The Emergent Role of Digital Technologies in the Context of Humanitarian Supply Chains: A Systematic Literature Review

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Abstract

The role of Digital Technologies (DTs) in Humanitarian Supply Chains (HSC) has become an increasingly researched topic in the operations literature. While numerous publications have dealt with this convergence, most studies have focused on examining the implementation of individual DTs within the HSC context, leaving relevant literature, to date, dispersed and fragmented. This study, through a systematic literature review (SLR) of 110 articles on HSC published between 2015 and 2020, provides a unified overview of the current state-of-the-art DTs adopted in HSC operations. The literature review findings substantiate the growing significance of DTs within HSC, identifying their main objectives and application domains, as well as their deployment with respect to the different HSC phases (i.e., Mitigation, Preparedness, Response, and Recovery). Furthermore, the findings also offer insight into how participant organizations might configure a technological portfolio aimed at overcoming operational difficulties in HSC endeavours. This work is novel as it differs from the existing traditional perspective on the role of individual technologies on HSC research by reviewing multiple DTs within the HSC domain.

Keywords: Humanitarian Supply Chains (HSC), digital technologies (DTs), supply chain management, digitalisation, systematic literature review (SLR).

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1. Introduction

Disasters, emergency situations, natural hazards and/or public health crises are an unexpected, abrupt or gradual phenomenon with unprecedented consequences, such as large-scale loss of human life, disrupting critical social systems or the infrastructure and environment (Gunasekaran et al., 2018; Dubey et al., 2019a). One of the most recent examples is the 2020 public health crisis caused by the pandemic of the SARS-CoV-2 virus (also referred to as COVID-19), which has created both supply and demand uncertainties and capacity fluctuations, causing gaps and disruptions in commercial as well as humanitarian supply chain (HSC) networks worldwide (Kovács and Falagara Sigala, 2021).

In the aftermath of such calamitous events, concerns for recovery and readiness receive significant attention from governments, policymakers, non-governmental organizations and/or scholars (Altay et al., 2018; Dubey et al., 2019b). In this context, the adoption of DTs becomes crucial for supporting operational activities before, during and after an adverse event has emerged (Galindo and Batta, 2013; Dubey et al., 2019c). Indeed, DTs have proven to play a key role in improving HSC efficiency and effectiveness throughout the disaster management cycle, and providing continuity throughout the phases—mitigation, preparedness, response and recovery (Reddick, 2011; Yadav and Barve, 2015).

However, despite the widely acknowledged potential of DTs in humanitarian operations, the study on the adoption of technologies in HSC is still somewhat immature and has so far been approached principally from a technology-centric perspective (e.g. Big Data (Dubey et al., 2019b), Radio Frequency Identification—RFID (Yang et al., 2011), Sensors (Alamdar et al., 2017), Internet of Things—IoT (Sinha et al., 2019), Blockchain Technology (Dubey et al., 2020a), Artificial Intelligence (Dash et al., 2019), among others) and oriented mostly towards the isolated effect of individual technologies on HSC activities (e.g. Logistics (Gavidia, 2017), Warehouse (Yang et al., 2011), Procurement (Heaslip et al., 2018), Planning (Dubey, 2019), Human Resource (de Camargo Fiorini et al., 2021), and Finance (Heaslip et al., 2018)). In view of this, extant literature in this field has been fragmented and dispersed into different streams of research (Kabra et al., 2017), thereby hindering uniform comparisons across technologies and making it difficult to draw substantial conclusions over their objectives in HSC, adoption domains, as well as their deployment across the HSC framework.

Against this backdrop, this work aims to contribute to the scholarly fields of HSC and DTs. In this vein, the purpose of this study is twofold. Firstly, to identify, by means of a Systematic Literature Review (SLR) (Webster and Watson, 2002; Rowe, 2014; Paré et al., 2015; Snyder, 2019), the current state-of-the-art DTs adopted within HSC operations. Secondly, to elucidate the main objectives of adopted DTs within the HSC, distinguishing main application domains as well as their deployment with respect to different HSC phases, that is, mitigation, preparedness, response, and recovery (Reddick, 2011; Yadav and Barve, 2015). To the best of our knowledge, there has been no study conducted to identify the different technologies adopted in HSC research. Accordingly, the value of this study is to provide a comprehensive and unified outlook on the various current DTs in the HSC domain. Further value is derived by illustrating the role of these technologies—in terms of main objectives, application domains, and deployment phases—within the HSC framework.

With these objectives in mind, we have conducted a SLR set on a protocol widely endorsed by scholars in the field of HSC (Dubey et al., 2017; Akter and Fosso Wamba, 2019; Gupta et al., 2019). Hence, a total of 55,322 articles published in peer-reviewed journals between 2015 and 2020 relating to the field of HSC, were extracted from renowned scholar databases (ABI/Inform, EBSCO Business Search, ScienceDirect, Scopus, Web of Science, Wiley Online), out of which 110 were relevant and included in the final analysis. By doing so, this article contributes to the literature in three ways. First, it provides an up-to-date review on the state-of-the-art DTs adopted within the HSC field. Second, it underscores the main objectives, application domains and deployment of these technologies according to the HSC phases. Finally, it sheds light on the configuration of a technological portfolio aimed at supporting participant organizations involved in HSC operations.

This paper is organized as follows: After this introduction (Section 1), a theoretical framework and positioning of the study on digital technologies and HSC is presented in Section 2; Section 3 introduces the methodological approach; Section 4 presents the findings that were obtained; and finally, Section 5 presents the discussion and conclusion of the findings, outlining the implications, limitations and future work perspectives.

2. Theoretical Framework and Positioning of the Study

During the past decades, HSC has grown as a field of research, garnering greater attention from academicians and practitioners, and positioning itself as a prominent topic within supply chain management (Kovács and Spens, 2007). Primarily, HSC aims to develop operational principles and practices for humanitarian aid, markedly different to those found in other industries, such as automotive, retail, or transportation (Behl and Dutta, 2019). Specifically, the concept of HSC explores how to improve the operational efficiency of international agencies, relief aid organisations, suppliers and donors to minimize the impact of a crisis (Charles, 2010). As such, over time, HSC has proven to be a growing yet still challenging research topic because of the high uncertainty that characterises disasters, hazards and emergency situations (Kovács and Spens, 2011; Day et al., 2012; Holguín-Veras et al., 2012; Seifert et al., 2018). Hence, the design and formation activities in HSC are significantly more complex than in commercial supply chains (Banomyong et al., 2019; Dubey et al., 2019c; Dubey et al., 2020b; Queiroz et al., 2020; Schiffling et al., 2020). In addition, HSC involves the participation of many different actors, coming together with the aim of providing aid and responding to affected people (Van Wassenhove, 2006). Within that complex organisational context, research is showing that collaboration, swift-trust and resilience may be pivotal influences on HSC management characteristics (Tatham and Kovács, 2010; Dubey et al., 2018a, 2019b; Dubey et al., 2020a). All the aforementioned aspects have allowed HSC to gain traction and support as a topic of concern among international organizations, including the United Nations (UN) (Behl and Dutta, 2019).

Before proceeding any further, it is important for our study to clarify that nowadays the transition from disaster management to HSC is a maturing research field comprised of multiple stakeholders and an extended range of research (Behl and Dutta, 2019). Since 2011, literature in this domain has experienced an increasing number of studies 'labelling' HSC from multiple perspectives and signalling this year as the turning point for studies related to HSC. Accordingly, this milestone year marked a shift in the scholarly discussion from a 'disaster management' perspective towards a 'HSC' one (Behl and Dutta, 2019).

Extant research has explored multiple dimensions of the HSC from various 'business' disciplines, such as operations management, economics, finance, and information systems (Prasanna and Haavisto, 2018). Concurrently, previous literature shows that HSC professionals are demanding that more attention be paid to a better understanding of the existing trends so that they feel more equipped for the future (Van Wassenhove, 2006). In alignment with this call, research on the use and new applications of DTs to improve the quality and efficiency of the humanitarian actions, is an increasingly demanded approach in the HSC literature (Vinck, 2013; Sandvik et al., 2014; Modgil et al., 2020). Furthermore, given the fact that technological innovations are mostly emerging and developing far away from the traditional humanitarian actors, HSC requires an intensified focus on the adoption of technology, systematic assessment and diffusion (Vinck, 2013).

DTs are operationalised for the purpose of this study as systems, devices, tools and resources that generate, store or process data and are combinations of information, computing, communication and connectivity technologies (Bharadwaj et al., 2013). The overall change process enabled by DTs is conceptualized into digital transformation (Vial, 2019) leading and demanding for new capabilities (Sebastian et al., 2017).

DTs aim to make supply chains and production processes more dynamic, flexible, precise and autonomous (Tortorella and Fettermann, 2018). Likewise, DTs enable the integration of processes both at an inter-organisational and an intra-organisational level (Ghobakhloo, 2020), and are able to provide solutions for the incremented needs of automation and informatisation in different organisations (Xu et al., 2018a).

The adoption and integration of DTs is essential in delivering more value to HSC (Rodríguez-Espíndola et al., 2020). A variety of individual domains of HSC has been discussed in the literature from a technological perspective: risk and need assessment (Dmitry, Dolgui and Sokolov, 2019), data generation and collection (Kane, 2014; Gunther et al., 2017), procurement and donation management (Lasi et al., 2014; Ülkü et al., 2015), agility (Schniedderjans and Hales, 2016; Dubey et al., 2020b), coordination and collaboration with other relief agencies (Kabra and Ramesh, 2015; Lu et al., 2018), capacity building of institutions and people (Chute and French, 2019), resilience in supply chain networks (Papadopoulos et al., 2017, Dubey et al., 2020a), strategic planning for emergency relief (Gavidia et al., 2017), relief logistics (Delmonteil et al., 2017), improved forecasting and early warning systems (Jeble et al., 2019), inventory management (Ozguven and Ozbay, 2013), performance evaluation (Yang et al., 2011) and continuous improvement in preparedness and response practices (Mesmar et al., 2016).

Studies on the role of DTs in HSC have gained pace from 2011onwards (Behl and Dutta, 2019). A range of individual DTs have already been applied to study the impact on HSC; from the integrated use of IT (Kabra and Ramesh, 2016, 2017) to cloud technologies (Schniedderjans and Hales, 2016), use of network technologies to optimise operations (Yang et al., 2011), or the application of big data analytics (Fosso Wamba et al., 2015; Papadopoulos et al., 2017).

In this regard, previous studies have also shown that the impact of ruinous events can be attenuated by applying digital technologies to reduce human losses, as well as to reduce the disruption of critical infrastructures (Pedraza-Martinez and Van Wassenhove, 2016). These studies were primarily published within the 2007–2009 timeframe (Jefferson, 2006; Day et al., 2009; Van der Laan et al., 2009a, 2009b), ostensibly increasing their pace from 2012. During this period, the major focus was on exploratory approaches on the state-of-the-art technologies linked to HSC (Privett, 2016). Such a growing number of publications is allowing scholars to craft frameworks under which to observe the role of technologies in different disaster management life-cycle stages, that is, within different stages comprised in HSC: mitigation, preparedness, response and recovery (Green and McGinnis, 2002; Waugh, 2000; Altay and Green, 2006; Carter, 2008).

A mitigation phase refers to any activity and/or measure taken in advance of a disaster, hazard, and/or emergency situation, in order to prevent or minimise its impact. Mitigation includes the application of measures aimed at either preventing the onset of a disaster or reducing the impacts of it were it to reoccur (Altay and Green, 2006). In the preparedness phase, it is ensured that an effective response capacity is achieved through the issuance of timely and effective early warnings, as well as the early evacuation of people from property and threatened locations (UNISDR, 2009). Response relates to the ability to employ resources and/or implement emergency procedures to revitalize and preserve life, property, the environment, and/or social, economic, and political structures of the affected areas (Altay and Green, 2006). Recovery alludes to the actions taken in the long term after the impact of a disastrous event, imminent hazard and/or emergency situation. It essentially aims to stabilise the community and restore normality (Altay and Green, 2006). In the literature, these four stages can be grouped into two main groups: pre-event response and post-event response (Tufekci and Wallance, 1998). The former includes prediction and analysis tasks to avoid potential risks; the latter starts when the disaster happens and while the emergency event is in progress.

As part of its Agenda 2030 agreements, the United Nations Office for Disaster Risk Reduction pointed out the use of DTs and applied research as an essential aspect in its roadmap to address global disasters (UNDRR, 2020). Within this context, Behl and Dutta (2019) indicate that most of the integration of DTs in HSC literature has been focused on pre-event responses, while studies on the impact of technology on the post-event response are less frequent but were needed to help improve the performance of stakeholders in HSC. In addition, most studies within the HSC context examine the impacts from a single-technology perspective, focusing mainly on the weaknesses and strengths of each specific technology (Rodríguez-Espíndola et al., 2020).

This dearth in research has motivated our approach, which adopts a holistic perspective on the current state-of-the-art, and the utilization of a multiple-technology lens in the context of HSC. Thus, we envision a distinctive main applicability and impact of DTs on HSC, particularly throughout all the HSC management phases. Our purpose is therefore to provide a contemporary categorization of DTs and their main objectives and application domains in HSC, while understanding their impacts on the different stages of HSC. By performing our analysis, we will give a guide to readers and professionals on which technology to use at what stage, and how to utilize them, in order to optimise usage and benefits.

For these reasons, this paper intends to encapsulate the relevant literature from the years 2015 to 2020, embracing trends that can significantly clarify the role of multi-technology integration in the HSC context.

3. Research Method

SLR is an established and proven method that enables the location, selection, and evaluation of the contributions that the literature has made to a research topic. In essence, it consists of categorizing and analysing the past, current, and future trends on a specific topic of discipline of science (Rowe, 2014; Paré et al., 2015; Snyder, 2019; Webster and Watson, 2002; Wolfswinkel et al., 2013). Over the years, multiple variations of SLR have been adapted within business and management research, particularly in the Operations and Supply Chain Management (OSCM) fields (Glock et al., 2017; Govindan et al., 2015; Govindan and Soleimaini, 2017) or HSC (Abidi et al., 2014; Dubey et al., 2019a; Kovács and Spens, 2007), highlighting the importance of the relationship with DTs (Machado et al., 2019; Núñez-Merino et al., 2020; Pagliosa et al., 2019).

We adapted a five step protocol which consists of: identifying a research topic; locating and selecting relevant studies; selection and appraisal criteria; analysis and synthesis; and dissemination of review findings (Tranfield et al., 2003; Denyer and Tranfield, 2009). Seminal works of Dubey et al. (2017), Behl and Dutta (2019), Akter and Fosso Wamba (2019), or Gupta et al. (2019), serve as benchmark studies for creating and adapting a protocol on our research objectives. Additionally, these seminal works provide insights on the rigor required for conducting SLR research. The following sub-sections discuss the details of our research methodology.

3.1 Planning our review – search syntax, databases selection and search criteria

We have performed a pilot test to obtain an initial understanding of the literature's scope regarding the research topic. In response to our overall research aim, to focus on a multi-technology perspective of DTs in the HSC context, we have developed and detected a set of keywords related to HSC. These keywords were assessed through a pre-screening of the works of Behl and Dutta (2019), Akter and Fosso Wamba (2019), or Gupta et al. (2019). Hence, bearing in mind the fact that the topic of DTs was covered in the technology oriented subdisciplines of business and management, keywords were observed in the works of Garay-Rondero et al. (2019), Ghobakhloo (2018, 2020), Oztemel and Gursev (2020), Verhoef et al. (2019), or Vial (2019).

We then proceeded with our search syntax development and determined our targeted scholar databases. Previous SLR studies quite commonly focused on only a few databases, such as Web of Science (WoS), Scopus, or ABI/Inform, particularly due to their size and the volume of available academic journals (Gupta et al., 2019) or indexing possibilities (Núñez-Merino et al., 2020; Quieroz et al., 2020). However, to ensure comprehensive coverage by following rigorous, systematic review and synthesis procedures without omitting any relevant research works (Akter and Fosso Wamba, 2019) and reducing any possible research bias (Thomé et al., 2016; Durach et al., 2017), we have decided to cover six scholar databases, namely: ABI/Inform, EBSCO Business Search, ScienceDirect, Scopus, Web of Science, and Wiley Online. This decision is consistent with the works of Dubey et al. (2017), focusing on ten scholar databases, or the works of Ben-Daya et al. (2019) and de Campos et al. (2019), which included similar database sets as ours. Extending and diversifying possible literature sources is expected to reinforce our findings since HSC is a relatively new and emerging topic in scholarly debates (Dubey et al., 2017; Dubey et al., 2019a).

Our search syntax was performed using an identified set of keywords in combination with Boolean connectors (AND and OR). The keywords were derived from previously mentioned articles in OSCM and technology-oriented fields and determined jointly by the authors of this study through brainstorming sessions and a pilot study. Keywords were expected to be sufficiently broad so as not to restrict the number of studies, but at the same time sufficiently specific to locate only studies related to the topic (Thomé et al., 2016; Durach et al., 2017).

Due to limitations imposed by the (user) interfaces for the search syntax of several scholar databases, our final syntax presented a complex item that demanded a simplification through iterative search and a combination of syntax items (i.e., item I and items II to XII). Table 1 presents a detailed overview of our research protocol, targeted databases, publication type, and use of keywords in a search syntax through Boolean connectors.

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3.2 Literature Identification, Retrieval and Analysis

Our research took place in the months of January and February 2020, with a focus on peer-review journal papers available in the English language and published between January 2015 and January 2020. This particular time span was selected for several reasons.

First, drawn from previous studies, we considered the last quinquennium to be an appropriate temporal horizon to distinguish principal trends in HSC research. This period can enable comprehensive analysis of the most relevant and actual tendencies of our targeted scope, i.e., DTs and HSC. Both of these concepts have experienced a relative maturity in scholarly discussions and literature, having a dramatic increase in publications in the period between 2011 and late 2014 (Behl and Dutta, 2019; Akter and Fosso Wamba, 2019). This enables us to argue that the period following early 2015 is the most appropriate starting point for our research design. Moreover, similar SLR analyses performed by Behl and Dutta (2019), Govindan et al. (2015) and Akter and Fosso Wamba (2019), justify the appropriateness and suitability of the five-year period as it is common practice in the OSCM field. Furthermore, focusing on the 2015 to 2020 time period is also due to the complexity of our research design, where we wanted to ensure a manageable review of multiple technologies and the resulting literature emerging in multiple scholar databases. Finally, focusing on this specific time span, between January 2015 and January 2020, enables us to pin-down development trends and tendencies with DTs in the HSC context prior to the disruption caused by the COVID-19 global healthcare crisis (officially marked as a pandemic in March 2020 by the World Health Organization).

Databases were allocated/divided among three authors of this study, where for each search syntax item we have focused on the review of the title, abstract, and keywords (Quieroz et al., 2020). This enables us to form inclusion and exclusion criteria (Denyer and Tranfield, 2009). The inclusion criteria in this step were explicit in the need for having a degree of relationship between DTs and HSC, whilst the exclusion of studies were possibly conference papers and book chapters, or peer-review papers, which lacked sufficient quality regarding DTs and the HSC context. The application of these criteria by three authors also resulted in the prevention of the possible bias of a single researcher.

Following the application of these abovementioned criteria, articles were evaluated and full papers downloaded for further analysis. This body of literature was reviewed again to confirm the inclusion of the studies that comply with the established search criteria (Denyer and Tranfield, 2009).

3.3 Categorisation of the Findings

The initial cumulative number of database articles searched, following the first item of our search syntax, was 55, 322. Through further scrutinization of this research set, with an iterative approach of following search syntax items, we narrowed this number to a total of 137 articles, which were downloaded. For additional screening, full text articles were retrieved and reviewed individually and meticulously by all the authors. This process was executed to ensure the validity of our results and to eliminate possible duplicates.

After the elimination of duplicate papers, assuring that only English language and peer-reviewed journal publications were taken into closer analysis, our final literature body (i.e., shortlisted articles) consisted of 110 papers (see Figure 1). Hence, this literature body enabled us to classify according to the main technology category, as well as with complementary information such as distribution according to journals, discipline, type of study, technology domain, or to discuss the main objectives and application domain within HSC stages. Such a categorization was derived from similar SLR thematic analyses encountered in the seminal works of Abidi et al. (2014), Behl and Dutta (2019), Dubey et al. (2017), or Gupta et al. (2019). Figure 1 graphically represents our research protocol.

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4. Findings

4.1 Technologies Reviewed and Primary Description

As previously stated, research on the convergence between HSC and DTs is currently dispersed and fragmented across different literature streams (Kabra et al., 2017). This has generated a vast range of technological descriptions from multiple perspectives and adapted to various domains (Heaslip et al., 2018; Dubey, 2019; de Camargo Fiorini et al., 2021). Accordingly, before reporting the findings of this study, it is deemed necessary, from our point of view, to state clear descriptions to allow for a better understanding of the inherent capacity of DTs within the context of this paper, and so to avoid misunderstandings or misinterpretations. To this aim, Table 2 provides descriptions of the 18 DTs examined in our analysis. These descriptions have been selected following a two criteria: (i) suitability for the HSC contexts and, (ii) capacity to describe the scope of the technology in a seamless manner. Correspondingly, all three authors of this study agreed to these descriptions according to the criteria described above.

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4.2 Articles Published by Journals

Table 3 shows how the articles included in the review relate to their classification by the journal in which they were published. We observed a flat distribution of publications across different journals with no clear pattern for a particular journal where the number of publications is particularly remarkable. Nonetheless, we identified two journals in the field of operations and logistics management research that included a significant number of the selected publications. Articles published in *Annals of Operations Research* and the *Journal of Humanitarian Logistics and Supply Chain Management* represent jointly 12 out of 110 (11 percent) papers included in the review. Our review also identified the prominence of two interdisciplinary journals publishing articles within the scope of our review; *IEEE Access* and *International Journal of Disaster Risk Reduction,* which included 7 out of 110 (7 percent) listed articles.

Therefore, our SLR identified an emergent interest in the role of digital technologies in Operations research and OSCM journals. Despite this, 91 out of 110 (83 percent) articles were published in journals that accounted for only one or two articles in our SRL. This observation is consistent with one of our initial motivations for this study; the degree of fragmentation and dispersion of literature in this area.

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4.3 Articles Published by Disciplines

According to our protocol, the papers were also classified to bring out the main disciplines in which they were published. The results presented in Table 4 show that research on the implementation of DTs in HSC is spread across five main areas of knowledge: (i) Business Management, Economics, and Law; (ii) Computer Science, Technology, and Robotics; (iii) Engineering, Mathematics, and Physics; (iv) Environmental Science, Natural Science, and Social Science; and (v) Operations Strategy, Supply Chain Management, and Production/Manufacturing. In terms of the number of articles within the scope of our review, the most significant research field was: (ii) Computer Science, Technology and robotics, representing 38 out of 110 articles (35 percent), followed closely by group (v): Operations Strategy, Supply Chain Management, and Production/Manufacturing, which accounted for 30 out of 110 articles (28 percent). In addition, out of 110 articles, 22 come from (iv) Environmental, Natural and Social Sciences. Finally, areas (iii) Engineering Mathematics and Physics, and (i) Business Management, Economics and Law, were identified as the minority fields in our review, accounting for 12 out of 110 (11 percent) and 8 out of 110 (7 percent), respectively.

In coherence with the scope of our review, the vast majority of our selected publications came from both the Technological and OSCM areas, jointly representing 68 out of 110 articles (62 percent). In addition, a key aspect in light of this classification is that the number of publications from the technological field (38) were higher than the number of published studies included from OSCM (30). It means that research in the application of DTs in HSC has been mainly addressed from a technological perspective instead of through the lens of OSCM research.

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4.4 Publications by Type of Study

One of the interesting outcomes from our SLR is a category on main research methods/theoretical approaches applied within the selected papers, a category determined in the seminal works of Akter and Fosso Wamba (2019) and Queiroz et al. (2020). Within this category we have observed the distribution of the selected papers into six groups, as represented in Table 5:

- conceptual/theoretical
- empirical (qualitative)
- empirical (quantitative)
- literature review,
- mixed methods
- technical development/experimental.

We have identified that the majority of articles rely on the combination of conceptual/theoretical and technical development/experimental approaches, particularly 65 out of 110 (59 percent) of the total selected papers. Interestingly, the number of studies adapting qualitative, quantitative, or a mixed approach, comprises cumulatively 30 out of 110 (27 percent) of the total selected papers. Lastly, studies based on literature reviews are represented in 15 out of 110 (14 percent) of the total selected papers. These percentual divisions can be justified by the fact that certain digital technologies are a complete novelty within the HSC context. These technologies remain an uncharted field in the academic literature and demand more empirically backed studies to determine characteristics of their (technological) maturity throughout the four-disaster management/DM stages.

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4.5 Publications by Technology Domain

In this subsection, we classify the articles reviewed according to the technology domain they belong to. This study includes 18 technology domains that contain the 110 papers examined for the purpose of our research. In Table 6, the main results which emerged from our analysis reveal that 4 technology domains (i.e., Big data (21), UAV (20), IoT (12), and IT (11)) represent almost 60 percent of the total articles explored in this study. On the other hand, it also discloses that 10 technology domains (i.e., Satellite (4), RFID (3), Additive Manufacturing (2), Artificial Intelligence (2), Cloud Computing (2), Crowdsourcing (2), Predictive Technologies (2), Mobile Phone (1), Sensors (1), and VGI (1)) constitute only less than 20 percent of the overall reviewed articles. Such a disparity, in terms of percentage, to the total number of articles, highlights the growing interest of the scientific community in certain DTs, particularly Big data, UAV, and IoT, within the HSC context (Dubey et al., 2019b; Sinha et al., 2019). However, in broad terms, the results which arose from this classification indicate that the research on DTs in HSC is, to date, highly concentrated is distinctive technologies and requires further development (Kabra et al., 2017).

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4.6 The role of DTs within HSC: objectives, application domains, and deployment phases

As a way to provide a comprehensive and holistic presentation of the role of the revisited DTs within HSC, Table 7 comprises the results of 87 articles (80 percent) extracted from the studies included in our review in three main categories: main objectives, main application domains, and HSC deployment phases (i.e., Mitigation, Preparedness, Response, Recovery). The rationale for selecting the studies were as follows: (1) studies explicitly stating at least one main objective within HSC of DTs examined; (2) studies explicitly interrelating DTs with at least one HSC application domain; and (3) studies explicitly associating at least one HSC deployment phase to the DTs reviewed. Based on the above, we present from a unified standpoint, the general role of the 18 technologies analysed in this study. We suggest that this way of presenting results is as convenient as it is valuable, as it allows to connect DTs with their respective main objective and main application domain, while also clearly depicting which HSC phase has deployed every digital technology or not. Furthermore, this way of displaying results offers the possibility to compare DTs and elucidate similarities and differences with respect to the different categories analysed (i.e., objectives, application domains, and phases of deployment). Altogether, it facilitates a clear interpretation of results while also serving as a theoretical guideline to support organizations in the search for the appropriate DTs to support HSC operations.

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5. Discussion

By analysing 110 articles following a SLR method, this study provides important contributions to the HSC scientific community, shedding light on the different DTs adopted within the HSC literature. Our findings show the existence of a flat distribution of publications (110 articles in 82 journals), which indicates that the confluence of HSC and DTs, as a growing field of research, is to date fragmented into a wide variety of journals. Moreover, they reveal that computer science, technology, and robotics (38 out of 110 articles) lead as research disciplines within the HSC, reaffirming that the role of DTs in HSC distinctly follows a technology-centric research perspective (Dubey et al., 2019b). Likewise, findings also show that most of the research is so far compiled in conceptual/theoretical and technical/experimental studies (65 out of 110 articles), which suggests that research in this area is still in its exploratory phase (nascent) and requires more confirmatory studies and empirical validation. With regard to the most relevant technology domains Big data, UAV, and IoT are at the forefront of the research in this convergence (53 out of 110 articles) with almost 60 percent of the overall articles explored in this study. Finally, our findings unveil, from a unified standpoint, main objectives, application domains, as well as deployment phases within the HSC context of the 18 different DTs (87 out of 110 articles) examined for this research. Overall, these contributions have a number of important theoretical and managerial implications for researchers and practitioners.

5.1 Theoretical contributions

This study adopts an integrative approach for analysing the role of DTs in HSC. This has a significant implication to both HSC and digital technology literature, as most of the research on this convergence focuses principally on the isolated effect of individual technologies on HSC activities. Accordingly, we contribute to the literature by providing a comprehensive and unified outlook on the analysis of DTs within the HSC context, a perspective so far neglected in the literature. Furthermore, this study provides new insights into the literature on DTs within HSC by disclosing relevant aspects associated with fields of research, discipline domains, as well as technologies leading the research on this convergence. In this regard, our research responds to recent calls to address the extant research gap on this convergence (Kabra et al., 2017).

5.2 Managerial Implications

This work, through a holistic approach to DTs, contributes to humanitarian actors by providing new insights into how they might configure a technological portfolio to better deal with the inherent complexity of HSC. More empirically backed studies were called for through the academic literature with an ail to help practitioners and interested stakeholders to understand the application frameworks and roadmaps on real issues and problems arising from emergency situations. Our results might be applied by participant organisations in HSC to sustain the development of specific strategies for the integration and implementation of DTs in any critical situation.

Recent studies emphasise the need for a more comprehensive strategy for technology utilization throughout different HSC operations and deployment phases to achieve real benefits (Sakurai and Murayama, 2019; Rodríguez-Espíndola et al., 2020). Within that context, our findings extend the knowledge on the application and integration of DTs in HSC, enabling us to discuss the development of new digital capabilities that may facilitate digital transformation in humanitarian organisations.

5.3 Digital Technologies Within HSC Phases

DTs in HSC deployment stages is an issue that has been ascribed critical importance by recent calls for further analysis (Pyakurel and Dhamala, 2017; Akter and Fosso Wamba, 2019). Our study contributes to the body of knowledge concerning practicality of DTs at different stages comprised in HSC: Mitigation, Preparedness, Response, and Recovery (Cegeila, 2006; Van Wassenhove, 2006; Carter, 2008). Previous studies have addressed the use of DTs in HSC deployment phases from a single technology perspective, i.e., Big Data, Information and Communication Technology, Satellites or Geospatial Technologies (Walter, 1990; Shklovski et al., 2008; Akter and Fosso Wamba, 2019; Sakurai and Murayama, 2019). In our study we apply a novel multi-technological perspective by mapping the application of 18 DTs to the different HSC deployment phases.

According to Behl and Dutta (2019), studies on the integration of DTs in HSC phases have been mainly oriented to explore their role on pre-event response, while applications on post-event response remain insufficiently researched. Our findings serve as a grounding to argue for a more comprehensive scholarly discussion on how to integrate DTs in HSC at both pre-event response and post-event response stages. We suggest that a number of DTs may provide specific contributions at each of the four stages (i.e., Preparedness, Response, Rehabilitation, and Mitigation). Concretely, 12 out of 18 sub-categories (Big Data, IT, IoT, Mobile, RFID, Satellite, Sensor, Social Media, UAVs, VAR and VGI) can arguably impact all phases. In addition, according to our findings, other sub-categories (Additive Manufacturing, AI, BT, CC, Crowdsourcing and Robots) show a higher degree of application specificity in HSC, contributing only to certain phases. From that perspective, these multi-purpose DTs represent an interesting domain of discussion due to their versatility that allows them to facilitate and increase the level of preparedness, mitigate risks during critical events, and subsequently collaborate within response and recovery phases.

5.4 Adding Value to Methodology of Research in the HSC Context

As mentioned earlier, the true value of this study is to provide a comprehensive and unified outlook on the various current DTs in the HSC domain. This meant an overview of the roles of these technologies in terms of main objectives, application domains, as well as their deployment with respect to different HSC phases (Mitigation, Preparedness, Response, and Recovery). The complexity of our overall research protocol (search syntax development, database selection, scope of technologies covered, inclusion and exclusion criteria, analysis and synthesis procedure) showcase the uniqueness of our contributions to the methodology of SLR research. To the best of our knowledge, similar studies aiming to give such an extensive scope of DTs as ours, have not yet been adopted in HSC research.

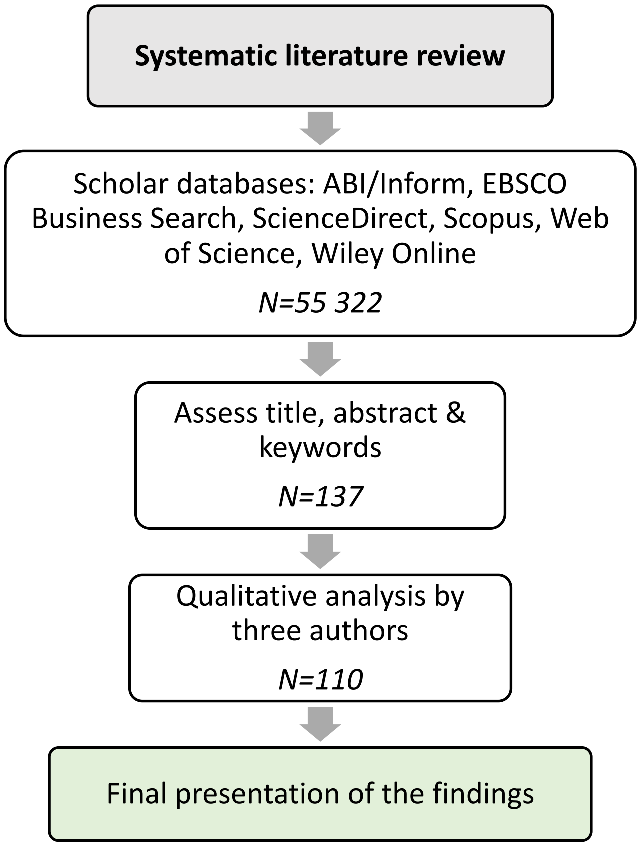
5.5 Limitations and Future Research

The limitations of our SLR are observed in the general research protocol. Our exclusion criteria eliminated all the papers written in languages other than English. Moreover, our study dismissed books, book chapters, conference proceedings and other (unpublished) literature sources. Thus, we may have discarded some sources that could contain relevant information for this study. Moreover, our time period from 2015 to 2020 could be expanded to include the most recent studies published during the global healthcare crisis.

Future research avenues could focus on the collection of insights from various stakeholders (technology developers, business practitioners, supply chain managers, humanitarian organisations, and policymakers) with an aim to explore multiple perspectives on the novelty of a specific DT within the HSC context. This could lead to discoveries of new processes, methods, organizational structures, and managerial frameworks for HSC operations that are trending with digitalisation advancements. Lastly, future research avenues could also envisage the expansion of possible scholar databases included in SLR to obtain more comprehensive data on the topic of DTs and the HSC context.

Appendix

Figure 1: Research protocol to the SLR.



Tables

Table 1: Research protocol details.

Table 1: Research protocol	
Research protocol	**Details description**
Research databases:	ABI/Inform, EBSCO Business Search, ScienceDirect, Scopus, Web of Science, Wiley Online
Publication type:	Peer-review journal publications
Language:	English language
Date range:	January 2015 to January 2020
Search fields:	Titles, abstracts & keywords
Search terms:	i. "Humanitarian Supply Chain" OR "Humanitarian Operations" OR "Emergency Management" OR "Natural Hazard" OR "Disaster" ii. "Industry 4.0" OR "Smart Industry" OR "Digitalisation" OR "Digital Transformation" iii. "Information Technology" OR "IT" iv. "Internet of Things" OR "IoT" v. "3D Printing" OR "Advanced Manufacturing" OR "Additive Manufacturing" vi. "Robotics" OR "Automotive Industry" vii. "Augmented Reality" AND "Virtual Reality" viii. "Big Data" OR "Big Data Analytics" AND "Predictive Technologies" ix. "Cloud Computing" x. "Digital Platforms" AND "Social Media" AND "Crowdsourcing" xi. "Unmanned Vehicles" OR "UAV" AND "Drones" xii. "Block-chains" OR "Blockchain Technology"
Criteria for inclusion:	Direct connection to the article research objectives
Criteria for exclusion:	Lack of direct relationship to article's research objectives
Data extraction:	Authors´ consensus at each stage to reduce biases
Data analysis & synthesis:	Qualitative analysis

Table 2: Technologies reviewed and description.

Table 2: Technologies reviewed and description	
Technology	**Description**
Additive Manufacturing	*"refers to a range of technologies that build objects up in layers without the need for a mould or cutting tool".* Tatham et al. (2015, p. 191).
Artificial Intelligence (AI)	*"a system's ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation".* Kaplan and Hanlein (2019, p. 17).
Big Data (BD)	*"a holistic approach to manage, process and analyse 5Vs (i.e., volume, variety, velocity, veracity and value) in order to create actionable insights for sustained value delivery, measuring performance and establishing competitive advantages".* Fosso Wamba et al. (2015, p. 215).
Blockchain Technology (BT)	"*refers to a fully distributed system for cryptographically capturing and storing a consistent, immutable, linear event log of transactions between networked actors*". Risius and Spohrer (2017, p. 386).
Cloud Computing (CC)	*"use of computing services (hardware and software) delivered on-demand to customers over a network in a self-service fashion, independent of device and location".* Marston et al. (2011, p. 177).
Crowdsourcing	"*a problem-solving and completing tasks model which involves the participation of the internet crowd (…) to harness collective intelligence*". Estellés-Arolas et al. (2015, p. 43).
Information Technology (IT)	*"any technology used to support information gathering, processing, distribution and use; composed of hardware, software, data and communication technology".* Beynon-Davies (2009, p. 5).
Internet-of-Things (IoT)	*"a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual 'things' have identities, physical attributes, and virtual personalities and use intelligent interfaces and are seamlessly integrated into the information network".* Vermesan et al. (2011, p. 10).
Mobile Phone	*"any device and application that uses cellular (or wireless) technology to send information or communication across distances to other devices or people".* Lefebvre (2009, p. 491).
Predictive Technologies (PT)	

	"set of tools that enable to analyse patterns from records or previous data for forecasting likely future behaviour". Nyce and Cpcu (2007, p. 1).
Radio Frequency Identification (RFID)	*"a radiofrequency (RF) electronic technology that allows automatic identification or locating of objects, people, and animals in a wide variety of deployment settings".* Hu et al. (2015, p. 260).
Robot	*"a constructed system that displays both physical and mental agency but is not alive in the biological sense".* Richards and Smart (2016, p. 6).
Satellite	*"any technology enabled by Earth-orbiting satellites, including the information produced directly by satellites (e.g., images) as well as the information gathered using satellites (e.g., communication)".* Delmonteil and Rancourt (2017, p.58).
Sensors	*"a device that can be controlled and queried by an external device to detect, record, and transmit information regarding a physiological change or the presence of various chemical or biological materials in the environment".* Annamalai et al. (2003, p. 1942).
Social Media	"*refers to internet-based services that allow individuals to create, share and seek content, as well as to communicate and collaborate with each other*". Lee and Ma (2012, p. 332).
Unmanned Aerial Vehicles (UAVs)	*"uninhabited and reusable motorised aerial vehicles, which are remotely controlled, semi-autonomous, autonomous, or have a combination of these capabilities, and that can carry various types of payloads, making them capable of performing specific tasks within the earth's atmosphere, or beyond, for a duration, which is related to their missions".* Van Blyenburgh (1999, p. 43).
Virtual & Augmented Reality	*"VR is an immersive computing technology that allows people to enter and experience things inside an artificial virtual world as if it were real" (Kwok et al. 2019, p. 713) / "AR technology supports the production of a live direct view of real-world environments whose elements are augmented by technologies such as videos, graphs, or GPS data".* Demir et al. (2017, p. 194).
Volunteered Geographic Information (VGI)	*"the widespread creation and sharing of geographic information by private citizens, often through platforms such as online mapping tools, social media, and smartphone applications".* Haworth, 2016, p. 189).

Table 3: Articles published by journals.

Sources	References	Articles
Acta Astronautica	Denis et al. (2016), Clark (2017).	2
Advanced Robotics	Tadokoro et al. (2019).	1
Aircraft Engineering and Aerospace Technology: An International Journal	Mascarello and Quaglioti (2017).	1
Annals of Operations Research	Mishra et al. (2018), Prasad et al. (2018), Akter and Fosso Wamba (2019), Behl and Dutta (2019), Griffith et al. (2019), Gupta et al. (2019), Sinha et al. (2019).	7
Annals of the American Association of Geographers	Burns (2018).	1
Automation in Construction	Ha et al. (2019).	1
Benchmarking: An International Journal	Jeble et al. (2019).	1
Big Data	Ofli et al. (2016).	1
Big Data & Society	Mulder et al. (2016).	1
Buildings	Nawari and Ravindran (2019).	1
Business Process Management Journal	Mishra et al. (2017).	1
Circulation: Cardiovascular Quality and Outcomes	Angraal et al. (2017).	1
Comptes Rendus Physique	Tanzi and Isnard (2019).	1
Computer Networks	Erdelj et al. (2017a).	1
Computers & Industrial Engineering	Kwok et al. (2019).	1
Computers, Environment and Urban Systems	Granell and Ostermann (2016).	1
Decision Support Systems	Horita et al. (2017).	1
Disasters	Jumbert (2018).	1
Energies	Ejaz et al. (2019).	1
Future Generation Computer Systems	Rego et al. (2018).	1
Future Internet	Latif et al. (2017).	1
Gadjah Mada International Journal of Business	Dwiputranti et al. (2019).	1
Geoforum	Cinnamon et al. (2016).	1
Geosciences	Yu et al. (2018).	1

IEEE Access	Ray et al. (2017), Li et al. (2019), Liu and Wang (2019), Shakhatreh et al. (2019).	4
IEEE Internet Of Things Journal	Xu et al. (2018).	1
IEEE Transactions on Parallel and Distributed Systems	Li et al. (2017).	1
IEEE Vehicular Technology Magazine	Merwaday et al. (2016).	1
IEEE Wireless Communications	Zhao et al. (2019).	1
IGI Global	Kabra and Ramesh (2017).	1
Industrial Robot: An International Journal	Bogue (2016), Pransky (2018).	2
Information Systems Frontiers	Abedin and Babar (2018), Poblet et al. (2018).	2
Interdisciplinary Description of Complex Systems	Kiss Leizer and Tokody (2017), Kiss-Leizer and Karoly (2018).	2
International Journal of Disaster Risk Reduction	Alamdar et al. (2017), Rabta et al. (2018), Bhuvana and Arul Aram (2019).	3
International Journal of Distributed Sensor Networks	Sanchez-Garcia et al. (2016).	1
International Journal of Distributed Systems and Technologies	Croatti et al. (2017).	1
International Journal of Future Generation Communication and Networking	Ghapar et al. (2018).	1
International Journal of Geo-Information	Hu et al. (2018).	1
International Journal of Health Geographics	Kamel Boulos et al. (2018).	1
International Journal of Information Management	Ragini et al. (2018), Elbanna et al. (2019).	2
International Journal of Law in the Built Environment	Stickley et al. (2016).	1
International Journal of Operations & Production Management	Brinch (2018).	1
International Journal of Organizational Innovation	Li and Li (2017).	1
International Journal of Production Economics	Chowdhury et al. (2017), Dubey et al. (2019).	2
International Journal of Production Research	Dubey et al. (2020a).	1
International Journal of Supply Chain Management	Khan et al. (2019).	1
Journal of Cleaner Production	Papadopoulos et al. (2017).	1

Journal of Decision Systems	Collins et al. (2016), Drosio and Stanek (2016).	2
Journal of Disaster Research	Kumagai et al. (2019), Usuda et al. (2019).	2
Journal of Humanitarian Logistics and Supply Chain Management	D'Haene et al. (2015), Tatham et al. (2015), Delmonteil and Rancourt (2017), Tatham et al. (2017), Shavarani (2019).	5
Journal of Information Systems and Technology Management	Ahmed (2015).	1
Journal of Information Technology Case and Application Research	Wang et al. (2015).	1
Journal of Information, Communication and Ethics in Society	Madhavaram et al. (2017).	1
Journal of International Technology and Information Management	Angeles (2018).	1
Journal of Manufacturing Technology Management	Haddud et al. (2017).	1
Journal of Strategic Innovation & Sustainability	Bidgoli (2018), Dash et al. (2019).	2
Journal of Usability Studies	Demir et al. (2017).	1
Mobile Information Systems	Ahn et al. (2018).	1
Multimedia Tools and Applications	Sebillo et al. (2016).	1
Natural Hazards	Nedjati et al. (2016), Golabi et al. (2017).	2
Natural Hazards and Earth Systems Sciences	Giordan et al. (2018).	1
Networks	Otto et al. (2018).	1
Nuclear Engineering and Technology	Kim et al. (2017).	1
Nuclear Technology & Radiation Protection	Jang and Woo (2019).	1
Online Information Review	Lai (2017).	1
Peer-to-Peer Networking and Applications	Chung and Park (2016).	1
Pervasive Computing	Erdelj et al. (2017b).	1
Physics of Life Reviews	Bellomo et al. (2016).	1
PloS one	Bjerge et al. (2016).	1
Production and Operations Management	Swaminathan et al. (2018), Bravo et al. (2019).	2
Progress in Disaster Science	Sakurai and Murayama (2019).	1
Public Management Review	Hu and Kapucu (2016).	1
Reviews of Geophysics	Zheng et al. (2018).	1
Risk, Hazards & Crisis in Public Policy	Kabra and Ramesh (2016).	1
Safety Science	Grabowski et al. (2016), Landwehr et al. (2016).	2

Sensors	Jorge et al. (2019).	1
Social Network Analysis and Mining	Goswami and Kumar (2016).	1
Supply Chain Management: An International Journal	Schniederjans et al. (2016).	1
Technologies	Savonen et al. (2018).	1
Telecommunication Systems	Hu et al. (2015), Li et al. (2016).	2
The International Journal of Logistics Management	Dubey et al. (2018b).	1
The Journal of Transport and Supply Chain Management (JTSCM)	Ittmann (2015).	1
Total number of articles		**110**

Table 4: Articles published by discipline.

Table 4: Articles published by discipline

Sources	**References**	**Articles**
Business Management, Economics and Law	Stickley et al. (2016), Mishra et al. (2017), Bidgoli (2018), Jumbert (2018), Ragini et al. (2018), Dash et al. (2019), Elbanna et al. (2019), Jeble et al. (2019).	**8** (7%)
Computer Science, Technology and Robotics	Ahmed (2015), Hu et al. (2015), Wang et al. (2015), Bjerge et al. (2016), Bogue (2016), Chung and Park (2016), Collins et al. (2016), Drosio and Stanek (2016), Goswami and Kumar (2016), Granell and Ostermann (2016), Li et al. (2016), Ofli et al. (2016), Sanchez-Garcia et al. (2016), Sebillo et al. (2016), Angraal et al. (2017), Croatti et al. (2017), Erdelj et al. (2017a), Erdelj et al. (2017b), Horita et al. (2017), Li et al. (2017), Madhavaram et al. (2017), Ray et al. (2017), Abedin and Babar (2018), Ahn et al. (2018), Angeles (2018), Ghapar et al. (2018), Poblet et al. (2018), Pransky (2018), Rego et al. (2018), Savonen et al. (2018), Xu et al. (2018), Jorge et al. (2019), Kumagai et al. (2019), Kwok et al. (2019), Liu and Wang (2019), Tadokoro et al. (2019), Usuda et al. (2019), Zhao et al. (2019).	**38** (35%)
Engineering, Mathematics and Physics	Grabowski et al. (2016), Merwaday et al. (2016), Kim et al. (2017), Mascarello and Quaglioti (2017), Otto et al. (2018), Ejaz et al. (2019), Ha et al. (2019), Jang and Woo (2019),	**12** (11%)

	Li et al. (2019), Nawari and Ravindran (2019), Shakhatreh et al. (2019), Tanzi and Isnard (2019).	
Environmental Science, Natural Science and Social Science	Bellomo et al. (2016), Cinnamon et al. (2016), Denis et al. (2016), Mulder et al. (2016), Nedjati et al. (2016), Alamdar et al. (2017), Clark (2017), Demir et al. (2017), Golabi et al. (2017), Kiss Leizer and Tokody (2017), Lai (2017), Papadopoulos et al. (2017), Burns (2018), Giordan et al. (2018), Hu et al. (2018), Kamel Boulos et al. (2018), Kiss-Leizer and Karoly (2018), Rabta et al. (2018), Yu et al. (2018), Zheng et al. (2018), Bhuvana and Arul Aram (2019), Sakurai and Murayama (2019).	**22** (20%)
Operations Strategy, Supply Chain Management and Production/Manufacturing	D'Haene et al. (2015), Ittmann (2015), Tatham et al. (2015), Hu and Kapucu (2016), Kabra and Ramesh (2016), Landwehr et al. (2016), Schniederjans et al. (2016), Chowdhury et al. (2017), Delmonteil and Rancourt (2017), Haddud et al. (2017), Kabra and Ramesh (2017), Latif et al. (2017), Li and Li (2017), Tatham et al. (2017), Brinch (2018), Dubey et al. (2018b), Mishra et al. (2018), Prasad et al. (2018), Swaminathan et al. (2018), Akter and Fosso Wamba (2019), Behl and Dutta (2019), Bravo et al. (2019), Dubey et al. (2019), Dwiputranti et al. (2019), Griffith et al. (2019), Gupta et al. (2019), Khan et al. (2019), Shavarani (2019), Sinha et al. (2019), Dubey et al. (2020a).	**30** (27%)
Total number of articles		**110**

Table 5: Articles published by type of study.

Table 5: Articles published by type of study

Sources	References	Articles
Conceptual/Theoretical	Ahmed (2015), Hu et al. (2015), Ittmann (2015), Bellomo et al. (2016), Collins et al. (2016), Goswami and Kumar (2016), Ofli et al. (2016), Stickley et al. (2016), Angraal et al. (2017), Erdelj et al. (2017b), Latif et al. (2017), Li and Li (2017), Mascarello and Quaglioti (2017), Ray et al. (2017), Bidgoli (2018), Jumbert (2018), Kiss-Leizer and Karoly (2018), Poblet et al. (2018), Swaminathan et al. (2018), Dash et al. (2019), Ha et al. (2019), Jeble et al. (2019), Khan et al. (2019), Nawari and Ravindran (2019), Sakurai and Murayama (2019), Tanzi and Isnard (2019).	**26** (24%)
Empirical (Qualitative)	D'Haene et al. (2015), Wang et al. (2015), Mulder et al. (2016), Alamdar et al. (2017), Clark (2017), Delmonteil and Rancourt (2017), Lai (2017), Burns (2018), Pransky (2018), Prasad et al. (2018), Elbanna et al. (2019).	**11** (10%)
Empirical (Quantitative)	Hu and Kapucu (2016), Kabra and Ramesh (2016), Haddud et al. (2017), Kabra and Ramesh (2017), Papadopoulos et al. (2017), Dubey et al. (2018b), Bhuvana and Arul Aram (2019), Dubey et al. (2019), Dwiputranti et al. (2019), Sinha et al. (2019), Dubey et al. (2020a).	**11** (10%)
Literature Reviews	Tatham et al. (2015), Erdelj et al. (2017a), Mishra et al. (2017), Brinch (2018), Giordan et al. (2018), Kamel Boulos et al. (2018), Mishra et al. (2018), Otto et al. (2018), Yu et al. (2018), Zheng et al. (2018), Akter and Fosso Wamba (2019), Behl and Dutta (2019), Gupta et al. (2019), Jorge et al. (2019), Shakhatreh et al. (2019).	**15** (14%)
Mixed Methods	Bjerge et al. (2016), Cinnamon et al. (2016), Drosio and Stanek (2016), Granell and Ostermann (2016), Landwehr et al. (2016), Schniederjans et al. (2016), Demir et al. (2017), Angeles (2018).	**8** (7%)
Technical Development/Experimental	Bogue (2016), Chung and Park (2016), Denis et al. (2016), Grabowski et al. (2016), Li et al. (2016), Merwaday et al. (2016), Nedjati et al. (2016), Sanchez-Garcia et al. (2016), Sebillo et al.	**39** (36%)

	(2016), Chowdhury et al. (2017), Croatti et al. (2017), Golabi et al. (2017), Horita et al. (2017), Kim et al. (2017), Kiss Leizer and Tokody (2017), Li et al. (2017), Madhavaram et al. (2017), Tatham et al. (2017), Abedin and Babar (2018), Ahn et al. (2018), Ghapar et al. (2018), Hu et al. (2018), Rabta et al. (2018), Ragini et al. (2018), Rego et al, (2018), Savonen et al. (2018), Xu et al. (2018), Bravo et al. (2019), Ejaz et al. (2019), Griffith et al. (2019), Jang and Woo (2019), Kumagai et al. (2019), Kwok et al. (2019), Li et al. (2019), Liu and Wang (2019), Shavarani (2019), Tadokoro et al. (2019), Usuda et al. (2019), Zhao et al. (2019).	
Total number of articles		**110**

Table 6: Articles published by technology domain.

Table 6: Articles published by technology domain

Sources	**References**	**Articles**
Big Data	Ittmann (2015), Bellomo et al. (2016), Drosio and Stanek (2016), Goswami and Kumar (2016), Grabowski et al. (2016), Mulder et al. (2016), Horita et al. (2017), Mishra et al. (2017), Papadopoulos et al. (2017), Brinch (2018), Dubey et al. (2018b), Mishra et al. (2018), Prasad et al. (2018), Ragini et al. (2018), Swaminathan et al. (2018), Yu et al. (2018), Akter and Fosso Wamba (2019), Behl and Dutta (2019), Dubey et al. (2019), Gupta et al. (2019), Jeble et al. (2019).	**21** (19%)
Unmanned Aerial Vehicles (UAV)	Merwaday et al. (2016), Nedjati et al. (2016), Sanchez-Garcia et al. (2016), Chowdhury et al. (2017), Erdelj et al. (2017a), Erdelj et al. (2017b), Golabi et al. (2017), Kiss Leizer and Tokody (2017), Mascarello and Quaglioti (2017), Tatham et al. (2017), Giordan et al. (2018), Kiss-Leizer and Karoly (2018), Otto et al. (2018), Rabta et al. (2018), Bravo et al. (2019), Ejaz et al. (2019), Li et al. (2019), Shakhatreh et al. (2019), Shavarani (2019), Zhao et al. (2019).	**20** (18%)
Internet of Things (IoT)	Chung and Park (2016), Li et al. (2016), Haddud et al. (2017), Latif et al. (2017), Li and Li (2017), Ray et al. (2017), Ahn et al. (2018),	**12** (11%)

	Ghapar et al. (2018), Rego et al. (2018), Xu et al. (2018), Liu and Wang (2019), Sinha et al. (2019).	
Information Technology (IT)	Bjerge et al. (2016), Hu and Kapucu (2016), Kabra and Ramesh (2016), Kabra and Ramesh (2017), Madhavaram et al. (2017), Bidgoli (2018), Dwiputranti et al. (2019), Khan et al. (2019), Kumagai et al. (2019), Sakurai and Murayama (2019), Usuda et al. (2019).	**11** (10%)
Robots	Bogue (2016), Kim et al. (2017), Li et al. (2017), Pransky (2018), Ha et al. (2019), Jang and Woo (2019), Jorge et al. (2019), Tadokoro et al. (2019), Tanzi and Isnard (2019).	**9** (8%)
Social Media	Collins et al. (2016), Landwehr et al. (2016), Lai (2017), Abedin and Babar (2018), Burns (2018), Bhuvana and Arul Aram (2019), Elbanna et al. (2019).	**7** (6%)
Blockchain Technology (BC)	Angraal et al. (2017), Angeles (2018), Kamel Boulos et al. (2018), Nawari and Ravindran (2019), Dubey et al. (2020a).	**5** (5%)
Virtual & Augmented Reality	Sebillo et al. (2016), Croatti et al. (2017), Demir et al. (2017), Hu et al. (2018), Kwok et al. (2019).	**5** (5%)
Satellite	Denis et al. (2016), Clark (2017), Delmonteil and Rancourt (2017), Jumbert (2018).	**4** (4%)
Radio Frequency Identification (RFID)	Ahmed (2015), Hu et al. (2015), Wang et al. (2015).	**3** (3%)
Additive Manufacturing	Tatham et al. (2015), Savonen et al. (2018).	**2** (2%)
Artificial Intelligence	Ofli et al. (2016), Dash et al. (2019).	**2** (2%)
Cloud Computing	D’Haene et al. (2015), Schniederjans et al. (2016).	**2** (2%)
Crowdsourcing	Poblet et al. (2018), Zheng et al. (2018).	**2** (2%)

Predictive Technologies	Stickley et al. (2016), Griffith et al. (2019).	**2** (2%)
Mobile Phone	Cinnamon et al. (2016).	**1** (1%)
Sensors	Alamdar et al. (2017).	**1** (1%)
Volunteered Geographic Information (VGI)	Granell and Ostermann (2016).	**1** (1%)
Total number of articles		**110**

Table 7: The role of DTs within HSC.

Table 7: The role of DTs within HSC

Technology	Main objective	Main application domain	HSC deployment phases Miti gation	Prepar edness	Re sponse	Re covery
Additive Manufacturing	• To understand 3D printing technology rapid manufacturing at the sites of humanitarian crises. Savonen et al. (2018). • To investigate 3D printing potential to improve the efficiency and effectiveness of humanitarian logistics. Tatham et al. (2015).	• Development of a new type of 3D printer and possibility to manufacture a particular item or equipment at a location affected by an emergency situation. Savonen et al. (2018). • Reduction of supply chain lead times, the use of logistic postponement techniques and the provision of customised solutions to meet unanticipated operational demands. Tatham et al. (2015).	○	✓	✓	✓
Artificial Intelligence (AI)	• To predict trends, warehousing optimisation and set logistics prices in Humanitarian Operations. Dash et al. (2019). • To process and analyse large volumes of data to be integrated into an Artificial Intelligence platform for	• Humanitarian Logistics Operations. Dash et al. (2019). • Artificial Intelligence for Disaster Response (AIDR) Ofli et al. (2016).	○	✓	✓	○

	Disaster Response (AIDR). Ofli et al. (2016).					
Big Data	• Capability of an organisation adopting Big Data and Predictive Analytics (BDPA) positively impacts both visibility and coordination in the HSC. Dubey et al. (2018b). • Big Data Analytics Capability (BDAC) as an organisational culture positively impacts the collaborative performance and swift trust between military and civil organisations working together in disaster relief operations (Dubey et al. 2019). • BDPA, as a capability, improves effectiveness of humanitarian operations to achieve its objectives, and combined with social capital can improve HSC performance. Jeble et al. (2019). • To predict crowd behaviour in extreme situations of evacuation. Bellomo et al. (2016). • BDA to leverage opportunities to generate RISE (rapid, impactful, sustained, and efficient) operations in	• Coordination and Collaboration in HSC. Dubey et al. (2018b), Dubey et al. (2019). • Crisis Management. Bellomo et al. (2016), Drosio and Stanek (2016), Horita et al. 2017), Ragini et al. (2018). • Efficiency and Responsiveness in Humanitarian Operations. Mulder et al. (2016), Swaminathan et al. (2018), Jeble et al. (2019). • Resource allocation in DM. Grabowski et al. (2016). • Supply chain resilience. Papadopoulos et al. (2017). • Humanitarian Response Management Mulder et al. (2016).	✓	✓	✓	✓

	humanitarian context. Swaminathan et al. (2018). • To address resource allocation challenges in remote locations. Grabowski et al. (2016). • To improve efficiency in DM through sentiment analysis of social media data. Ragini et al. (2018). • To support decision-making in crisis/disaster management. Drosio and Stanek (2016), Horita et al. 2017). • To explain the role of supply chain resilience and achieve sustainability. Papadopoulos et al. (2017). • To improve participatory humanitarian response by using open Big Data. Mulder et al. (2016). • To design better interventions by understanding the data attributes that impact on cost, propagation, deliverables and lead-times in humanitarian operations. Mulder et al. (2016).					
Blockchain Technology (BT)	• To understand how BT can influence operational supply chain transparency (OSTC) and	• BT-enabled collaboration among actors engaged in disaster relief operations and supply chain	○	✓	○	✓

	swift trust (ST) among stakeholders in disaster relief operations. Dubey et al. (2020a). • Conceptualization of the BT use in the healthcare industry. Angeles (2018). • To improve the authenticity and transparency of healthcare data. Angraal et al. (2017). • To understand implications of geospatially enabled BT solutions. Kamel Boulos et al. (2018). • To explore BT application in the Architecture, Engineering, and Construction (AEC) industry. Nawari and Ravindran (2019).	resilience (SCR). Dubey et al. (2020a). • Medical and healthcare industry (healthcare data exchange and interoperability; drug supply chain integrity and remote auditing; and clinical trials and population health research). Angeles (2018). • Reconstruction of buildings and infrastructure in post-disaster recovery stage. Nawari and Ravindran (2019). • Geospatial BT record of validated location, allowing accurate spatiotemporal mapping of physical world events (such as disasters). Kamel Boulos et al. (2018).				
Cloud Computing (CC)	• To improve collaboration between organisations and suppliers in HSC. Schniederjans et al. (2016). • To enhance inter-organisational trust and agility in HSC context, accelerating supply chain integration. D'Haene et al. (2015). • To increase flexibility and responsiveness in the IT capabilities of humanitarian	• Collaboration and Agility in HSC. Schniederjans et al. (2016), D'Haene et al. (2015). • Performance measurement in HSC Schniederjans et al. (2016).	○	✓	✓	○

	organisations. (Schniederjans et al. 2016).					
Crowdsourcing	• To discuss advantages and limits of using crowdsourcing methods and tools in disaster management. Poblet et al. (2018). • To identify crowdsourcing-based data acquisition method and discuss their potential issues. Zheng et al. (2018).	• Conceptualisation of crowdsourcing roles and platforms in disaster management. Poblet et al. (2018). • Management of crowdsourcing projects, data quality, data processing, and data privacy in crowdsourcing-based data acquisition methods. Zheng et al. (2018).	○	○	✓	○
Information Technology (IT)	• To provide a holistic perspective on the use of IT throughout all disaster management phases. Sakurai and Murayama (2019). • To design an IT system that integrates all the parties involved in humanitarian relief operations. Dwiputranti et al. (2019). • To develop an IT platform infrastructure to facilitate “cross-ministerial information sharing” of the various disaster-response governmental	• Disaster relief operations. Dwiputranti et al. (2019), Bjerge et al. (2016). • Disaster management information services. Usuda et al. (2019). • Disaster response management. Kumagai et al. (2019). • Emergency and disaster management. Madhavaram et al. (2017), Hu and Kapucu (2016). • Humanitarian Logistics. Khan et al. (2019). • Humanitarian relief operations. Kabra and Ramesh (2016).	✓	✓	✓	✓

organizations. Usuda et al. (2019).

- To develop an early warning system based on a portable IT unit as an alternative communication means to mitigating disaster damages. Kumagai et al. (2019).
- To discuss a new IT (mobile phone-based service) for informing concerned authorities, family and friends about the well-being of an affected individual in emergency cases. Madhavaram et al. (2017).
- To examine how emergency management organizations utilize ITs in their communication and coordination with other organizations in the emergency management network. Hu and Kapucu (2016).
- Analyse the role of ITs in humanitarian product and service supply after a disaster strikes. Khan et al. (2019).
- To assess the relationships between IT utilization, mutual trust, agility, flexibility, adaptability and performance in

- Healthcare system. Bidgoli (2018).

	an HSC context. Kabra and Ramesh (2016).					
Internet-of-Things (IoT)	• To present a Software Defined Network (SDNs)-based architecture for urban traffic monitoring in emergency situations in the context of smart city environments. Rego et al. (2018). • To propose an IoT architecture for flood data management that collects, transmits and manages flood related data. Ghapar et al. (2018). • To develop reliable IoT Networks for unmanned air vehicles (UAVs) in disaster search and rescue operations. Ahn et al. (2018). • To propose an evacuation planning algorithm to provide personalized evacuation planning schemes for users in order to guide them to the most reasonable shelter. Xu et al. (2018). • To design a traffic emergency response system based on Internet of Things to improve the level of emergency response. Liu and Wang (2019).	• Urban traffic management. Rego et al. (2018). • Flood forecasting. Ghapar et al. (2018). • Disaster rescue operations. Ahn et al. (2018). • Emergency evacuation planning. Xu et al. (2018). • Traffic emergency response. Liu and Wang (2019). • Healthcare System. Latif et al. (2017). • Disaster management operations. Sinha et al. (2019).	✓	✓	✓	✓

	• To analyse how IoT (in confluence with other technologies) has the potential to revamp the healthcare system, in order to cope with the burden of modern diseases and the challenge of scaling up to ever-increasing populations. Latif et al. (2017). • To propose a IoT based solution using the task-technology fit approach for an effective and efficient disaster management. Sinha et al. (2019).					
Mobile Phone	• To examine the use of actively and passively produced mobile phone data for managing humanitarian disasters. Cinnamon et al. (2016).	• Disease disaster management. Cinnamon et al. (2016).	✓	✓	✓	✓
Predictive Technologies (PT)	• To facilitate authorities to better distinguish the probability of occurrence of natural hazards and make improved decisions about mitigation plans. Stickley et al. (2016). • To make quicker decisions in supply chain operations (i.e.,	• Natural disaster management. Cinnamon et al. (2016). • Humanitarian Logistics Operations. Griffith et al. (2019).	✓	○	✓	✓

	patient evacuation and improved medical care delivery to military missions in conflict areas). Griffith et al. (2019).					
Radio Frequency Identification (RFID)	• Remote identification and tracking of patients, staff, drugs, and equipment. Hu et al. (2015). • An RFID-based solution to improve the retrieval of buried facilities as part of disaster recovery efforts. Wang et al. (2015). • To evaluate the potential of RFID for emergency management tasks within the emergency management life cycle. Ahmed (2015).	• Electronic Health (eHealth) systems. Hu et al. (2015). • Disaster recovery operations. Wang et al. (2015). • Emergency Management. Ahmed (2015).	✓	✓	✓	✓
Robots	• To collaborate in search and rescue activities (SAR) through exploration of affected areas and acquisition of three-dimensional (3D) information. Bogue (2016), Li et al. (2017), Tanzi and Isnard (2019). • To acquire and process key environmental information, becoming extremely useful to collect data in particularly	• Search and Rescue (SAR). Bogue (2016), Li et al. (2017), Tanzi and Isnard (2019). • Natural disaster management. Kim et al. (2017), Pransky (2018), Ha et al. (2019), Jang and Woo (2019). • Relief operations. Kim et al. (2017), Tadokoro et al. (2019).	○	○	✓	✓

	polluted or radioactive environments. Kim et al. (2017), Pransky (2018), Ha et al. (2019), Jang and Woo (2019). • To support relief operations in HSC, being particularly useful with their deployment in extreme natural hazards. Kim et al. (2017), Tadokoro et al. (2019). • To help in recovery works and reducing the impact of the disaster by avoiding imminent post-disaster hazards in extremely harsh environments. Kim et al. (2017), Ha et al. (2019), Jang and Woo (2019).	• Post-disaster Management. Kim et al. (2017), Ha et al. (2019), Jang and Woo (2019).				
Satellite	• To assess the impact of Earth Observation (EO) satellites' performance in supporting emergency response services. Denis et al. (2016). • To review the creation of a common licensing scheme for the access and use of satellite earth observation (EO) data. Clark (2017). • To explore the relevance of surveillance technologies for detecting and gathering	• Emergency Management Service (EMS). Denis et al. (2016). • International disaster management (DM) activities. Clark (2017). • Border management. Jumbert (2018). • Disaster relief logistics. Delmonteil and Rancourt (2017).	✓	✓	✓	✓

	• information to control maritime borders. Jumbert (2018). • To investigate the role of commonly used satellite technologies in relief logistics: imagery and mapping. Delmonteil and Rancourt (2017).					
Sensors	• To analyse how multi-vendor sensor derived data is produced and exchanged, and how the information obtained can be useful for emergency decision-making. Alamdar et al. (2017).	• Flood disaster management. Alamdar et al. (2017).	✓	✓	✓	✓
Social Media	• To investigate implications of social media platforms in emergency situations. Elbanna et al. (2019). • To explore the use of microblogging platforms by Emergency Response Organisations (EROs) during extreme natural events. Abedin and Babar (2018). • To underline different patterns of social media use by the collectives in emergency response. Lai (2017).	• Social media's role in rapid propagation of information in emergency situations. Abedin and Babar (2018). • Use of different social media networks in the disaster management response stage. Lai (2017). • Social media’s role in dissemination and diffusion of information by non-institutional stakeholders in emergency situations. Abedin and Babar (2018).	✓	✓	✓	✓

	• To understand the institutional and community-based politics that frame the types of data produced in disasters. Burns (2018). • To distinguish spatially related information from unhelpful or speculative social media ‘noise' in the aftermath of a disaster. Collins et al. (2016).	• Development of the Crisis Communication Tool (CCT) in an emergency event. Collins et al. (2016). • Advantages and limitations of Twitter as a social media platform that can help to mitigate disasters. Landwehr et al. (2016).				
Unmanned Aerial Vehicles (UAVs)	• To prevent and/or to quickly detect natural disasters by monitoring environmental conditions and collect data (humidity, temperature, wind, etc.). Ejaz et al. (2019). • To positively impact relief distribution. Nedjati et al. (2016), Chowdhury et al. (2017), Golabi et al. (2017), Rabta et al. (2018), Shavarani (2019). UAVs are used to access cut-off areas when infrastructures has collapsed, overcoming last-mile distribution problems. Tatham et al. (2017), Rabta et al. (2018). • To improve search and rescue (SAR) activities thanks to their speed and autonomous operation. Erdelj et al., (2017a)	• Natural disaster management. Ejaz et al. (2019). • Relief distribution. Nedjati et al. (2016), Chowdhury et al. (2017), Golabi et al. (2017), Tatham et al. (2017), Rabta et al. (2018), Shavarani (2019). • Search and Rescue (SAR). Erdelj et al., (2017a) Chowdhury et al. (2017), Shakhatreh et al. (2019), Shavarani (2019). • Planning of Humanitarian Operations. Chowdhury et al. (2017), Bravo et al. (2019), Li et al. (2019), Shakhatreh et al. (2019). • Waste Management. Kiss Leizer and Tokody (2017), Giordan et al. (2018), Kiss Leizer and Karoly (2018).	✓	✓	✓	✓

	Chowdhury et al. (2017), Shakhatreh et al. (2019). • UAVs help to increase rapidity and efficiency to supply essential resources and keep people alive, particularly in the first 12-24 critical hours. Shavarani (2019). In this regard, UAVs can identify “hot spots” where it could be more likely to find survivors. Chowdhury et al. (2017). • To create updated maps of impacted areas, collaborating in the creation of path planning operation. Chowdhury et al. (2017), Golabi et al. (2017), Bravo et al. (2019), Li et al. (2019), Shakhatreh et al. (2019). • To collaborate in waste management by offering a safe identification of any dangerous material, working in toxic environments or even collecting data about radioactivity or gas concentrations. Kiss Leizer and Tokody (2017), Giordan et al. (2018), Kiss Leizer and Karoly (2018). • A group of UAVs allows a Flying Ad Hoc Networks (FANET) to be eployed, which means a flexible and fast communication	• Communication Networks. Merwaday et al. (2016), Sanchez-Garcia et al. (2016), Zhao et al. (2019), Ejaz et al. (2019), Shakhatreh et al. (2019), Zhao et al. (2019), Mascarello and Quagliotti (2017). • Damage Assessment. (Erdelj et al., 2017b; Li et al., 2019; Chowdhury et al., 2017).	

	network able to provide crucial communication services and wireless connection for HSC in a disaster. Merwaday et al. (2016), Sanchez-Garcia et al. (2016) Zhao et al. (2019), Ejaz et al. (2019), Shakhatreh et al. (2019), Zhao et al. (2019), Mascarello and Quagliotti (2017). • To help in damage assessment through aerial images, video inspection and sensor data to evaluate the state of key infrastructures (Erdelj et al., 2017b; Li et al., 2019; Chowdhury et al., 2017).					
Virtual & augmented reality	• To explore the adoption of augmented reality (AR) techniques and applications in emergency situations. Sebillo et al. (2016). • To discuss the importance of an appropriate simulation training for responders. Kwok et al. (2019). • To enable better prepared responders on health, security and managerial issues emerging in disaster management. Sebillo et al. (2016).	• Development of a hazard simulation system with the capability to recreate large scale and multi-agency emergency incidents - virtual collaborative simulation-based training (VCST). Kwok et al. (2019). • Three-dimensional (3D) visualizations of disaster scenes based on mobile VR. Hu et al. (2018). • Adoption of AR techniques and applications in emergency situations. Sebillo et al. (2016).	✓	✓	✓	✓

	• To support coordination between multiple stakeholders in disaster management response stage through AR technologies. Demir et al. (2017).	• Development of distributed collaborative systems for teams of rescuers and operators involved in a rescue mission. Croatti et al. (2017). • Integration of wearable devices and AR technology (AR) to support activities in disaster management response stage. Demir et al. (2017).5				
Volunteered Geographic Information (VGI)	• To identify important analytical trends and use patterns on the utilization of VGI and geo-social media for disaster management. Granell and Ostermann (2016).	• Natural and man-made disaster management. Granell and Ostermann (2016).1	✓	✓	✓	✓

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