer stresses that there is a need to make efforts to create flexibility and agility while preserving the structure and discipline when responding to stakeholders during emergency evacuation scenarios. The complexity of every disaster specific evacuation requires a basic evacuation plan that will be flexible and adaptable according to the disaster situation. One aspect of paramount importance is training, and how this training must be oriented towards empowering people to avoid them just repeating and depending on the higher levels of the hierarchy. Adaptability is an important element to be considered when prioritising decisions for evacuations. For example, in Iceland simulations are used in the occurrence of the disaster to predict its impact in the next few hours. Based on the predictions the existing basic evacuation plans are adapted. A central government organisation officer responded:

"So, what we did based on the simulations was draw initial grounds to show the advance of the disaster. So one and a half hours after the eruptions starts, the water is at this stage. After two hours it has advanced across the road here and it's still again, uninhabited areas up here and after two and a half hours, it's closing the road junction up here. So based on that information, we looked at the inhabited area and decided on the evacuation priority." (CGO, IL)

The necessity for considering victim/individual needs during the time of evacuation was found to be a key element of adaptability. Based on the evolving needs

of the disaster situation each evacuation is continuously adapted according to the evacuees needs. Specifically, one of the civil protection managers highlighted that:

> "Yes and in fact that sort of evaluation is the heart of our activity. We describe ourselves as not delivery specialists but as being able to pay attention to evolving needs, so assessment is continuous and we don't have a survey approach, but once we are in touch with the people, the community, we know that the needs are evolving with the event and that we need to anticipate the evolution of those needs. That is a very important that it will evolve very quickly if you were not able to respond at one time, you may get a chance to respond later on or just drop that and take a chance to respond to the next wave that will come, but there is no way to, we know by experience what the needs are but the response will be different depending on the type of people." (CP)

The above statement noticeably highlights the importance of realising that structured planning and organization are only effective if the ability to improvise is preserved, which leads to flexibility. In other words, without improvisation, evacuation operations and management lose flexibility in the face of everchanging conditions and needs of the beneficiaries. Overall, the interview findings clearly indicate that flexibility and adaptability are key elements that are considered during evacuation operations. Managers are interested in achieving more flexible and adaptable responses, but they struggle to implement initiatives that can lead to better operations.

4.3. Evacuation routes and facilities planning

As part of the evacuation operation, the findings indicate that facilities (e.g. shelter and emergency distribution centres) location and evacuation route planning are key factors for efficient and timely response when an incident occurs and there is a need for immediate mobilization and action of multiple stakeholders for the provision of varying supplies and services needed by the victims. Most of the government organisation interviewees highlighted that evacuation route planning is a complex process consisting

of several consecutive phases. For instance, after the detection of an incident, responsible managers (decision makers) need to promptly assess the potential threat for specific areas and then issue an evacuation order and develop a plan for these areas if the risk is significant and there are no shelters to provide adequate in-place protection. An interviewee from the civil protection organisation as a planner of evacuation operations emphasised the importance of local *knowledge of staff and the information provided* at this point helps with timely evacuation routes and facilities planning and to respond accordingly. Without the lack of knowledge of the full environment that includes the local knowledge and information, it would be challenging for the evacuation planner for example to find the shortest routes to closest exits as they do not know the impact of the disaster on potential evacuation routes, and cannot consider capacities. The interviewee stated:

> "I can ask this assistant of the quarter policemen because he knows the population who live there. Of the caretaker, concierge, the caretaker. I must have an information about the register of the building. Then very quickly I can have the list of the persons who are registered for this house. After that then in the circulation plan which are the different roads. Which roads can I use for, to make the evacuation? Which safe place for the regroupment, this, when the people are outside. Which are a safe place, I must be sure that it's a safe place and obviously away from future problem. There is how many people in the building, and which kind of population. It may be that the caretaker will give me information because I have old people and old people which have problem too, and then it's for him it's very difficult to follow directly the instruction. And maybe I must go out there with the presence of the medical support…." (CP, BE)

The above response by the civil protection officer emphasises the significance of exploiting local knowledge and engaging both local staff and the beneficiaries in achieving timely evacuation planning and operations. One of the Central Government Organisation interviewees from Iceland reported that in order to manage emergencies

more effectively and timely, decision makers may benefit from having in-place evacuation plans for scenarios which are most likely to happen, although real-time design or re-evaluation of evacuation plans may be required after an incident occurs. The interviewees from the Central Government organisation in Iceland stated:

> "We have been making evacuation maps, I can show you later I have also a slide of that and then we have marked areas and different levels, we have level one and two and three. Level one is, that is the most serious. That is the first area we evacuate so closest to the hills, to the mountains and this is made by the IMO and the evacuation itself is performed by the locals, by the head of police and the civil defences…" (CGO, IL)

The respondent stressed the need for evacuation planning where authorities in surrounding areas have an important role to play in facilitating agile evacuation operations. Thus, highlighting that route and facilities planning undertakings such as traffic management, providing shelter, and delivering equipment and services are an integral set of activities in ensuring effective mass evacuation operations. Furthermore, one of the officers from Civil Protection organisations mentioned that:

> "You have prearranged places where you can bring people in some incidents. And what you do is, in the initial planning, you sit down actually and figure out who will we need if we have to evacuate this and this facility. We need somebody to transport people, we need somebody to host people until they can get back to their homes, and we need somebody to feed them, and so on and so on. And then, you bring in all the different sectors or companies or whatever it is." (CP, BE)

Thus, the above interviewee statements clearly emphasise the need for the pre-planning and operational aspects to include the involvement of multiple stakeholders in the plan in order to execute a timely evacuation response when an incident strikes. One of the major challenges the interview findings highlighted in evacuation operations is that evacuation zone exit routes are often limited in number and insufficient in capacity

to handle the traffic surge during a large-scale emergency evacuation. In particular, the capacity of transportation networks generally cannot satisfy the intense demand for transportation during an evacuation, and that even on small neighbourhood-scale evacuations, transportation networks can impede the fast clearing of the population from an effected area. This calls for organisations to work together and pool their resources in order to effectively carry out an evacuation operation and to address resource limitations and demand fluctuations.

4.4. Evacuation drill and training

The findings highlight that the evacuation drills and training provided to support staff working in emergency management roles, outlining procedures during the incident, are helpful in preparing staff to react promptly and efficiently during evacuation operations, thus, having a positive impact on agility. It was noted that training about emergency planning in collaboration with different organisations, instead of independently, plays an important role as part of the disaster preparedness process. Different authorities are involved in emergency planning such as civil defence, Red Cross, crisis experts, research institutes, and governments. An expert from the Civil Protection in Belgium stated:

> "The institute organises specific training for various authorities about emergency
> planning and the organisation of rescue services. So it's mainly for provincial
> authorities that we organise our information days for. We also develop internal
> and external emergency planning know how and risk identification. Risk analysis
> and management know how for local and national or international authorities. We
> try to set up networks with academics, experts and centres and the European and
> international level." (CP, BE)

However, it was also noted that training for evacuations is not limited to disaster response authorities. Training of volunteers and the public takes place in all three

countries which aids with improved awareness for public evacuation leading to prompt response an incident occurs and the public reacting faster. There seems to be a need for psychosocial first aid training for both volunteers and public during evacuations people face stressful situations due to traumatic events. One of the respondents from the civil protection organisation in Belgium stated:

> "We have been working quite a lot with the authorities with their training volunteers and gradually we see any interest moving to let's say organisation of their own like private firms, not for profit organisations that are requiring first assistance in any emergency they are confronted with and ready prevention as well. And we are considering having a sort of separate training for individuals so that people get first aid emergency training, they would have psycho social first aid training to have an idea of what it is." (CP, BE)

The above statement shows an initial step to involve beneficiaries to improve operations, acknowledging that their preparedness and actions affect the whole response system. The importance of evacuation plans to be driven by the evacuees needs is evident here. Different exercises take place frequently by both government and non-government organisations in order to prepare the public for evacuations. Public preparation for mass evacuations in order to be able to respond to the evacuation guidelines from authorities is a significant element for agile evacuation. An interviewee from the Civil Protection in Denmark stated:

> "Then on the other hand, if they might die from a smoke suffocation, if they are alerted, you might better get them up and then you start the sirens all over the country. And everybody, I think everybody in Denmark knows that if they hear the sirens, they know this means go indoor, close windows, stop ventilation, listen to the radio." (CP, DK)

The importance of public drill is emphasised by the civil protection officer and thus highlighting that no evacuation planning effort is complete without testing. For

example, periodic drills may be an effective way to get a realistic view of how an evacuation operation might work. Especially, the involvement of public community groups and the necessary emergency services to participate in these drills will instil preparedness and swift evacuation operations when a disaster does strike. In sum, it is most certain that evacuation drill and training provision is key for both staff of organisations involved evacuation operations and public for an efficient and prompt response to disasters.

4.5. Role of Technology

The findings highlight that technology systems have an important role in agility of evacuation operations. There was a range of channels (e.g. telephone, radio, website, warning systems, sirens etc) used to disseminate public messages in the event of an emergency scenario. For instance, in Belgium, radio alarm receiver systems were installed in households which could be remotely activated to warn the individuals in the house in case of an emergency. Countries also had more technologically advanced warning systems such as a telephone warning service used in Belgium to disseminate a warning message to the household phones and which helps with the agility of evacuation operations. One of NGO respondents highlighted how it worked:

> "Well we use an automatic tool to alert people in which the scenarios are built in so it's not a person dialling one person after another, it picks a scenario and the tool starts to call people and page people and send emails with any possible communication." (NGO, BE)

The above statement emphasised the use of an automated tool was key to efficient and quick information transfer and communications between the organizations involved and the public. Thus, the use of technology in this instance provided immediate action for the effective and agile management of evacuation operations for

pre-planned multiple scenarios by reducing response time to unforeseen events. Apart from the role of technology for warning and generating awareness to public, some of the government organisations in Denmark highlighted that in-house technical systems for the staff members helped with speeding up their internal operations. A civil protection respondent highlighted:

> "very simple technical system which enabled you to send out a pre-recorded messaged on the cell phones. So for instance, it goes out to, you can setup different groups according whom you want to alert. And then, you can send it out, and it calls up all the members, board members of the National Operational Staff saying due to an incident so and so, you are called to the National Operational Staff, and please respond if you can be present within thirty minutes; please press 2, if you could be present within an hour; please press 3, if you cannot come in. …… So, that has helped us a lot when we have to get a big group, a large group into the operations there." (CP, DK)

Having an automated technical system to coordinate the different authorities involved in evacuations as groups will speed up the evacuation process by eliminating wasting time to check for staff and or volunteer's availability. Hence, the timing required for evacuation seems to be considerably affected by the warning message, so its timeliness is important. The interview findings highlight that network failure, the time of the day when the evacuation order is issued and the medium of channel (radio versus website) used for warning dissemination have an effect on the level of information provided to evacuees, which in turn can delay evacuation operations.

Overall, Table 3 and the above analysis of the findings provides an understanding of practices affecting agility in evacuations operation from 24 managers representative both government and non-government organisations across three countries. Findings clearly highlighted the significance of multi-stakeholder *collaboration* and *coordination* amongst organisations in the countries that affects

agility in evacuation operations. Adaptability in preparedness and the response planning was found to be a common important factor related to agility in evacuations. There was also consensus amongst organisations that evacuation models should be built in a way that could be adapted to the different emergency situations and thus there is no single way for responding in mass evacuations, and flexibility of plans is essential. The emphasis on technology was mostly reported in civil protection, non-government organisations and emergency services and there was reliance on automation and specialist evacuation systems for agile evacuation operations.

Table 3. Summary of the findings of practices affecting evacuation operation agility mapped against the government organisations.

Evacuation Operations Factors	Belgium							Denmark					Iceland				
	Central government	Civil Defence	Civil Protection	Emergency services	Local government	Non-government	Research organisation	Central government	Civil Defence	Civil Protection	Emergency services	Local government	Central government	Civil Defence	Civil Protection	Emergency services	Local government
Collaboration and Coordination																	
Collaboration	x	x	x	x	x	x			x	x	x		x	x	x	x	x
Internal Communication	x	x		x				x	x	x	x		x	x	x	x	x
Cross Functional Coordination	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x
Public Engagement	x	x			x	x		x	x	x	x		x	x	x	x	x
Information exchange	x	x	x	x				x					x				
Organisation structure				x					x	x	x	x	x		x		
Command of Decision making									x	x	x	x	x		x		
Adaptability and Flexibility																	
Response speed			x	x		x		x			x	x					
Resources availability	x				x	x					x	x			x	x	x
Victim Needs			x	x		x		x			x					x	
Readiness to Change		x	x								x						
Evacuation routes and facilities planning																	
Fast Recovery		x		x					x	x	x				x		
Shelters/refuges					x				x	x	x				x	x	
Demand planning			x	x	x												x
Pre-planning/Preparedness/Readiness		x	x	x			x	x	x	x	x	x	x			x	
Local knowledge and support					x				x	x	x		x			x	
Evacuation drill and training																	
Post Incident Learning			x		x				x				x		x	x	
Staff Training	x	x	x			x		x	x	x	x				x	x	
Public Education and Training						x		x	x	x	x				x	x	
Evaluation and Risk Assessments			x			x	x									x	
Role of technology																	
Automation	x	x							x	x	x				x		
Crowdsourcing																x	
Specialist evacuation systems			x			x	x		x	x					x	x	
Mobile communication system			x			x			x	x			x			x	x

5. Agile Evacuation Operations (AEO) Framework

5.1. Framework development

The interviews gathered from stakeholders in the three countries provided insights about relevant elements that ought to be considered to improve evacuation operations under different contexts. In this section, a framework for the introduction of agile operations for evacuation planning and management is presented (See Table 4). The framework is integrated by the different steps of evacuation planning stated by Southworth (1991) and the different components of agile practices. This research argues that instead of a linear model, evacuation planning requires to be cyclic in nature to introduce agile practices. The framework is joining practices declared by organisations with opportunities for improvement based on their needs.

This study is adapting the classification presented by Maskell (2001) to fit the evacuation setting. Beneficiary involvement was introduced as part of evacuation because of the need to look at the value of the service provided to the victims. Loss and Crave (2011) mention that in times of crisis, it is important to change the roles from "passive" victims to more engaged stakeholders. Unlike commercial settings, in humanitarian logistics the value added to the customer is related to the reduction of death and suffering (Nathan et al. 2017). To that end, the items listed under beneficiary involvement are looking at practices enabling the victims to engage with organisations in order to have more robust plans and operations, integrating different stakeholders, and introducing reconfiguration possibilities as part of design looking to adapt and react based on different conditions.

In humanitarian logistics, technology has been commonly viewed as a valuable asset to improve operations (Özdamar and Ertem 2015). To make agility functional and benefit from its advantages, it is important to exploit technology to introduce

appropriate systems for information management and communication. At the same time, there is a need to train staff with the skillset to manage them. The practices included in this category are related to collecting, sharing, and managing real-time information to improve evacuations. These items are looking at the use of knowledge-based systems to integrate stakeholders and introduce interactive solutions that can be used to support decision-making.

Cooperation and coordination are required because of the high number of stakeholders involved during disasters (Drabek and McEntire 2003). The purpose is to exploit the capabilities and expertise of each one of the stakeholders at the same time as their weaknesses are minimised. Starting with internal collaboration, the practices proposed in the framework are looking at the need to simplify processes and interactions between departments to enhance responsiveness. External collaboration is also included, encouraging the exploitation of opportunistic alliances and co-operative partnerships (Maskell 2001). The engagement of different stakeholders at different stages and the analysis of potential alternative sources of resources (both human and material) are also encouraged. The combination of these elements would allow to create a collaborative network that can achieve more efficient and agile operations (Loss and Crave 2011).

The practices included in the category of fitness for change are looking to ensure that the organisation(s) involved in evacuation are able to handle and adapt to turbulences. The uncertainty experienced during disaster situations require a high degree of flexibility to fulfil the needs of the customer (Maskell 2001). The items listed in this category are introducing that degree of flexibility, empowering the teams in the field to react and make informed decisions, and to allow the introduction of improvement initiatives. This category is strengthening the interaction between the

organisations, technology and the victims with the capability to react, adapt and recover under different settings.

5.2. Discussions

The interviews undertaken stressed the importance of embedding flexibility during evacuations. Although there is an acknowledgement of the value of different models used at each stage of the evacuation process, in reality, managers needed to adapt to changing circumstances which can hardly be foreseen by prescriptive models. This idea is closely related to the category of "fitness for change", in which the purpose was to develop capabilities that would allow managers to have a robust response and enable them to modify according to the circumstances experienced.

Individual and human behaviour came across as one of the main aspects in need for agile approaches. There are different studies looking at the characteristics and variations of this behaviour, but to implement an agile approach it is important to engage more with the beneficiaries. This engagement can be achieved through the use of two-way communication, involvement in planning, and the training of local representatives/liaisons to help organise the population. Engaging and ensuring beneficiaries take part in the process can lead to smoother operations and to exploit the use of their knowledge and collective intelligence to design more reliable plans.

An interesting approach to have constant communication with beneficiaries during evacuation was the use of automated dissemination systems based on pre-designed scenarios. In a more flexible strategy, however, real-time information about the actual conditions can be more valuable for organisations, staff and beneficiaries. The advent of information technology can be an enabler to improve the value of the information provided through the use of practices such as crowdsourcing.

Table 4. Framework for agility in evacuations

	Beneficiary involvement	Staff and information	Cooperation and coordination	Fitness for change
Trip generation	• Interface with customers about vehicles and preferences • Consider evacuation per family (unit) • Encourage prepared and informed beneficiaries	• Use interactive real-time collection methods to support the implementation of the plan • Close monitoring of victims' queries in digital media • Automate dissemination systems based on response scenarios	• Look at potential suppliers for substitute resources (vehicles) • Introduce co-operative arrangements • Coordinate with companies in the area affected to join resources	• Consider the use of local liaisons to monitor changes in infrastructure and resources • Introduce flexible plans/processes to account for the varying conditions (time, day, etc.) • Adopt methods to decide the optimal scale of deployment from volunteers
Trip departure	• Account for customer behaviour • Disseminate good practices to reduce household evacuation time • Use local knowledge about the community	• Introduce monitoring systems to control departures and allow modifications of the plan • Use social media to guide evacuees during the preparation process • Determine evacuation priority using updated information	• Simplify processes and engage with other stakeholders to make the evacuation process more efficient • Facilitate communication between different services	• Liaison with local leaders and representatives to allow smother management and more efficient flows of evacuees. • Use staged evacuation based on local expertise
Trip distribution	• Introduce customer preferences and dynamics of their network • Engage with the private sector to allow the increase in the pool of resources if needed • Introduce customer knowledge and opinion about the infrastructure to avoid re-evacuations	• Monitor in real-time facility occupation to recalibrate plans if necessary • Introduce systems and apps to allow people to follow the evacuations • Empower employees to adapt he plan and look for areas of opportunity	• Use a decentralised approach to facilitate evacuation and facility management • Flattening structures to have more reactive departments • Integration of "functional departments" similar to clusters	• Modularise and cluster areas into plans allowing reconfiguration under changing conditions • Allow flexibility in the organisational structure of shelters to adapt depending on the requirements • Monitor shelters continuously to feedback to the staff on the field and allow them to adapt
Network assignment	• Introduce local knowledge into the planning • Consider the preferences of other potential stakeholders in the area at the time of evacuation • Inform independent evacuees of recommended evacuation routes	• Employ crowdsourcing information to update routes • Use real-time traffic information and alternatives • Adopt different channels, digital platforms and varied formats to reach the victims	• Allow for opportunistic alliances with NGOs, voluntary groups and other stakeholders. • Enable collaboration with self-initiated participants	• Consider reconfigurable routes for evacuation • Provide training for employees to be able to take up different roles according to the circumstances • Introduce dynamic services for handicapped or injured people
Planning and testing	• Introduce feedback loops from the customers about the evacuation process in drills and focus groups • Consider the potential and implications (positive and negative) of citizen-led initiatives • Engage people at different levels of society through volunteer programmes to smooth interaction • Constant contact with evacuees across the evacuation stages	• Use of early warning systems to inform and prepare people • Introduce two-way communication systems to evaluate the strategy • Direct communication contact between authorities and beneficiaries • Empower employees to introduce continuous improvement practices	• Introduce "emergency cells" for cross-disciplinary coordination of self-contained blocks • Simplify process for escalation of deployment • Engage multiple stakeholders and introduce continuous improvement practices	• Consider reconfiguration options at the time of deciding on barricades and control strategies • Engage in discussions with employees on the field to improve plans • Introduce campaigns to train response community representatives and liaisons • Introduce team-based, cross-functional improvement initiatives

Dissemination channels can be linked to these sources of information to reduce uncertainty during the evacuation.

Humanitarian operations are carried out in chaotic environments which require a degree of flexibility and adaptability. These conditions often clash with standard procedures. There was mention of the way plans and instructions are given to staff in the field to follow them in the best way they can, but changing conditions and unexpected situations can make it often difficult to follow those guidelines. An important idea found in the interviews was the importance to engage staff in decision-making. This involvement should take place at two times: at the planning stage and at the response stage. At the planning stage it is vital to consider their experience and insights to have a more realistic picture of the situation and develop implementable plans. But it is even more important is to empower the employees to use their judgement under complex situations at the response stage. Training staff to adapt to the circumstances, to learn how to exploit local knowledge, and to understand the implications of different alternatives can serve to react appropriately to dynamic conditions. The success of this measure also relies on the information provided to the staff. The use of tracking systems and coordinated communication plans has been suggested during the interviews, but constant monitoring and real-time updates of the evolution of the evacuation *and* the conditions of the safe areas have to be in place to allow staff to perform informed decision-making.

There was a lot of emphasis on cooperation and coordination as key elements to implement an agile approach. Often, the level of responsiveness desired can create even more problems if those components are missing. The key takeaways from the interviews were the importance of opportunistic partnerships to expand capabilities, and the value of communication among stakeholders. Currently, it is very difficult for smaller/less established organisations to liaise with the government, which causes a number of self-initiated

participants creating congestion and clashing with each other. Given the uncertainty about the location and magnitude of disasters, it is important to ease the potential interaction with other organisations to make up for shortcomings of human and material resources for evacuation. Encouraging these opportunistic alliances working under a collaborating umbrella through standardised procedures and prior contact can save significant time and effort during the disaster. On the other hand, these partnerships require constant communication and high level of visibility to prevent problems with overcrowding, duplication of efforts and inconsistent operations.

Modularity is a concept from the agile toolbox that can be useful to enhance evacuation management. Decentralisation has been commonly postulated as a good approach for disaster management, but modularisation can make it more functional for the evacuation setting. The interviews made evident the jurisdictional boundaries for different organisations, but that resembled a silo approach more than a well-connected response system. Similar to the clustering system currently designed by the Inter-Agency Standing Committee (IASC), managers from different agencies/organisations can structure evacuation response in the way of modules that fit together depending on the circumstances. Then, the concept of emergency cells suggested by interviewees becomes an interesting solution that could enable an agile evacuation. These cells are cross-disciplinary units for decision-making focused on a well-defined area, and they have the possibility to make decisions and take action. The use of this approach can simplify the organisational structures and enable more responsive operations, but it relies heavily in communication and information sharing for collaboration inside and outside the cell. In that sense, the size of the cell as well becomes a relevant factor. It was set as a fix number during the interviews (5 people), but its implementation would be better served through a set of well-defined roles which are filled depending on the magnitude of the event.

An argument worth mentioning was related to the importance of the destination. Commonly, there is a significant emphasis on the activity of transporting people, but a significant factor to avoid the need for relocation and reluctance from the evacuees to follow the plan is to put more emphasis on what interviewees called "the reception". This is closely related to the human factor in decision-making, because the conditions of the safe facility and the way evacuees are received can affect the need for relocation, which can create congestion especially in staged-evacuations.

The framework presented shows how agility can be a useful approach across the different stages of evacuation planning and provides pointers about planning evacuations using an agile approach. At each stage, the interaction between people, staff, organisations and systems can enable decision-makers to prepare flexible and adaptable strategies to improve the service provided to the beneficiaries. It is also important to mention the cyclic approach presented. At the planning stage, it involves engaging the different stakeholders and setting up the processes for evacuations, which can be tested through drills and discussions. The purpose is to pursue continuous improvement and enhance the evacuation capabilities of the region.

5.3. Framework implementation

The AEO evidence-based framework (Table 4) proposed in this article can be used to aid planning and preparedness for mass evacuations. Following the traditional process for transportation planning, the framework proposed can be seen as a five-stage procedure for evacuation planning in disaster situations.

The implementation of this framework requires looking at the four aspects of agility whilst planning each one of the stages for the evacuation. The steps to follow are:

- ***Identify the area, the disaster and its characteristics*** – Analyse the potential conditions and recognise the potential sources for demand *and* the resources from different stakeholders that are available for the evacuation. Once these elements are known, it is essential to identify the way in which they will interact, and the feedback loops integrated to improve their engagement. Finally, approaches to cope with potential changes or mistakes in planning must be incorporated to allow the system to be adaptive and responsive.

- ***Determine the conditions of departure*** – Factors such as willingness to evacuate, capacity of the infrastructure, and potential for staged evacuation should be carefully analysed. At this stage, the elements identified previously are combined to identify the most suitable plan to start the evacuation. As in the previous stage, the beneficiaries and the stakeholders available must be intertwined to increase swiftness and coordination in the process, paying attention to exploit local knowledge and putting provisions in place to modify the plan if needed.

- ***Allocate evacuees to safe areas*** – Through an analysis of the conditions stated at stage one, the stakeholders need to determine the final destination of the evacuees and the criteria for selection of these destinations depending on the geographical location of demand. This allocation has to consider the dynamic conditions of the disaster through careful communication and monitoring of capacities, engaging with beneficiaries to ensure their awareness of the decision to prevent re-evacuations, and it should be introducing ideas to adapt to unforeseen changes such as flattening structures and allowing for decentralisation.

- ***Route selection*** – Once the demand, evacuation order and destinations are assessed and known, the next step is to transfer the beneficiaries from the affected area to safe locations. This stage is related to transportation and it has to look at the expertise of

the different stakeholders, including local knowledge from the beneficiaries. Coordination among stakeholders is crucial at this stage to avoid congestion, and flexibility driven by the notion to empower employees to react to changing conditions.

- *Plan preparation* – This stage is bringing the outcome of the different stages together and integrating a holistic evacuation plan. At this stage procedural and structural decisions are made to facilitate the execution of the different stages, and feedback is gathered from different stakeholders (including beneficiary representatives) to find potential improvements.

Once feedback has been collected, a new iteration starting from the trip generation stage can be started to improve the plan. The number of iterations depends on the decision maker and the feedback obtained, but this approach adheres to the principles of operational excellence portraying continuous improvement.

5.4. Implications for managers

The implementation of the AEO framework proposed in practice relies in changing the paradigm from disaster victims to beneficiaries. Introducing agility in evacuation planning and response has the potential to considerably improve operations through enhanced flexibility and adaptability. The implications of this approach are:

- Empower staff to make informed decisions based on their expertise and their interaction with the beneficiaries.

- Delegate activities and decisions to ground units, which will allow managers to become coordinators instead of micro-managers.

- Enhanced and robust communication between stakeholders. Thus, ensuring a streamlined and cohesive communication strategy for stakeholders including the beneficiaries during mass evacuation operations.

- The important role of technology to monitor in real-time facility occupation to recalibrate plans if necessary and introduce systems and apps to allow people to follow the evacuations in order to have responsive evacuation operations. There is also a need for managers to explore and leverage the use emerging technologies such as robotics, artificial intelligence-based platforms and unmanned aerial vehicles (e.g. drones) for mass humanitarian operations. For instance, using these technologies could mean that managers during emergency operations can map terrain more effectively, increase situational awareness, and deliver relief faster and more efficiently.

- The potential function of decentralisation provided by modularisation to reduce response time and bottlenecks in the command centre.

- Managers will need to be able to liaise with community representatives to ensure a good level of service at the same time as plans are continuously reviewed and inclusion of beneficiaries in the all the evacuation planning stages.

The AEO framework developed in this research was based on data collected from three European countries. This framework could be used for agility planning for mass evacuation in other European countries facing similar types of disasters. However, the countries examined were developed countries and the interaction of the beneficiaries with authorities has been found to be related to cultural and socio-economical aspects. Thus, the application of this framework should be adapted accordingly to the specific region to be used for evacuation planning in developing countries where technological infrastructure, and cross-organisational collaboration may be limited. This can be done within the purview of the

principles of flexibility, adaptability and empowerment stemming from the result of this research.

6. Conclusions

Facing a large-scale crisis, efficient and effective evacuation management can be the difference between life and death for a lot of vulnerable people. Unfortunately, this activity is plagued with uncertainty. Variables such as the conditions of the disaster and the context (i.e. time of the day, day of the week, etc.) affect the behaviour of the victims and the viability of different alternatives. Hence, despite the value of prescriptive plans, a high degree of flexibility and adaptability is needed to achieve successful evacuations.

A relevant finding of this research is the evidence of some activities to add a degree of flexibility to evacuations introduced by managers. However, we argue that the impact of these initiatives relies on the adoption of agility as part of the holistic view. Introducing agility as part of the strategy for evacuation planning involves considering the interaction between beneficiaries, organisations, information and staff. The synergy of those elements can boost the performance during evacuations and increase the level of impact of that activity.

The implementation of agility in evacuation planning also relies on looking at the different stages and the impact of decisions from one step to the next. Although a lot of emphasis has been placed on transportation itself, the interaction and consistency with the approach to decide on resources, understand the demand, determine timings, prepare control measures, and identify the best destinations needs to be carefully considered to achieve the benefits of agility in evacuations.

Engaging beneficiaries, having smaller self-contained decision-making units, exploiting local knowledge, training and empowering staff, and introducing information

systems for improved decision-making are some of the requirements to achieve more flexible humanitarian operations. The implementation of these requirements lead to an added level of adaptability with the potential to increase responsiveness and enhance the experience of the beneficiaries.

Overall, this study has looked at the potential implementation of agile practices to improve evacuation planning. Beyond the popular focus on relief fulfilment, this paper has gathered information from several managers in three different countries to propose a framework for the implementation of agile practices for evacuation planning. The framework can inform authorities (both from government and non-governmental organisations) in different countries about the requirements and conditions needed to successfully introduce agility in evacuations.

There are interesting research venues for future work departing from the results of this study. Looking at the change in the paradigm about the role of the beneficiaries, a possible area for future research would be to analyse the potential citizen-driven operations as part of the implementation of agile practices. Additionally, the value of communication and information sharing to introduce agility makes a study about the use of analytics and big data to enable agile evacuation very interesting. Also, the literature review shows the little attention that has been placed to evacuation to achieve continuous improvement. The study of the value of different operational excellence approaches for evacuation management is another opportunity for further study. Finally, extending this study looking at the link between evacuation, casualty transportation and search-and-rescue would provide valuable insights for the development of an integrated agile disaster response plan.

References

ADB. "Global Increase in Climate-related Disasters."
https://reliefweb.int/sites/reliefweb.int/files/resources/global-increase-climate-related-disasters.pdf.

Altay, Nezih, and Walter G. Green. 2006. "OR/MS research in disaster operations management." *European Journal of Operational Research* 175 (1):475-93. doi: 10.1016/j.ejor.2005.05.016.

Altay, Nezih, Angappa Gunasekaran, Rameshwar Dubey, and Stephen J. Childe. 2018. "Agility and resilience as antecedents of supply chain performance under moderating effects of organizational culture within the humanitarian setting: a dynamic capability view AU - Altay, Nezih." *Production Planning & Control*:1-17. doi: 10.1080/09537287.2018.1542174.

Apivatanagul, Pruttipong, RachelA Davidson, and LindaK Nozick. 2012. "Bi-level optimization for risk-based regional hurricane evacuation planning." *Natural Hazards* 60 (2):567-88. doi: 10.1007/s11069-011-0029-9.

AZDS. "Disaster Emergency Evacuation Preparedness: A guide to manage the essential elements of disaster preparedness strategies ".
https://azdhs.gov/documents/licensing/childcare-facilities/training/deep-manual.pdf.

Baham, Corey, Rudy Hirschheim, Andres A. Calderon, and Victoria Kisekka. 2017. "An Agile Methodology for the Disaster Recovery of Information Systems Under Catastrophic Scenarios." *Journal of Management Information Systems* 34 (3):633-63. doi: 10.1080/07421222.2017.1372996.

Balcik, B., and B. M. Beamon. 2008. "Facility location in humanitarian relief." *International Journal of Logistics Research and Applications* 11 (2):101-21. doi: 10.1080/13675560701561789.

Bayram, Vedat. 2016. "Optimization models for large scale network evacuation planning and management: A literature review." *Surveys in Operations Research and Management Science* 21 (2):63-84. doi: https://doi.org/10.1016/j.sorms.2016.11.001.

Beamon, Benita M., and Stephen A. Kotleba. 2006. "Inventory management support systems for emergency humanitarian relief operations in South Sudan." *International Journal of Logistics Management* 17 (2):187-212. doi: 10.1108/09574090610689952.

Bogard, William C. 1988. "Bringing Social Theory to Hazards Research: Conditions and Consequences of the Mitigation of Environmental Hazards." *Sociological Perspectives* (2):147. doi: 10.2307/1389080.

Boyatzis, Richard. 1998. *Transforming qualitative information: Thematic analysis and code development*: SAGE.

Bruce, Margaret, and Lucy Daly. 2011. "Adding value: challenges for UK apparel supply chain management – a review AU - Bruce, Margaret." *Production Planning & Control* 22 (3):210-20. doi: 10.1080/09537287.2010.498574.

Caunhye, Aakil M., Xiaofeng Nie, and Shaligram Pokharel. 2012. "Optimization models in emergency logistics: A literature review." *Socio-Economic Planning Sciences* 46 (1):4-13. doi: 10.1016/j.seps.2011.04.004.

Chandra, Charu, and Sameer Kumar. 2001. "Enterprise architectural framework for supply-chain integration." *Industrial Management & Data Systems* 101 (6):290-304. doi: doi:10.1108/EUM0000000005578.

Charles, A., M. Lauras, and L. Van Wassenhove. 2010. "A model to define and assess the agility of supply chains: building on humanitarian experience." *International Journal of Physical Distribution & Logistics Management* 40 (8-9):722-41. doi: 10.1108/09600031011079355.

Christopher, M., and P. Tatham. 2011. *Humanitarian logistics : meeting the challenge of preparing for and responding to disasters*. Edited by M. Christopher & P. Tatham: London : Kogan Page, 2011.

Cozzolino, Alessandra, Silvia Rossi, and Alessio Conforti. 2012. "Agile and lean principles in the humanitarian supply chain: The case of the United Nations World Food Programme." *Journal of Humanitarian Logistics and Supply Chain Management* 2 (1):16-33. doi: 10.1108/20426741211225984.

CRED. "Annual Disaster Statistical Review 2016: The Numbers and Trends." https://reliefweb.int/sites/reliefweb.int/files/resources/adsr_2016.pdf.

Dikert, Kim, Maria Paasivaara, and Casper Lassenius. 2016. "Challenges and success factors for large-scale agile transformations: A systematic literature review." *Journal of Systems and Software* 119:87-108. doi: https://doi.org/10.1016/j.jss.2016.06.013.

Drabek, T. E., and G. J. Hoetmer. 1991. *Emergency management: principles and practice for local government*: International City Management Association.

Drabek, T. E., and D. A. McEntire. 2003. "Emergent phenomena and the sociology of disaster: Lessons, trends and opportunities from the research literature." *Disaster Prevention and Management* 12 (2):97-112. doi: 10.1108/09653560310474214.

Durage, Samanthi W., Lina Kattan, S. C. Wirasinghe, and Janaka Y. Ruwanpura. 2014. "Evacuation behaviour of households and drivers during a tornado." *Natural Hazards* 71 (3):1495-517. doi: 10.1007/s11069-013-0958-6.

Easterby-Smith, Mark, Richard Thorpe, and Paul Jackson. 2012. *Management research : an introduction / Mark Easterby-Smith, Richard Thorpe and Paul Jackson*: London ; Thousand Oaks, CA : SAGE, 2012. 4th ed.

EEA. 2018. "Economic losses from climate-related extremes."

EM-DAT. 2015. "Advance search." Accessed 18th March. http://www.emdat.be/advanced_search/index.html.

Galindo, Gina, and Rajan Batta. 2013. "Review of recent developments in OR/MS research in disaster operations management." *European Journal of Operational Research* 230 (2):201-11.

Ifandoudas, Panayiotis, and Ross Chapman. 2009. "A practical approach to achieving Agility–a theory of constraints perspective AU - Ifandoudas, Panayiotis." *Production Planning & Control* 20 (8):691-702. doi: 10.1080/09537280903107473.

Kolen, Bas, Matthijs Kok, Ira Helsloot, and Bob Maaskant. 2013. "EvacuAid: A Probabilistic Model to Determine the Expected Loss of Life for Different Mass Evacuation Strategies During Flood Threats." *Risk Analysis: An International Journal* 33 (7):1312-33. doi: 10.1111/j.1539-6924.2012.01932.x.

Kovács, Gyöngyi, and Karen M. Spens. 2007. "Humanitarian logistics in disaster relief operations." *International Journal of Physical Distribution & Logistics Management* 37 (2):99 - 114.

L'Hermitte, Cécile, Peter Tatham, Ben Brooks, and Marcus Bowles. 2016. "Supply chain agility in humanitarian protracted operations." *Journal of Humanitarian Logistics and Supply Chain Management* 6 (2):173-201. doi: 10.1108/JHLSCM-09-2015-0037.

Lauras, Matthieu, Lionel Dupont, and Vérane Humez. 2012. "A decision support system for optimising the order fulfilment process AU - Okongwu, Uche." *Production Planning & Control* 23 (8):581-98. doi: 10.1080/09537287.2011.566230.

Lee, H. Wally, and Zbinden Marc. 2003. "Marrying logistics and technology for effective relief." *Forced Migration Review, Iss 18, Pp 34-35 (2003)* (18):34.

Li, Shuying, Jun Zhuang, and Shifei Shen. 2017. "A three-stage evacuation decision-making and behavior model for the onset of an attack." *Transportation Research Part C: Emerging Technologies* 79:119-35. doi: https://doi.org/10.1016/j.trc.2017.03.008.

Loss, Leandro, and Servane Crave. 2011. "Agile Business Models: an approach to support collaborative networks." *Production Planning & Control* 22 (5-6):571-80. doi: 10.1080/09537287.2010.536646.

Lotfi, Maryam, and Soroosh Saghiri. 2017. "Disentangling resilience, agility and leanness: Conceptual development and empirical analysis." *Journal of Manufacturing Technology Management* 29 (1):168-97. doi: 10.1108/JMTM-01-2017-0014.

Lujak, Marin, and Stefano Giordani. 2018. "Centrality measures for evacuation: Finding agile evacuation routes." *Future Generation Computer Systems* 83:401-12. doi: https://doi.org/10.1016/j.future.2017.05.014.

Mafakheri, Fereshteh, Fuzhan Nasiri, and Mahmood Mousavi. 2008. "Project agility assessment: an integrated decision analysis approach AU - Mafakheri, Fereshteh." *Production Planning & Control* 19 (6):567-76. doi: 10.1080/09537280802360884.

Maskell, Brian. 2001. "The age of agile manufacturing." *Supply Chain Management: An International Journal* 6 (1):5-11. doi: 10.1108/13598540110380868.

Miles, Matthew B., and A. M. Huberman. 1994. *Qualitative data analysis : an expanded sourcebook*: Thousand Oaks, Calif. ; London : Sage, 1994. 2nd ed.

Mingers, John, Alistair Mutch, and Leslie Willcocks. 2013. "CRITICAL REALISM IN INFORMATION SYSTEMS RESEARCH." *MIS Quarterly* 37 (3):795-802.

Moyano-Fuentes, José, Sebastián Bruque-Cámara, and Juan Manuel Maqueira-Marín. 2018. "Development and validation of a lean supply chain management measurement instrument AU - Moyano-Fuentes, José." *Production Planning & Control*:1-13. doi: 10.1080/09537287.2018.1519731.

Murray-Tuite, P., and B. Wolshon. 2013. "Evacuation transportation modeling: An overview of research, development, and practice." *Transportation Research Part C: Emerging Technologies* 27:25-45. doi: 10.1016/j.trc.2012.11.005.

Nagarajan, M., D. Shaw, and P. Albores. 2012. "Disseminating a warning message to evacuate: A simulation study of the behaviour of neighbours." *European Journal of Operational Research* 220 (3):810-9. doi: 10.1016/j.ejor.2012.02.026.

Nathan, Kunz, N. Van Wassenhove Luk, Besiou Maria, Hambye Christophe, and Kovács Gyöngyi. 2017. "Relevance of humanitarian logistics research: best practices and way

forward." *International Journal of Operations & Production Management* 37 (11):1585-99. doi: 10.1108/IJOPM-04-2016-0202.

Nelan, Mary M., Tricia Wachtendorf, and Samantha Penta. 2018. "Agility in Disaster Relief: A Social Construction Approach." *Risk, Hazards & Crisis in Public Policy* 9 (2):132-50. doi: 10.1002/rhc3.12135.

Oloruntoba, Richard, and Richard Gray. 2006. "Humanitarian aid: an agile supply chain?" *Supply Chain Management: An International Journal* 11 (2):115-20. doi: 10.1108/13598540610652492.

Özdamar, Linet, and Mustafa Alp Ertem. 2015. "Models, solutions and enabling technologies in humanitarian logistics." *European Journal of Operational Research* 244 (1):55-65. doi: http://dx.doi.org/10.1016/j.ejor.2014.11.030.

Patton, Michael Quinn. 2002. *Qualitative research & evaluation methods*: Thousand Oaks, Calif. ; London : Sage, ©2002. 3rd ed / Michael Quinn Patton.

Potdar, Pavan Kumar, Srikanta Routroy, and Astajyoti Behera. 2017. "Agile manufacturing: a systematic review of literature and implications for future research." *Benchmarking: An International Journal* 24 (7):2022-48. doi: 10.1108/BIJ-06-2016-0100.

Purvis, L., S. Spall, M. Naim, and V. Spiegler. 2016. "Developing a resilient supply chain strategy during 'boom' and 'bust' AU - Purvis, L." *Production Planning & Control* 27 (7-8):579-90. doi: 10.1080/09537287.2016.1165306.

Qu, Sandy Q., and John Dumay. 2011. "The qualitative research interview." *Qualitative Research in Accounting & Management* 8 (3):238-64. doi: doi:10.1108/11766091111162070.

Quarantelli, E.L. 1980. "Evacuation Behavior and Problems: Findings and Implications from the Research Literature." In. Delaware, USA.

Rawls, Carmen G., and Mark A. Turnquist. 2010. "Pre-positioning of emergency supplies for disaster response." *Transportation Research Part B: Methodological* 44 (4):521-34. doi: 10.1016/j.trb.2009.08.003.

Rodríguez-Espíndola, Oscar, Pavel Albores, and Christopher Brewster. 2018a. "Disaster preparedness in humanitarian logistics: A collaborative approach for resource management in floods." *European Journal of Operational Research* 264 (3):978-93. doi: https://doi.org/10.1016/j.ejor.2017.01.021.

———. 2018b. "Dynamic formulation for humanitarian response operations incorporating multiple organisations." *International Journal of Production Economics* 204:83-98. doi: https://doi.org/10.1016/j.ijpe.2018.07.023.

Santos-Reyes, Jaime, Rafael Alvarado-Corona, and Samuel Olmos-Peña. 2010. "Learning from Tabasco's floods by applying MORT." *Safety Science* 48 (10):1351-60. doi: http://dx.doi.org/10.1016/j.ssci.2010.05.008.

Shaughnessy, John J., and Eugene B. Zechmeister. 1985. *Research methods in psychology*, *Research methods in psychology*. New York, NY, US: Alfred A. Knopf.

Shaw, Duncan, Pavel Albores, Susan Anson, Paul Kailiponi, Magesh Nagarajan, Patrick Tissington, and Tom Hart. 2011. "Evacuation Responsiveness by Government Organisations (ERGO). Final Rport." In, edited by Aston Centre for Research into safety and Security (CRISIS), 318. Birmingham, UK.

Sherali, Hanif D., Todd B. Carter, and Antoine G. Hobeika. 1991. "A location-allocation model and algorithm for evacuation planning under hurricane/flood conditions." *Transportation Research Part B: Methodological* 25 (6):439-52. doi: 10.1016/0191-2615(91)90037-J.

Soni, Gunjan , and Rambabu Kodali. 2012. "Evaluating reliability and validity of lean, agile and leagile supply chain constructs in Indian manufacturing industry AU - Soni, Gunjan." *Production Planning & Control* 23 (10-11):864-84. doi: 10.1080/09537287.2011.642207.

Southworth, F. 1991. "Regional evacuation modeling: A state-of-the art review." In.

Suri, Harsh. 2011. "Purposeful Sampling in Qualitative Research Synthesis." *Qualitative Research Journal* (2):63. doi: 10.3316/QRJ1102063.

Tatham, P., and K. Spens. 2011. "Towards a humanitarian logistics knowledge management system." *Disaster Prevention and Management* 20 (1):6-26.

Thomas, A, and M Mizushima. 2005. "Logistics training: necessity or luxury?" *Forced Migration Review* 22:60-1.

Toledo, Tomer, Ido Marom, Einat Grimberg, and Shlomo Bekhor. 2018. "Analysis of evacuation behavior in a wildfire event." *International Journal of Disaster Risk Reduction* 31:1366-73. doi: https://doi.org/10.1016/j.ijdrr.2018.03.033.

Van-Maanen, John. 1983. *Qualitative Methodology*: SAGE.

Van Wassenhove, L. N. 2006. "Humanitarian Aid Logistics: Supply Chain Management in High Gear." *The Journal of the Operational Research Society* (5):475. doi: 10.2307/4102445.

Whybark, D. Clay, Steven A. Melnyk, Jamison Day, and Ed Davis. 2010. "Disaster Relief Supply Chain Management: New Realities, Management Challenges, Emerging Opportunities." *Decision Line* 41 (3):4-7.

Wu, Chong, David Barnes, Duska Rosenberg, and Xinxing Luo. 2009. "An analytic network process-mixed integer multi-objective programming model for partner selection in agile supply chains AU - Wu, Chong." *Production Planning & Control* 20 (3):254-75. doi: 10.1080/09537280902856047.

Yin, Robert K. 2011. *Applications of case study research*, *Applied social research methods series:*: London : SAGE, 2003. rnd ed / Robert K. Yin.