A NEW CLASSIFICATION MODEL OF DISASTERS BASED ON THEIR LOGISTICS IMPLICATIONS

Cécile L'Hermitte (*)
Australian Maritime College, UTAS, Newnham, TAS 7248, Australia
+61 (0)451 287 143, C.Lhermitte@amc.edu.au

Marcus Bowles
Australian Maritime College, UTAS, Newnham, TAS 7248, Australia
+61 (0)3 6324 9720, M.Bowles@amc.edu.au

Peter Tatham
Griffith Business School, Gold Coast Campus, QLD 4222, Australia
+61 (0)7 555 28490, p.tatham@griffith.edu.au

(*) Corresponding author

Submission Type: Research

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Cécile L'Hermitte, Australian Maritime College, UTAS, Newnham, TAS 7248, Australia
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Marcus Bowles, Australian Maritime College, UTAS, Newnham, TAS 7248, Australia
+61 (0)3 6324 9720, M.Bowles@amc.edu.au
Peter Tatham, Griffith Business School, Gold Coast Campus, QLD 4222, Australia
+61 (0)7 555 28490, p.tatham@griffith.edu.au

ABSTRACT

This paper aims to clarify the concept of disaster from a humanitarian logistics perspective. To this end, a disaster is defined on the basis of two criteria: the destructive impact and a call for international assistance. Then, the paper examines the typology of disasters commonly used in the humanitarian logistics literature and establishes that this classification focuses on physical phenomena rather than on dimensions that reflect the logistics implications. From this, a new disaster classification model is developed based on generic characteristics of disasters (over time and space) and on five situational factors reflecting the influence of the external environment. Whilst the generic characteristics of disasters generate similarities in the logistics requirements, the external situational factors account for the uniqueness of each disaster. Therefore, it is argued that the characteristics of the disaster itself cannot be dissociated from the disaster's external environment.

Keywords: disasters; classification; humanitarian logistics; generic characteristics; external environment.

INTRODUCTION

Relief logistics exists to prepare for, and respond to a disaster situation [16]. In the same way that different commercial environments generate different logistics and supply chain needs and strategies [16], different disasters generate different logistics requirements [59] and a specific disaster environment prescribes a specific supply chain design [16]. This paper is motivated by the need to better define the boundaries of what a disaster situation is and to identify different disaster scenarios according to their logistics impact in order to facilitate further research on the suitability of the application of business logistics operational principles and strategies. The purpose of this conceptual paper is, thus, to propose a new and meaningful typology of disasters based on generic disaster characteristics that reflect the logistics impacts. This new classification is designed to be an alternative to the commonly used typology based on natural vs. man-made disasters and sudden-onset vs. slow-onset disasters. To achieve this goal, this paper draws on the key academic literature, in particular in the social science of disasters.

Section 1 of this paper sets the boundaries of the study by defining the relevant concepts and, in particular, the concept of disaster. The next section discusses the limitations of the commonly used classification that is based on the origin of a disaster and its speed of onset. The new disaster classification model is presented and explained in section 3. Section 4

identifies the limits of the new model as well as further areas of research, and the final section provides concluding comments.

DEFINING THE CONCEPT OF DISASTER

In order to delineate the boundaries of what will be studied in this paper, this section focuses on existing definitions of, and the criteria for a disaster. As this paper focuses on disasters, humanitarian logistics operations that aim to facilitate the carrying out of development activities in order to improve the resilience and the long-term welfare of communities are not considered.

What is a disaster? A humanitarian logistics approach

There is no consensus among scholars regarding the definition of disaster [44]. Shaluf [54] notes that variations can be observed across disciplines, whereas Perry [44] argues that different definitions serve different objectives. That said, a clear and simple definition is offered by the United Nations International Strategy for Disaster Reduction (UNISDR) [64], namely that a disaster is 'a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources'. UNISDR [64] further explains that 'disaster impacts may include loss of life, injury, disease and other negative effects on human physical, mental and social well-being, together with damage to property, destruction of assets, loss of services, social and economic disruption and environmental degradation'. Interestingly in the context of this paper, UNISDR defines a disaster by focusing on its impact rather than on the event itself. Thus, the focus of this definition is not the trigger event (earthquake, technological failure, drought, etc.), but the results: disruption, destruction, and inability to cope. In this way, the UNISDR definition differentiates a disaster from a hazard. Simonović [55, p. 3] defines a hazard as 'a potentially damaging physical event, phenomenon, and/or human activity, which may cause loss of life or injury, property damage, social and economic disruption, or environmental degradation'. A hazard is, thus, a potential disaster [36].

Given its widespread use, the UNISDR definition of disaster will be employed as the basis for the further discussion within this paper. In doing so, it will be appreciated that the two essential components of this definition are (1) the destructive impact and (2) the paralysing effect on national authorities unable to cope with the situation on their own. By implication, and for the purpose of this paper, a situation where national authorities are able to deal with the destructive impact of the event is not considered to be a disaster [32] [61].

After having defined a disaster, the specific criteria used to characterise an event as a disaster are now considered. Just like there are various definitions of a disaster, there are multiple criteria [54]. The characteristics used by the Centre for Research on the Epidemiology of Disasters (CRED) have been widely mentioned in the academic literature [18] [54], including the humanitarian logistics literature. CRED [14] enters a disaster into its database when at least one of the following criteria is met:

- Ten or more people reported killed,
- Hundred or more people reported affected,
- Declaration of a state of emergency,
- Call for international assistance.

The CRED criteria are close to the UNISDR definition. However, these criteria are extremely broad and, consequently, capture all types of incidents that are not necessarily relevant to this study, such as a bus accident or a nightclub fire. Boin [9] argues that a catch-all notion of a disaster is confusing and contributes to a devaluation of the meaning of the concept. It also fails to take the local conception of disaster into account. Indeed, Boin [9] claims that there are differences in the perceptions of what a disaster is and illustrates these differences as follows: in 2001, in the Netherlands, due to the lack of public transport during a dance festival, thousands of people have been compelled to wait hours in cold rains. The situation has been described by the media as a 'near disaster'. In the same year, a deadly explosion in a fireworks factory in China was fatalistically seen as a normal accident.

As a consequence, above mentioned CRED criteria will not be used in this paper when determining which events should be categorised as a disaster. Rather, and for the sake of precision, this study delineates a disaster as any destructive event resulting in a call for international assistance by the national authorities. From that perspective, the criteria for a disaster mirror the UNISDR definition above. For the purpose of this paper, it is not necessary to determine the level of destruction, not least because this will vary according to the circumstances and the resilience level of the impacted community or nation. The key element is that the national authorities have judged the situation to be sufficiently destructive and beyond their capacity to respond and hence, that they have chosen to call for international assistance. This, in turn, is what will trigger the involvement of humanitarian organisations into the relief process.

In selecting these criteria, we acknowledge that some significant incidents may fall out of scope. For example, some countries such as China and India are very reluctant to call for international assistance as they consider that they have sufficient resources to deal with major incidents. However, it is believed that these exceptions do not invalidate the basic model that will be described in greater detail below.

Having defined a disaster on the basis of two criteria (the destructive impact and a call for international assistance), the next part of this paper aims to distinguish the concept of disaster from closely related concepts. This is particularly important as the disaster literature is somewhat confusing: across sources the same terms are sometimes used with different meanings, whereas it is not uncommon that authors use different words to refer to the same concept.

Disasters vs. emergencies

Distinctions between emergencies, disasters, and catastrophes can be identified in the current literature. The differentiation depends on the level of the human, material, and environmental impact on a community, as well as on the ability of the national/local authorities to cope with the destructive event and, consequently, the need or not to involve external parties in the relief process [18] [24] [48]. While noting that some degree of gradation in terminology has occurred, this is incidental to the primary focus of this paper. For the purpose of this study, the definition of an emergency is aligned with the concept that is referred to by humanitarian practitioners. Thus, an emergency is defined as an urgent situation 'which causes human suffering or imminently threatens human lives or livelihood' [66], requires that 'immediate and appropriate action is taken and which demands an extraordinary response and exceptional measures' [63]. This definition of an emergency as a need for urgent action to alleviate

human suffering will be used and considered in greater detail in a later section. For now, it is essential to note that the concept of emergency is not related to any particular disaster. An emergency calls for action whatever the origin of a disaster (an earthquake, a flood, a famine, etc.) [66]. In taking this perspective, it should be noted that this paper is diverging from the frequently used classification of disasters that focuses on the type of hazard, as will be clarified in the next section.

THE CASE FOR A NEW DISASTER CLASSIFICATION IN HUMANITARIAN LOGISTICS

This section examines the limitations of the typology that is commonly used in the humanitarian logistics literature and that characterises disasters in line with their origin and speed of onset. It also considers the emergent academic engagement in identifying other classification dimensions, and examines the benefits of using a relevant typology of disasters.

The limitations of the currently used classification

Academics have categorised disasters in many different ways in order to explain their multi-faceted implications [1]. To date, the typology most commonly referred to in academic humanitarian logistics studies is a matrix distinguishing between natural and man-made disasters, and between sudden-onset and slow-onset disasters [65]. Figure 1 shows this 2x2 categorisation.

FIGURE 1: CATEGORIES OF DISASTERS [65, p. 476]

	Natural	Man-made
Sudden-onset	Earthquake Hurricane Tornado	Terrorist attack Coup d'état Chemical leak
Slow-onset	Famine Drought Poverty	Political crisis Refugee crisis

This classification is focused on the nature and the physical features of disasters and therefore, does not allow researchers in humanitarian logistics to clearly derive specific logistics needs from each category. In other words, this classification does not define the types of phenomena from a logistics perspective [60]. In addition, some disasters cannot be easily classified by using this matrix as it does not grasp the complexity inherent in some phenomena [34]. For example, how should a flood be categorised? Whilst a flood occurring after the collapse of a dam or torrential rains can certainly be categorised as a sudden-onset disaster, a flood that builds up over days or even weeks from the rising water level of a river would be more appropriately considered as a slow-onset disaster. Furthermore, a flood can be both a natural and a man-made disaster. For instance, both natural phenomena and human activities can generate a flood, as illustrated by the collapse of a dam due to heavy rainfall beyond the dam's capacity. Is such a disaster a natural disaster resulting from the heavy

rainfall or a man-made disaster resulting from civil engineering miscalculations regarding the dam capacity? As stressed by Quarantelli [47] and Rosenthal [53], identifying the exact causes of a disaster can be a difficult exercise. Along the same line, some authors [16] [34] [56] underline that a disaster rarely occurs as an individual event. Rather, it is the result of interactions between multiple phenomena.

Extending the argument to its extreme limit, some scholars [31] [47] [51] [53] [57] claim that, ultimately, there is no such thing as a natural disaster as any such event does not exist outside a set of circumstances involving humans. For example, a severe earthquake occurring where no one lives would not be considered as a disaster because it would not generate any human casualties [41]. In a similar vein, Tomasini and Van Wassenhove [61] argue that not all hazards turn into disasters as disasters are not only the result of a hazard occurrence, but also reflect the outcome from a combination of hazard and vulnerability. Vulnerability makes a given population more likely to suffer from a hazard's effects, so that a similar hazard will impact differently on populations with different vulnerability levels [18]. Vulnerability results from different forces, such as rapid urbanisation, inappropriate actions by national/local authorities leading to a lack of preparedness, or unfavourable socio-economic conditions [61]. As vulnerability and poverty are often related concepts, developing countries are typically more vulnerable and, therefore, more affected by disasters [27]. Based on this analysis, it can be established that the 2x2 typology depicted in figure 1 is more focused on hazards (the trigger events) than on disasters (the outcomes). As a result, this typology is what Quarantelli [49] defines as an agent-focused rather than a response-focused typology – a differentiation that will be referred to in greater detail in the next section. However, when humanitarian logisticians formulate a strategy in response to a disaster, the problem they face is not the hazard (the physical phenomenon), but its logistics implications.

The inadequacy of the above classification is also compounded by the fact that the disaster landscape is changing and that there has been a qualitative shift in the nature of disasters over the last decades [17]. As explained by De Smet *et al.* [17], modern disasters are characterised by higher complexity as the result of three factors. First, some disasters have long-term and cross-border effects. Examples include the 1986 Chernobyl disaster, the contamination effects of which spread to most European countries. Secondly, due to globalisation and the world economic, commercial, and technological interconnections, disasters may trigger a series of cascade effects, as occur, for example, in pandemics. Finally, the occurrence of unanticipated or unknown disasters (such as 9/11) has consequences in terms of rethinking the response strategies. Hills [23] shares this idea of complexity in the disaster occurrence and, like the previous authors, supports the concept of escalation being inherent in certain disasters. Provitolo [46] also acknowledges the spreading nature of disasters, as does Rosenthal [53, p. 152] when referring to 'the disaster after the disaster'. However, these attributes of complexity and dynamism are not adequately encompassed in the categorisation of disasters represented above in figure 1.

First steps towards a new classification

Although the classification of disasters based on their origin and speed of onset is still commonly used in the humanitarian logistics literature, emergent discussions [3] [34] [57] [60] reveal the need for another classification based on characteristics that better reflect the operational implications of disasters. Research questioning the value of a classification of disasters based on their origin (natural vs. man-made) can also be found in the social science of disasters literature and can usefully be used to shed light on this study. According to

Quarantelli [47], instead of differentiating natural from man-made disasters, researchers should identify a set of generic characteristics. They should focus on genotypes (common non-observable features) rather than on phenotypes (observable physical features) [49]. Put another way, the classification of disasters has to shift from the nature of the disaster and its physical features to a combination of meaningful dimensions that are able to illustrate the shared characteristics of various disaster situations [47]. Emphasising the underlying characteristics of a disaster and its implications (in other words, the context of the occurrence) rather than its physical nature is all the more necessary as similar activities (such as evacuation or logistics preparedness) are carried out whatever the nature of the disaster (a volcanic eruption, a nuclear accident, or a flood). Consequently, a new typology of disasters based on generic characteristics would enable researchers to develop general disaster management principles and strategies that are applicable to various types of disasters. The resultant preparation and response activities will help to manage the impact of the event more efficiently and effectively [47].

Although Quarantelli [49] does not provide any specific typology, he alludes to the general dimensions of time and space to distinguish between disasters. These variables will be used in the next section. In other fields of study, practical classifications that have moved away from the traditional typology based on the nature of disasters can also be identified. For example, in a medical [10] or in a military context [6], authors have used situation-oriented classification perspectives to help individuals and organisations gain a better understanding of the disaster environments as well as the resource required and, therefore, better adapt the preparation and response operations.

In a humanitarian logistics context, Apte [3] chooses a classification based on time and location in order to focus on the logistics environment created by disasters and the level of operational complexity generated. Accordingly, she differentiates sudden-onset disasters from slow-onset disasters (time) and dispersed disasters from localised disasters (location). She underlines that dispersed and sudden-onset disasters are more difficult to manage from a logistics perspective, and that they call for more responsive operations than localised and slow-onset disasters. By contrast, localised and slow-onset disasters can be more easily planned and prepared for, and efficiencies can be achieved in transport and distribution. Holguín-Veras *et al.* [24] also identify several distinctive aspects characterising disasters according to the nature of the humanitarian logistics operations conducted. The authors list following features: the speed of onset, the warning time, the magnitude of the social and material impact, the geographic impact, the disaster duration, the disaster frequency, and the persistence of the threat after the disaster occurrence. Kovács and Tatham [35] also argue that the nature of a disaster, its speed of onset, predictability, recurrence, and material and human impact are factors that affect the configuration of the humanitarian response. Although the speed of onset is mentioned in the three above analyses, it should be noted that, according to Quarantelli [47], the speed of onset is a physical feature of a disaster and does not characterise the response pattern or the implications. Therefore, more generic characteristics such as the time available for action and/or predictability need to be considered.

Consistent with Quarantelli's [47] previously stated generic characteristics across the nature of disasters, Tatham *et al.* [60] advance a holistic and improved classification framework proposing thirteen major elements that characterise disasters and account for the nature and extent of the logistics response. These elements are (1) the time available for action, (2) the number of persons affected, (3) the population density of the impacted area, (4) the geographic extent of the impacted area, (5) the magnitude of the destruction, (6) the disaster

duration, (7) the urbanisation level of the affected area, (8) the topography of the impacted area, (9) the climatic conditions, (10) the socio-economic circumstances in terms of GDP per capita, (11) the impacted area's Logistics Performance Index, (12) the level of political stability, and (13) the event's occurrence/recurrence probability. The authors explain how these components of the disaster environment impact on the logistics intervention in different ways. Examples include the nature and the volume of the goods to be delivered, the timing of action, or the choices in terms of logistics and supply chain decisions and strategies.

Among all the characteristics of disasters listed by the different authors in the above analysis, commonalities can be identified. In some shape or form, most of the identified variables offered by the authors referred to above, reflect either to the time dimension (for example, the speed of onset, the warning time, the disaster duration, or the time available for action), the geographic dimension (for example, the geographic extent of the impact or the population density of the affected area), the intensity/severity dimension (for example, the magnitude of the impact or the number of persons affected), or the situational circumstances of disasters (for example, the climatic conditions, the socio-economic circumstances, the political stability, or the logistics capacities of the impacted area). These common elements will guide the separation of the multiple characteristics later in this study. Indeed, although the major features of disasters from a logistics perspective have been clearly identified in the literature, these variables have not been brought together to draw up a new typology that is focused on specific logistics situations. This is a gap that this paper will fill in section 3 after having identified the benefits of creating meaningful typologies.

Benefits of developing a typology of disasters

Although typologies of disasters can generate labels and give the impression that all disasters are clear-cut phenomena, the categories of a typology should be seen as archetypes enabling researchers to conduct further scientific and empirical enquiries [49]. Multiple benefits of developing a typology of disasters are well identified in the literature, three of which will now be considered. First, a typology helps clarify the concept of disaster [49]. Since a typology conveys meaning, it enables scholars to gain a more precise vision and structured understanding of what a disaster is and what its effects are [44]. Secondly, a typology of disasters facilitates analysis. It is useful as a tool to draw comparisons between categories, to explain and predict phenomena, and, consequently, to engage in theory development [43]. Similarly, Berren *et al.* [8] argue that distinguishing one disaster from another on the basis of the generated intervention activities is crucial for academics to move from descriptive to theory-focused research. Thirdly, developing a typology of disasters based on their logistics impacts is a step towards the differentiation and categorisation of the various humanitarian logistics settings. As argued by Kovács and Spens [33], the identification of literature categories will provide more structure to the humanitarian logistics discipline. Despite some emerging academic engagement [3] [24] [60], the literature is limited in respect of the cause-and-effect relationships between generically defined disasters and the appropriate humanitarian logistics and supply chain courses of action. Developing a new typology of disasters according to their logistics implications not only underlines the existence of multiple disaster situations (as opposed to just disasters), it also enables humanitarian logistics researchers to differentiate, explain, and predict the logistics implications (and, consequently, to engage in theory development more effectively).

In summary, this section argues that humanitarian logistics decisions are a function of the disaster context. However, this key point is not reflected in the commonly used typology of

disasters based on the disaster origin (natural vs. man-made) and the speed of onset (sudden vs. slow onset). Although each type of disaster occurs within a particular setting, common characteristics driving specific logistics needs can be identified across disasters. Initial thinking in this regard has been offered by Tatham *et al.* [60]. However, there is still a need for a new typology based on generically defined disasters. Such a typology is essential to differentiate disaster situations based on their logistics implications. This will also assist in improving the explanation and prediction of the logistics and supply chain operational requirements and strategy development. Consequently, developing generic disaster categories that better reflect the logistics operational impact of disasters is a first step towards theory development in the field of humanitarian logistics. The next section presents the new model through which to classify disasters according to their logistics implications.

A NEW CLASSIFICATION OF DISASTERS REFLECTING THE LOGISTICS IMPLICATIONS

The logistics and supply chain context of disasters

Self-evidently, good typologies relate to the problem being investigated. Therefore, it is essential to work within the boundaries of the issue under investigation [62] which is, in relation to this paper, the development of different categories of disasters that better reflect the logistics implications. However, as the greatest difficulty of typology development is that of identifying relevant variables [4], the choices made in this paper are now explained.

Logistics is about creating time and place value [5] along the supply chain. Consequently, two essential questions regarding the logistics implications of disasters are when and where humanitarian supplies should be made available [42] and it is from those perspectives that the time and space implications of disasters have to be considered. Additional questions relevant to humanitarian logistics are what and how much is needed [42]. These questions seem less relevant to the new classification for following reasons. What is needed relates to the types of goods to be delivered. However, humanitarian supplies are standardised and largely common to all types of disasters [19] [42]. In addition, as argued by Gattorna [21], what makes a good supply chain strategy is not the product category, but the customers' needs, expectations, and behaviours. How much is needed depends on the intensity/severity of a disaster, namely the destructive impact of a disaster. However, as previously established, the level of damages varies according to the vulnerability of the impacted area. Two hazards with the same physical magnitude will not necessarily have the same destructive impact [1], as illustrated by comparing the impacts of a major flood occurring in Pakistan and a similar event occurring in Australia. Consequently, the intensity/severity of a disaster is closely related to the disaster's external environment, namely the particular location where it occurs as distinct from the disaster itself. In addition, how much should be delivered reflects the extent of the response, and not the nature of the logistics operations to be conducted and/or the supply chain strategy decisions to be made. For these reasons, the types of humanitarian supplies and the intensity/severity of a disaster will not be considered as relevant criteria to classify disasters from a logistics perspective.

Rather, and as outlined earlier, the two dimensions chosen for the new typology are time and space. However, in line with Rosenthal's [53] view that a narrow time-space approach to the management of disasters is of limited value, these dimensions have been adapted to describe the time and space disaster situations in a humanitarian logistics context. The spatiotemporal approach has also been complemented by situational factors that account for the unique

characteristics of the disaster's external environment. Indeed, as the logistics context of a disaster not only depends on the characteristics of a disaster (here time and space), but also on the characteristics of the affected region, it is not possible to build a disaster model without considering the particular environment of the occurrence [41]. The external environment is, thus, integrated into the new model in the form of situational factors impacting on the humanitarian logistics operations. In summary, the logistics context of a particular disaster consists of following elements that will be explored in the remainder of this section:

- the generic characteristics of the disaster itself (over time and space),
- the external situational factors.

The time dimension of disasters

In relation to this paper, the time dimension of disasters should be understood as the time available for action, namely for delivery of the humanitarian supplies. The time dimension of disasters is highly relevant to humanitarian logistics as it determines the overall time for planning and preparing the relief operations [3] [24]. Thus, it impacts on the level of emergency of the response and the logistics decisions being made. Ludema and Ross' [39] typology of relief operations illustrates this point. The authors differentiate between short response time operations (emergency relief operations) and the long response time operations (rehabilitation relief operations, elementary/subsistence relief operations usually following emergency relief operations, and development relief operations). Ludema and Ross [39] explain some of the differences between these operations from a logistics point of view, in particular regarding the choice of the primary mode of transport. When speed is a crucial element (as in the case of emergency relief operations), air transport is a good option. However, since there is a negative correlation between speed and cost, other modes of transport are preferred when a swift response is not the dominant requirement [38] [39]. Cozzolino *et al.* [13] argue that the time factor affects not only the operational choices, but also the decision regarding the logistics and supply chain strategies.

The new typology, therefore, distinguishes between two disaster situations in relation to the time available for action:

- emergency disaster situations characterised by a need for urgent action and for immediate distribution of humanitarian supplies,
- protracted disaster situations, where the time allowed for action is of greater duration and the target distribution dates relatively remote.

Importantly, however, these dimensions should be seen as being located along a continuum from zero response time to extremely long response times rather than two opposite poles.

The time available for action depends on three elements: the warning time, the duration of a disaster, and the duration of its impact. As underlined earlier, this dimension goes beyond the speed of onset and the physical occurrence of the event (for example, a few seconds/minutes in the case of an earthquake). In this paper, and in line with Quarantelli's [49] perspective, what happens before, during, and after the physical occurrence (the whole life cycle of a disaster) is taken into account.

In the life cycle of a disaster, the warning time is the first element influencing the time available for action. It ranges from events with (nearly) no warning time (such as earthquakes) to occurrences that can be predicted months in advance (such as droughts) [17] [28]. However, even if the warning time is essential to determine the time available for action, long warning times cannot necessarily be associated with long times available for action. First, the warning time depends, to some extent, on the effectiveness of the early warning system that exists in a given country and in relation to a given disaster event [36]. Next, it is important to appreciate that a long (or short) response time is not correlated to the predictability (or not) of a disaster. Indeed, it has been established that typically unpredictable disasters (such as disasters resulting from earthquakes) can develop into more stable situations in the recovery phase [2] [25], and therefore evolve from emergency to protracted disasters. By contrast, emergency situations can exist in the context of predictable and ongoing disasters. As an example, Kim and Guha-Sapir [28] observe that, despite early warnings (sometimes months in advance) aimed at preventing food crises, humanitarian operations are sometimes delayed and the warnings do not trigger an early response. Consequently, emergency famine situations unfold and compel humanitarian organisations to operate in a reduced timeframe. This happened in the Horn of Africa where, although clear information regarding acute malnutrition levels in the region was already widely available at the end of 2010, only limited action was taken, so that, eventually, emergency aid had to be delivered in mid-2011.

The dimension related to the time available for action (emergency vs. protracted disasters) is in line with the relief operations conducted by some humanitarian organisations. As an example, two of the operation types conducted by the UN's World Food Programme (WFP) are the titled 'Emergency Operations' and 'Protracted Relief and Rehabilitation Operations'. Emergency Operations are designed to provide immediate assistance to the victims of a range of disasters (whatever its type, for example earthquakes, droughts, or crop failures) [67]. Protracted Relief and Recovery Operations are conducted if further assistance is needed over the longer term and/or to re-establish livelihoods that have been destroyed by a disaster [68]. Consequently, WFP can carry out Emergency Operations in the case of a famine, and Protracted Relief and Recovery Operations in the recovery phase of an earthquake. This confirms the relevance of a disaster classification based on the time available for action rather than on the type of disaster *per se*.

The space dimension of disasters

In the same way as the time dimension, space is crucial in humanitarian logistics. In this paper, the spatial dimension of disasters relates to the geographic scope of the affected area. From that perspective, the new typology distinguishes two disaster situations:

- localised disaster situations impacting a contained geographic location,
- diffuse disaster situations impacting a widespread geographic location.

The spatial dimension of disasters varies greatly from highly localised disasters (such as the 2010 Haiti earthquake) to extremely diffuse disasters (such as the 2004 South-East Asian tsunami or the recurring famines in the Sahel region of sub-Saharan Africa). In a similar way to the time variable, the space variable should be considered along a continuum rather than as two specific extremes.

The geographic extent of disasters impacts on the operational complexity and, in particular, the humanitarian transport and distribution operations [3]. In particular, space not only impacts on the type and number of logistics operations conducted (such as transhipment), but also affects the design of the transport and distribution network (for example, the number and locations of the intermediary nodes and the strategies used to shape the movements of goods, such as point-to-point or hub-and-spoke frameworks). All this, self-evidently, has a direct influence on the cost of the logistics operations [52].

Holguín-Veras *et al.* [24] also note that responding to a localised disaster is easier than responding to a diffuse disaster. Localised disasters are characterised by smaller travel distances (and, hence, times). This increases the potential for utilising alternative delivery modes and makes the need assessment process easier to carry out. For diffuse disasters, the implications are the reverse: longer travel times, greater uncertainty regarding the condition of the transport, logistics, and distribution networks, more challenging need assessments, and more complex and multi-layered distribution networks. In addition, diffuse disasters generally involve a higher number of relief organisations, which makes communication, interactions, and coordination all the more complex [2]. Diffuse disasters also complicate the monitoring of operations and exacerbate the administration challenges, particularly if the disaster is a cross-border event that involves different jurisdictions [17]. Finally, economies of scale are more difficult to achieve in a geographically widely spread area when compared to a localised disaster [58].

Overall, based on the above discussions, it is contended that generic disaster characteristics (time available for action and geographic scope) generate similar logistics requirements. This is not the case of the external situational factors.

The external situational factors of the disaster environment

Disasters do not occur in a vacuum, but within a defined environment. As a result, the external environment of the disaster represents an essential factor to consider over and above the characteristics of the disaster itself. Kunz and Reiner [37] identify four external situational factors that impact on the humanitarian logistics activities and performance:

- the government situational factors (such as the degree of cooperation from the national/local authorities or their level of corruption),
- the socio-economic situational factors (such as the availability of local suppliers),
- the infrastructure situational factors (such as the availability and condition of the transport network),
- the environmental situational factors (such as the topography or weather conditions of the affected area).

As argued by Kunz and Reiner [37], these factors are outside influences that affect the design and the complexity of the humanitarian logistics activities. They can impede logistics operations (they can be operational disruptors) or create a supportive operational environment (they can be operational facilitators). However, depending on the skills and experience of the organisation's staff, relief agencies can enhance the positive impact or reduce the negative impact of these influences. The external situational factors are now considered individually to determine their relevance to the logistics activities.

First, the government situational factors can have a positive or negative impact on the humanitarian logistics operations. For example, actions of national/local authorities can either facilitate the delivery of humanitarian supplies by accelerating customs clearance and reducing import duties, or restrict/delay it with bureaucratic formalities [34] [42]. In addition, corruption, either due to the breakdown of national/local authorities following a disaster or to its entrenchment in the impacted society, undermines the humanitarian effort by preventing supplies from reaching those who most need them [40].

Secondly, various aspects of the socio-economic environment have to be considered when conducting humanitarian logistics operations. For example, Holguín-Veras *et al.* [24] discuss how the condition and level of efficiency of the local transport and distribution networks can have an impact on the degree of complexity or effectiveness of the delivery effort.

Thirdly, the infrastructure condition is crucial to logistics activities as it impacts both on the accessibility to those affected and on the cost of the relief operations [34] [57]. The physical infrastructure of a disaster impacted area may have been non-existent/inadequate prior to the event or can have been damaged or destroyed by the disaster itself [24] [57]. In either case, alternative solutions, such as finding other modes of transport and/or other routes may be necessary [2]. Infrastructure is so crucial to humanitarian logistics operations that WFP conducts 'Special Operations' when there is a need to resolve infrastructure bottlenecks and enhance the movements of relief supplies. These operations can involve repairs to roads and bridges, as well as to airport or port infrastructure. As an example, WFP recently organised the dredging works in two Somali ports to enable them to accommodate bigger ships and, thereby, reduce the bottlenecks, increase the volumes of humanitarian supplies delivered to Somalia, and achieve economies of scale [71]. Generally, such Special Operations complement the Emergency Operations and the Protracted Relief and Recovery Operations mentioned earlier [69].

Finally, the environmental situational factors also underpin the size of the challenge facing the humanitarian logistician, in particular the level of accessibility to the affected population. Typically, poorer families – who are the most in need of support – are found in the most difficult to access locations [7] (for example, higher up the mountain side or on islands that are offshore and way from significant townships). Difficult terrain conditions can lead humanitarian organisations to use animals (such as mules, yaks, donkeys, or camels) to transport supplies to the most remote destinations [70]. On the other hand, providing aid in a urban environment can also create very specific challenges. This is due to, among other reasons, the higher density of population, poor housing (for example the existence of shanty towns or *favelas*), and the health threats caused by poor sanitation systems and the rapid spread of epidemics. Furthermore, when working in a urban environment, humanitarian organisations have to develop relationships and coordinate operations with additional administrative actors [22].

A fifth external environment has to be added to the four factors already identified by Kunz and Reiner [37]: the conflict environment. The level of security/insecurity has a significant impact on the logistics operations, not least because it raises safety issues and may generate additional requirements such as escorted convoys [6]. Such an environment also creates numerous challenges for humanitarian logisticians who must deal with actors such as warlords, militia, guerrilla forces, or various other political movements. Some come to play a role of gatekeepers at logistical nodes (such as ports) or road checkpoints, which compels relief organisations to negotiate access for humanitarian deliveries and makes the distribution

process more costly [22]. In addition, a conflict situation restricts the mobility of humanitarian agencies, and, consequently, the identification of humanitarian needs and the accessibility to the affected population [22]. Finally, security issues increase looting and diversion of humanitarian supplies and may prevent humanitarian organisations from storing supplies locally, thereby reducing the flexibility of the distribution operations [26].

Due to the external situational factors, each disaster is unique and poses different challenges for humanitarian logisticians [34]. Indeed, two disasters that belong to the same category (for example, emergency localised disasters) can differ from a logistics perspective due to the influence of the external environment, as clearly demonstrated by comparing the 2010 Haiti earthquake with the 2011 Christchurch (New Zealand) earthquake. Thus, it is suggested that the external factors account for the degree of complexity and uncertainty humanitarian organisations have to cope with and, consequently, for most of the adjustments that humanitarian organisations need to make to reflect the differences in the disaster environments. Humanitarian organisations must understand how these factors impact on the logistics operations and how they can adapt their response accordingly.

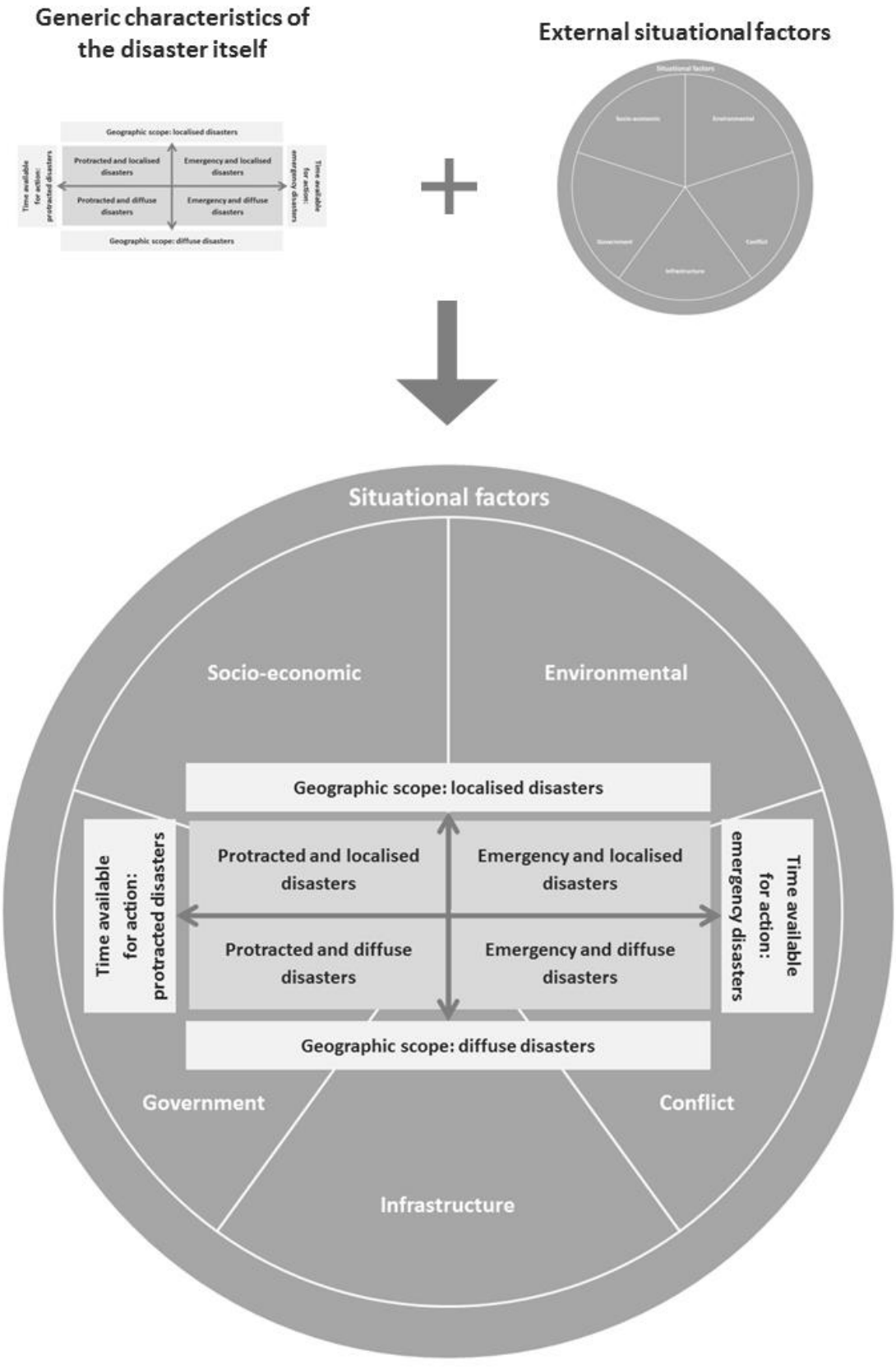
It should also be noted that the obstacles and complexities created by the external environmental factors are, in practice, not dissimilar to the conditions commercial organisations [12] [29] encounter when doing business in the least developed countries. For these companies, inadequate transport infrastructure, the lack of third-party logistics and transport expertise and services, underdeveloped information technology (leading to unreliable communication and data collection), political instability, the burden of bureaucracy, unethical/illegal practices (such as bribery or cargo pilferage), and hostile weather conditions [29] [50] [72] are part of their daily business. Consequently, they have developed expertise in coping with the uncertainties created by these hostile environmental factors [12] [29] [72]. Humanitarian organisations can learn from these commercial companies how to adapt to uncertain and changing environments.

From the above discussions, it can first be concluded that humanitarian logistics operations are not only affected by the generic characteristics of the disaster itself (the time and space factors), but also by a number of exogenous factors (the external environmental factors). From a logistics perspective, these two elements cannot be studied separately and have, therefore, been integrated into the same model. The second conclusion is that, whilst the time and space characteristics of disasters generate similarities in the operational requirements, the external situational factors create unique and complex logistics situations requiring humanitarian logistics organisations to develop adaptive capabilities. These conclusions will be further explored next.

The resultant model

Figure 2 represents the proposed logistics-focused disaster classification model that is based on (1) the four-quadrant scheme characterising the disaster itself and (2) the five external situational factors. This diagram highlights the importance of studying disasters within their external environment. The inserted table represents the generic dimensions of disasters (time available for action and geographic scope). It is posited that these characteristics generate similar logistics environments and reflect similarities in the operational requirements between the humanitarian context and the supply chain objectives and strategy orientations in use in a business context.

FIGURE 2: NEW DISASTER CLASSIFICATION MODEL (source: the authors)



For example, the uncertainties associated with emergency responses dictate a supply chain strategy that is totally focused on speed and flexibility in order to ensure the quick delivery [20] [21] [45] of humanitarian supplies to the disaster affected population. By contrast, service quality (such as delivering the right goods) and cost reduction may take precedence when humanitarian organisations respond to protracted disasters [2]. Due to the availability of future distribution dates, a protracted disaster environment is more predictable and stable and, consequently, shows similarities with the business logistics environment. This includes, for example, the regularity and repetitiveness of the flows of supplies (enabling logisticians to focus on operational optimisation and efficiency), structured processes and decision-making, or the possibility to reasonably establish demand [24]. It is suggested, therefore, that a protracted disaster environment may be approached using an efficiency optimisation strategy [20] (for example a continuous replenishment 'pull' system). On the other hand, as it has been established that the external situational factors create some unpredictability and instability, humanitarian organisations must retain some level of flexibility and responsiveness. This is essential to manage and adapt to the vagaries of the disaster's external environment and, despite the impacts of these forces, ensure reliability and consistency in the deliveries of humanitarian supplies. Possible measures to achieve that goal include carrying out infrastructure improvements, implementing systems for monitoring, inventory recording, and tracking, effectively planning the transport routes, adapting the packaging and labelling to the local circumstances, reducing the delivery times, increasing communication and information exchange [11], adapting to and using available (even rudimentary) modes of transport [29], working with reliable local transport and logistics partners [45], integrating the capabilities of the supply chain participants [30] [45], and building up buffer stocks against uncertainties [72] when foreign currency stocks are available in the impacted country [15].

LIMITS OF THE MODEL AND FURTHER AREAS OF RESEARCH

This new typology does not constitute a new paradigm, in the sense that it builds on previous research. However, it does provide a new analysis framework for future research. Indeed, the proposed model should not be seen as definitive, but rather as a first step towards further investigation and research. In particular, a key next stage is that of describing the different humanitarian logistics situations more thoroughly, identifying their distinctive and unique features, and understanding the logistics challenges and opportunities created by each of them. In other words, it is believed that further research should be undertaken to establish the characteristics of each disaster category and determine what specific logistics preparation and response strategies are suitable. This approach is aligned with the view of Holguín-Veras *et al.* [24] who argue that the lack of differentiation between the operational environments and the non-identification of their specific features prevents humanitarian logistics researchers from developing relevant analytical formulations and recommendations for improving the efficiency and effectiveness of the preparation and response.

Furthermore, to avoid remaining an academic exercise, the validity and utility of the model presented in this paper need to be tested both empirically and with practitioners so that its value as a decision-making tool can be better understood.

CONCLUSION

This paper addresses the deficiencies that have been increasingly exposed in the humanitarian logistics literature regarding the commonly used typology of disasters based on their origin (natural vs. man-made disasters) and the speed of onset (sudden vs. slow-onset disasters) and

proposes a new classification model of disasters. To that end, it redefines the boundaries of what a disaster is, and differentiates disasters according to their logistics impact. In this study, a disaster is treated both as a logistics outcome and as a context rather than a cause. Consequently, this paper views disasters from a generic perspective and goes beyond the physical phenomenon *per se* to focus on the logistics implications.

The proposed typology creates four categories of disasters based on two generic dimensions (time available for action and geographic scope). This paper goes on to argue that these dimensions alone are not sufficient to identify the logistics requirements because disasters always occur within a situational environment. Therefore, the new model integrates five situational factors reflecting the influence of the external environment on the logistics activities. This approach is designed to demonstrate that the nature of the humanitarian logistics operations is not only determined by the characteristics of the disaster itself, but also by external factors impacting the context. From a practical perspective, this paper argues that the study of disasters and of the preparation/response operations cannot be dissociated from the disaster's situational environment. Finally, it is argued that the generic disaster characteristics generate similar logistics requirements, whereas the external situational factors account for the uniqueness of each specific disaster.

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