

Non-functional Requirements and Key Propositions Elicitation for an HDSS: A Grounded Theory Approach

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ABSTRACT

Deciding humanitarian actions during relief distribution is a crucial and challenging task. Humanitarian decision-makers (HDM) make many critical decisions during disaster responses, but they suffer from incomplete, irrelevant, and sometimes excessive humanitarian operations-related disaster data in many situations. Hence, for constructive and meaningful support in decision-making, HDMs often appreciate computer-based information systems (IS) (i.e. humanitarian decision support systems) that require non-functional requirements (NFRs) for their development. To identify those necessary NFRs, we applied the grounded theory approach to analyze 61 literature- and field-based decision-making parameters reported in the primary author's previous research (Rahman and Majchrzak (2020)). Our analysis resulted in 13 essential NFRs and four key propositions to guide relief distribution decision-making in the initial stage and system development in the later stage. HDMs can benefit from such findings for practical decision-making, whereas the system development team can get help to plan and execute the system-building process accordingly.

Keywords

decision-making parameters, humanitarian decision support systems, non-functional requirements, grounded theory approach, key propositions.

INTRODUCTION

Deciding on impactful humanitarian actions, humanitarian decision-makers (HDMs) need to consider or at least check numerous parameters while making critical decisions involving different entities of humanitarian clusters, such as logistics, response, security, health, etc. Although they have insufficient time to respond, HDMs must act rapidly to distribute necessary relief goods from diverse organizations (local, national, and international) despite the deep, prevailing uncertainty arising from scarce, conflicting, and uncertain information. Furthermore, if the disaster-occurring area is densely populated, the loss (e.g., lives, societal, infrastructural, economic, and health) is enormous (Cavallo & Noy, 2009). Such disturbance further affects the area's social structure in ways that, in most cases, it is hard to overcome with its available resources (IFRC¹, 2016). Disaster scenarios-specific mathematical models were used to support HDMs in humanitarian relief distribution (HRD) decision-making, where end-users (mainly practitioners) remained absent in the development process. Those decision-making models were rarely implemented because of operational inconsistency or complexity (i.e., lack of user-friendliness). They must deal with many situational facets, which sometimes cause difficulties in identifying and using essential parameters for crucial decision-making under deep uncertainty. Therefore, humanitarian responders still need support systems to receive assistance in determining effective HRD (Kebriyaa et al., 2021). Hence, developing such humanitarian decision support systems (HDSS) is always the priority in humanitarian logistics (HL) and its operations.

Sprague Jr (1980) explained that a decision support system (DSS) is an IS artifact that supports and improves the performance of its users in specific contexts. Such an initiative would not be successful without applying information and communication technology (ICT) (Shukla & Asundi, 2012). A flexible and dynamic computerized operational system can ensure information accessibility, support decision-making, and help its users accomplish the complicated tasks of complex humanitarian problems (Comes & Van De Walle, 2016). Such a

¹ International Federation of Red Cross and Red Crescent Societies (www.ifrc.org)

DSS should be able to handle large datasets, process complex queries, and generate faster results in the desired formats (textual, tabular, and/or graphical). In this regard, Van de Walle and Turoff (2008) urged building an interactive IS to support software system development and a set of generic design principles. According to Vasquez et al. (2024), this software system design starts by defining various requirements, among which functional and non-functional requirements gain priority. Alencar et al. (2019) specifically suggested identifying non-functional requirements (NFRs) to ensure optimal performance of the envisioned DSS, thus gaining customer satisfaction. This is only possible with the system's increased usability or usefulness (Meesters & Beek, 2021). Aretoulaki et al. (2024) encouraged such requirement engineering initiatives to bridge the gap between theory and practice, thus designing and building technology-supported solutions to HL operations.

So, NFRs are defined as the qualities, restrictions, and limitations the system should address and maintain accordingly (Astarita et al., 2020; Moura et al., 2024). They must be understood and incorporated even before stepping into the system development phase (Supakkul et al., 2009). Since these NFRs play vital roles in goal achievement, they should be linked to any decision support software system (Petrenj et al., 2023). However, these affecting decision parameters have yet to be identified and studied to determine an effective relief distribution. This research gap directed us to find the potential NFRs of the envisioned IS-based interactive HDSS that require active collaboration among stakeholders participating in planned humanitarian actions. Failure to identify those crucial NFRs would cause higher maintenance costs and system failure (Alencar et al., 2019). So, we set up the following research question to guide this study: *What types of NFRs and related key propositions are required for HDSS software?* The answer to this question will contribute to the usability and universal design of HDSS software for relief distribution type emergency management.

The remainder of this paper is structured as follows. While introducing this research problem in this section, we briefly scan the related IS research in humanitarian contexts, specifically in HDSS, in the next section. Then, we will discuss this study's research method, and its findings will be reported afterward. The discussion on those findings, research limitations, and future research avenues is reported next. This study concludes by indicating the necessity of multimethodological research initiatives for deciding HRD.

RELATED RESEARCH

Deciding on humanitarian actions requires sophisticated, practical, and contextual operational solutions because they bring a larger impact on the survivors and significant consequences to the responding system (i.e., teams and their actions) (Benaben et al., 2023). For making such crucial decisions on different entities of humanitarian clusters such as logistics, response, security, and health, decision-makers mostly rely on their hard-earned personal experiences that are valuable with no doubt but suffer from tangible human lifespan, behavior, and attitude (Rahman, 2018). This hampers the evaluation of all the essential short-term and long-term consequences of such pragmatic decisions (Clarke & Campbell, 2020). Risker decisions can be made if any of these are not properly covered because some vital situational contexts may get ignored or overlooked (Wickens, 2002). Therefore, A computer-based, well-structured, and flexible DSS is necessary for assisting humanitarian responders' operational decision-making (Ashinaka et al., 2016; Yates & Paquette, 2011).

Hence, Astarita et al. (2020) investigated requirement analysis for exchanging information between the disaster field and the central system. They focused on mobile computing to receive data from the field and disseminate the decisions back to the field. Their "Mobile for Emergency" system relied on a cooperative crowdsourced system for data collection and mobile networks for information exchange between citizens and emergency management operators. The DSS they discussed should detect the disastrous area and alert the inhabitants about the disaster and the available road network for mobility and accessibility. Gehl et al. (2022) extended road accessibility by proposing a DSS for emergency road traffic management to recommend several potential itineraries that include indications on travel time, reliability of the itinerary, and necessary backup itineraries. However, Aretoulaki et al. (2024) advanced HL research by integrating drones to support operational decision-making and first response to the disaster field. Among other services, their proposed DSS was used for geospatial analysis to find vulnerable areas and calculate related uncertainties. They reported using this DSS to analyze and validate social media data for optimal resource allocation and suggest reconstruction and proper communication.

To do so, Shukla and Asundi (2012) brought the ICT concept to DSS development. They surveyed various disaster management systems, ongoing research projects, support systems, and concepts to identify and analyze software architecture quality parameters in emergency response. They noted that the support system should be available, reliable, modifiable, maintainable, interoperable, scalable, able to perform well, portable, and usable for making proper decisions in disaster management. Thus, Handayani et al. (2019) developed a requirement analysis for a web-based disaster logistic inventory information system in emergency response. They produced a list of functional requirements (FR), whereas obtaining minimum data needs was considered as the NFR for the system. Their system was able to store all inventory-related data (such as available items, suppliers, expiration dates, and

so on) accessed and processed by all the associated stakeholders. However, according to Nussbaumer et al. (2021), software and ethics should walk side-by-side during the design and development cycle of a DSS for emergency management. They provided a framework to guide the inclusion of ethics in the design process of DSS for allocating resources during disasters. So, they recommended recognizing necessary FRs and NFRs for the DSS first and, from them, identifying the ethical requirements for the system.

To assist HDMs and system developers, Rahman and Majchrzak (2020) extensively reviewed the decision/optimization models published in academic literature and reported a total of 61 decision parameters (as mentioned in the earlier section) that were later validated by a panel of humanitarian experts in the field of operation. Rahman et al. (2022) exploited that outcome to study the decision parameters in the associated problem areas and understand how multiple problem areas use (or share) similar parameters for individual decision-making. As a result, they proposed an ecosystem for humanitarian actions during relief distribution and thus extended Roy et al. (2012) concept of problem areas incorporation and concurrency. Furthermore, to enhance decision-making support in HRD, Rahman et al. (2019) suggested incorporating the deep uncertainty concept in the process model(s), thus producing decision alternatives. To define the systematic nature of the envisaged HDSS, Ariav and Ginzberg (1985) suggested conceptualizing and linking the decision environment, the function within this environment, the functional components that make it up, the links between these components and functions, and the resources required. Petrenj et al. (2023) complemented incorporating proper use case scenarios to finalize its scope, requirement, and system architecture, and to do so, identifying and recognizing the system's interacting key decision drivers (NFRs) is a must; otherwise, system quality and longevity would hamper (Shukla & Asundi (2012). However, Alencar et al. (2019) and Ijaz et al. (2019) reported that these performance-alternating NFRs are mostly overlooked or added if and only if needed, which may lead to poor system quality in total. So, we dedicate this study to finding all these essential NFRs for developing the targeted HDSS before its development initiative is taken.

Thus, humanitarian researchers are doing tremendous work to improve situational awareness and support human activities in emergencies. However, such activities are largely problem-area-specific, as Rahman et al. (2022) indicated, and we experience this from the discussion in this section. To build an HDSS for successful relief distribution operations, we should address Roy et al.'s (2012) suggestion of including representatives from all problem areas and confirm concurrent operations, thus fulfilling the implementation of the relief distribution ecosystem Rahman et al. (2022) proposed. In doing so, crucial NFRs and related key propositions must be identified before stepping into HDSS software design and development.

RESEARCH APPROACH

To answer the research question, Moura et al. (2024) recommended utilizing the grounded theory approach and finding essential decision-making parameters to finalize the software system functionalities. So, this research combined two studies conducted by the primary author and his colleagues: Rahman and Majchrzak (2020) and Rahman et al. (2022). This study extends the initial study by applying the knowledge generated in the later study. In the initial study, the authors utilized a two-round Delphi study to report 35 literature-based and 26 field-based (61 in total) decision-making parameters. In contrast, the later study used those decision-making parameters to understand the interconnections between the six problem areas involved in this decision-making process: relief distribution, facility locations, humanitarian supply chain, inventory management, transportation, and scheduling. Although Rahman and Majchrzak (2020) prioritized 22 (out of 61) decision-making parameters based on expert preference, the list cannot be used directly in the system design due to missing in-depth analysis. So, in this research, we analyzed the actual parameter list to find the NFRs - crucial for deciding the functional requirements of the named system and, thus, finalizing its output (Kassab et al., 2009). Since we know the important decision-making parameters, associated problem areas, and their weighted connections from those studies, extending these outcomes toward finding the HDSS software system's NFRs and guiding propositions is a correct initiative during this time.

To do so, we took the grounded theory approach by following Moura et al. (2024)'s recommendation. It allows us to systematically analyze data collected from social research settings and thus identify the emerging inner meaning or theory (Charmaz, 2006). By adapting the guidelines provided by Bishop (2014) and Bastani et al. (2021), this research also incorporated a three-fold approach to coding – open coding, axial coding, and selective coding. Open coding concentrates on analyzing the textual data (interview transcripts and written responses) and line-by-line coding (Bastani et al., 2021). These open codes are further analyzed in the axial coding process for deeper understanding and, thus, finding the emerging concepts (Shannak & Aldhmour, 2009). Such conceptual clustering is then utilized in selective coding to find emerging categories that facilitate final theorizing (Bishop, 2014).

Since the primary author and his colleague (in Rahman & Majchrzak (2020)) scrutinized and analyzed the

extracted optimization models from the literature and collected data from the field (via surveys and interviews) to propose the evaluated list of 61 decision parameters already, we approved it, fulfilling the requirements for the first step (open coding) of our research process. Please consult their paper for data collection, analysis, and reporting details. We then clustered the outcome into meaningful conceptual groups (axial coding) by comparing code against code. The emergent relationships identified during coding helped us define these conceptual groups as NFRs because the affiliated parameters were collected from the targeted audience and end users (Meesters & Beek, 2021) based on the tasks they performed or the limitations or challenges they faced (Vasquez et al., 2024). Afterward, we delved deeper into selective coding to identify and describe the relationships between the NFRs recognized in the previous step. These categories were utilized to find propositions for the emergent theoretical model (Bishop, 2014) presented in the results section. These propositions described the related NFRs of the said HDSS and their relationships where appropriate. Figure 1 illustrates the overall research approach.

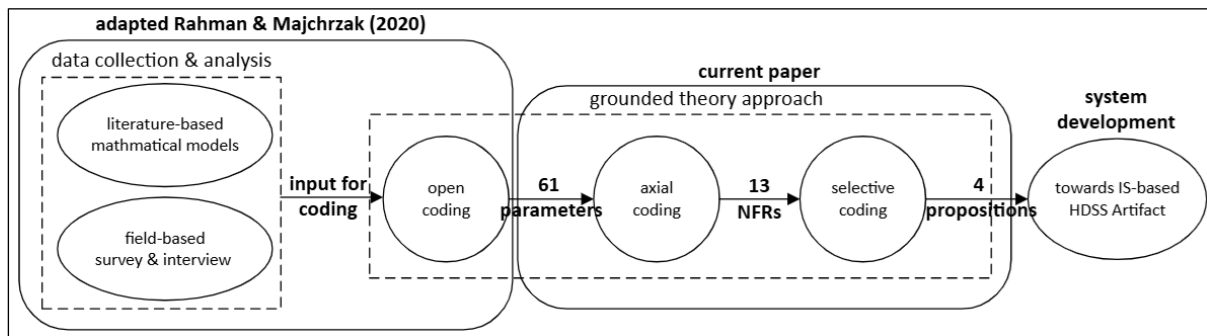


Figure 1: Research Approach.

FINDINGS

After analyzing the 61 decision parameters from the literature and the expert panel, 13 NFR concepts were identified and further summarized into four broad proposition-leading categories for better understanding, accessibility, and control. Table 1 shows the open, axial, and selective coding results.

The grounded theory method coding resulted in 13 essential NFRs for the IS-based HDSS artifact, which were listed in the Axial Coding column in Table 1. These NFRs were categorized into the following four propositions (KP):

- KP1: people & social contexts (related NFRs: local influence, decision analysis, operating environment),
- KP2: operational and contextual deep uncertainty (related NFRs: deep uncertainty, logistical modeling, operation execution, knowledge acquisition),
- KP3: humanitarian logistics (related NFRs: cost, time, and resource management), and
- KP4: operational deployment (related NFRs: road & transport, storing capacity, accessing local & global resources).

Since all NFRs were summarized into these propositions, further elaboration of these propositions incorporated discussion about the included NFRs in this section.

KP1: The challenge of 3L (local inhabitants, local contexts, local resources) affects decision implementation.

As Rahman and Majchrzak (2020) reported, the entire HRD decision-making process incorporates different groups of people in three different tiers. The top tier includes decision makers from various problem areas (mentioned earlier) who target to achieve individual objectives by serving a successful HRD deployment. The middle tier incorporates field workers (e.g., staff members, volunteers, informants, other responding teams, etc.) who provide valuable information about the operating environment and/or operational support to the deployment. Finally, the bottom tier covers the neighboring communities and the ultimate beneficiaries, those from previous tiers who make such efforts. So, the overall societal context must be considered (quantitative and qualitatively) to make useful and credible HDSS inferences. Hence, the targeted IS should elaborate on the social and environmental (operational) dimensions of the envisioned HDSS before discussing its information and technical dimensions, for example, prioritizing the most affected or vulnerable communities located far away, sharing a customized distribution plan with the beneficiaries in advance, and providing adequate logistical support at the distribution center. It should obtain adequate knowledge about the social capital of neighboring regions and communities of the affected areas and analyze it to understand their supporting and influencing capacities in the HRD process for serving maximum relief demands.

	Selective Coding (propositions)	Axial Coding (NFRs)	Open Coding (adapted Rahman & Majchrzak, 2020)
IS-based HDSS artifact	1. people & social contexts	local influence	social capital, social tension, In-country political situations
		decision analysis	Central influence on financial flow and other decisions, Serve maximum relief demands, Understanding and assessing the disaster situation
		operating environment	Safety and security to respondents, relief supply chain, and beneficiaries, Characteristics of affected areas, Geographical and environmental (weather) conditions of the disaster area, Civil-military relationship
	2. operational & contextual deep uncertainty	deep uncertainty	Need assessment for current and future operations, Characteristics of disasters, Coordinating with other relief distributing groups (big/small), Level of meeting humanitarian needs
		logistical modeling	Access to the point of distribution, Trained, committed and technology-supported volunteers/supporting staff, number of distribution center to cover all beneficiaries
		operation execution	Operational management models, Traffic control plan at distribution points, Relief distribution plan sharing with the beneficiaries, Total access cost of beneficiaries to travel and collect relief items
		knowledge acquisition	Targeted community's cultural knowledge or understanding, Knowledge acquisition on previous incidents and analysis, Knowledge on neighboring regions; geographical, topography and demography knowledge about the targeted point of distribution
	3. humanitarian logistics	cost management	total cost to operate the entire RD process, resource procurement cost, unused inventories and weighted shortage cost, Cost for unused relief items or unmet (un)certain needs, Fixed and variable cost to transport relief items to the demand points, Operational cost of supplying relief items (e.g., linking network cost, distribution centers' management and hand-out costs), Cost for setting up new or disrupted distribution centers, Cost for holding surplus or undelivered/undistributed relief items, Overstocking (of relief items) cost in global and central depots, Cost to transport relief items between central and other depots, Variable and fixed transshipment costs between regional depots
		time management	Duration of response operation, travel time to deliver relief items to the points of distribution, relief distribution time, Time, when a demand was or would be urged, Time taken to travel towards distribution points (based on, e.g., route selected, distance, resource allocated), Time taken to distribute necessary and available relief items (based on allocated resources)
		resource management	Digital communicating devices, Transportation quantity to meet flow quantity burden of distribution route, Demanded and prioritized relief items at demand points, Available budget to keep the distribution network active (e.g., budget for relief transportation or restoration of centers), Available relief items to be delivered and distributed, amount of commodity flow towards distribution centers
	4. operational deployment	road & transport	Dispatch maximum relief per transport trip, travel distance to distribute relief, Selection of optimal relief distribution route to transport maximum quantity, To be distributed, total distance relief items need to travel, Number of vehicles to traverse at selected routes (e.g., capacity of serving vehicles by volume and weight), Practical length of emergency route
		storing capacity	Capacity of central, regional, or local storages, Required number of central, regional, or local storehouses to support all demand points, Storing capacity
		accessing local & global resources	Social and communication infrastructure, Assessing local sources of supplies, Quantity of relief items to be delivered or supplied

Table 1: Grounded theory method coding results.

KP2: Decision alternatives are essential to deal with operational and contextual deep uncertainty.

Disasters are unique by nature because they bring different challenges in different periods, and even though they are typically in the same place, similar types occur. This makes the operational context deeply uncertain as new knowledge is unavailable for assessing the likelihood of plausible future extreme events. Furthermore, as mentioned previously, humanitarian relief operations encompass various interconnected problem areas, where researchers develop different optimization models to meet maximum demands by utilizing minimum resources within the shortest period. The outcomes of those problem areas were rarely linked to operating humanitarian actions in the field. Such irregularities occur due to improper logistical modeling and operation execution, such as inaccessibility to the points of distribution, lack of trained, committed, and technology-supported volunteers/supporting staff, insufficient number of distribution centers to cover all beneficiaries, insufficient or incorrect knowledge about the geography of the affected areas, and so on. On top of all these hurdles, the imbalanced intention of maximizing the business objectives of the member entities of the humanitarian ecosystem adds oil to the fire. This indicates that the future of humanitarian logistics operations will be subject to different interpretations of a disaster and its consequences and will depend on a decision-maker's expectations about the future based on various decision-making parameters - objectives, variables, and constraints. Thus, acquiring correct knowledge at the correct time is the key to this proposition.

KP3: Pragmatic steps can produce effective and equitable responses to disasters.

According to the existing literature, decision-making in HL is supported mainly by sophisticated and context-specific optimization or mathematical models and simulations with little concentration on practitioner realities. When necessary, various decision parameters were used in these models to optimize decisions, but they were never traced or studied further. However, such analyses are essential for understanding decision processes in humanitarian operations and how these parameters are used for decision-making in various problem areas that affect HRD decisions. For instance, while responding to disasters, practitioners react pragmatically to decide on relief procurement, warehousing, transportation, and effective distribution. Thus, a better pragmatic understanding of the humanitarian supply chain (HSC) is essential for identifying a suitable approach for requirements elicitation and the anticipated DSS design. Furthermore, to distribute relief goods within a shorter time, HDMs require adequate support to address operational uncertainty, maintain crucial communication and coordination, and exploit limited resources to achieve efficient and timely delivery. In doing so, an adaptive and robust HSC (specifically the downstream part of it) is always recommended, which can produce cost-efficient material flows, financial value flows, and adequate information flows to support operational decision-making in HL. So, to manage various operational costs, time, and resources, researchers and practitioners favor utilizing modern technologies.

KP4: All problem areas should be operated concurrently to deploy relief operations successfully.

Decision-making in HSC's downstream operations is critical and challenging. Here, HDMs must be involved in all processes to distribute relief goods to affected people: retrieving the delivered relief goods at entry points, warehousing and managing them in suitable locations, creating schedules and transporting them to the demand points, and, most importantly, distributing them among beneficiaries by accessing local and global resources. Although such a relief drive requires concurrent activities among these problem areas, the literature analysis has reported individual value-achieving without knowledge of the problem areas and the extent of their involvement in decision-making. Since decision-making in HL is traditionally supported by different mathematical models for achieving various decision objectives by optimizing multiple decision variables and constraints, researchers clustered into different problem areas. They concentrated only on achieving problem-area-specific decision objectives rather than working together in an integrated manner. This holistic understanding formed a basis for effective negotiations between decision-makers in the six problem areas mentioned earlier—balancing objectives to gain a precise combined (single) goal. By sharing customized versions of the decisions made in the center with beneficiaries and with ground staff at HRD points, effective HRD can be planned and executed.

Summary: These findings create a better understanding of humanitarian operations and, thus, would conceptually upgrade the HDSS software system development to help HL researchers find the tipping points of operational success. Based on the proposed KPs, system designers can select the software quality-assuring NFRs to find/explore the FRs of the HDSS software system (Aretoulaki et al., 2024). FRs bring expected output directly to the system users, whereas subjective and interdependent NFRs and KPs make FRs ready to function accordingly for such productions. This cycle can be reexplored for more clarification and understanding. Thus, NFRs and KPs play vital roles behind the scenes and indirectly influence the system's behavior. The theoretical model presented in Figure 2 represents these concepts.

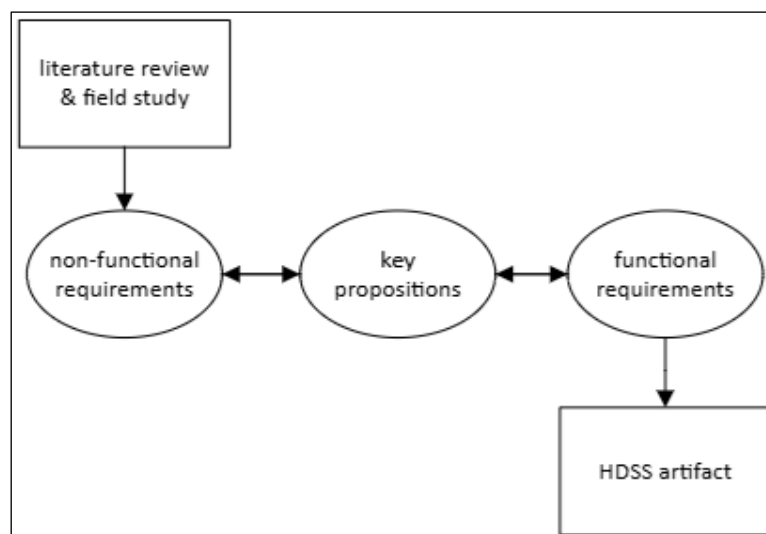


Figure 2: A theoretical framework for HDSS artifact development.

DISCUSSION

Since Rahman and Majchrzak (2020) collected those decision-making parameters from various optimization models in the literature and the operating field, they can be considered quality NFRs for the envisaged HDSS. If not addressed accordingly and properly, these quality parameters can easily alter the outcomes of the decision-making process in crucial disaster contexts. Therefore, to receive reliable decision alternatives or tangible functionalities for the targeted HDSS, our analysis of Rahman and Majchrzak's (2020) extensive list of decision parameters revealed 13 NFRs, which are categorized into four manageable and easily understandable propositions (KP1-KP4). The first proposition (KP1) emphasizes adequate knowledge creation on the people and contexts of the area of disasters – the non-cooperative operating field could cause significant failure to any outstanding decisions. The second proposition (KP2) encourages the production of decision alternatives to continue the relief drive and compensate for unfavorable scenarios during deployment. Since disasters create dynamic circumstances, taking static steps will not produce impressive response results – the third proposition (KP3) suggests taking pragmatic steps to understand the condition better. Thus, effective decisions can be made. Hence, the final proposition (KP4) highlights interdependencies and concurrent activities between all stakeholders involved in the deployment – a single unit negotiated initiative should be activated to accomplish a successful relief drive.

Understanding disasters and their consequences is difficult and sometimes impossible because each time they arise, disasters of a similar type show specific characteristics that were not previously experienced (Ashinaka et al., 2016; Campbell & Clarke, 2018). Even the population densities of affected areas (KP1) cause enormous suffering, not only to the survivors but also to the responders deploying essential humanitarian actions. Poor communication and accessibility infrastructures in these areas also hinder humanitarian decision-making at the correct times and in the right places. Due to the lack of proper integration, technological advancements, IS, and logistics, humanitarian logisticians (KP3) still lack adequate systematic support for making response activity decisions (Benaben & Lauras, 2019). Sahebjamnia et al. (2017) revealed the urgency of developing necessary DSSs for humanitarian responses in a similar stream. However, they reported that vital decision parameters (i.e., decision objectives, variables, and constraints) are scarcely identified and studied for such development.

Many task-specific initiatives (or models) can be identified in practice. However, none of those models provides practitioners holistic decision-making support by generating essential decision alternatives and/or useful recommendations. HRD decision-making involves (KP3) not only identifying relief goods (type, quantity, priority, etc.) but also deciding where to deliver these goods and at what time (Campbell & Clarke, 2018). HDMs must know how complicated the targeted problem is, what the degree of uncertainty (KP2) is, and what implications their choices will have on the ground (KP1) (Cioca & Cioca, 2010). They should also be capable of dealing with a large amount of data, limited resources, and the unpredictability of disasters and post-disaster situations (KP2) (Sahebjamnia et al., 2017). Such a physical system requires (machine) learning procedures to feed its model with the necessary information, as well as decision rules guiding computer programs to generate prioritized decision alternatives (KP2) (Bhat et al., 2020).

Since the time, place, and extensivity of disasters vary, HDMs face difficulties in disaster response, among which effective decision-making is one of their most critical challenges (KP1). HDMs struggle to identify required actors and parameters in their response operations (Chan & Comes, 2014). Hence, the interconnectedness between these key influential actors and their associated decision-making parameters should be studied (Campbell & Clarke, 2018; Darcy & Hofmann, 2003; Newman et al., 2017). Since relief distribution is the ultimate goal of any disaster response operation (Roy et al., 2012), Azmat et al. (2019) indicated that it is imperative to understand how different key actors in the affected areas share (or use) similar decision-making parameters. To fulfill the necessary decision requirements, researchers must work with practitioners to incorporate their values and keep them on board until the system is developed and implemented (KP4) (Coletti et al., 2017; Lynch & Gregor, 2004). Various but suitable decision alternatives can be recommended by incorporating essential decision-making parameters into the physical system (i.e., HDSS).

Like any research, this study has some limitations. Since the primary author and his colleague collected data for the devastating South Asian earthquake disasters (reported by Rahman and Majchrzak (2020)), the proposed NFRs and propositions could be exposed to regional bias. An updated data collection from other regions needed to be conducted. A recent study may produce efficient outcomes. Furthermore, data from various regions would enrich the dataset and help us compare regional scenarios. This will indicate the activation of different functions in the HDSS for different regions. So, we recommend upgrading to recent scenarios before finalizing the NFRs/FRs and stepping towards designing and developing the HDSS software system.

CONCLUSION

In this research, we demonstrated a way of finding crucial NFRs and related key propositions for the envisaged HDSS that can be designed and developed better if the dataset is adequately upgraded with new data, both from

the literature and the field. We proposed 13 NFRs summarized into four propositions as the key drivers for developing an interactive HDSS artifact. The nature of NFRs indicated the necessity of multimethodological efforts for interactive system development. It provides an overall understanding of the study's theoretical, experimental, observational, and developmental foundations. By presenting the conceptual background, this research participates in developing novel principles for design theories concerning HDSS. Such conceptual enrichment will guide the initiation of future multidisciplinary projects for the final HDSS software system modeling and development with adequate contributions from the practitioners. The findings from this study will complement such development and provide practitioners with an overall understanding of using the system to decide on effective relief distribution to the beneficiaries.

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