Risk Accelerators in Disasters

Insights from the Typhoon Haiyan Response on Humanitarian Information Management and Decision Support

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Abstract. Modern societies are increasingly threatened by disasters that require rapid response through ad-hoc collaboration among a variety of actors and organizations. The complexity within and across today's societal, economic and environmental systems defies accurate predictions and assessments of damages, humanitarian needs, and the impact of aid. Yet, decision-makers need to plan, manage and execute aid response under conditions of high uncertainty while being prepared for further disruptions and failures. This paper argues that these challenges require a paradigm shift: instead of seeking optimality and full efficiency of procedures and plans, strategies should be developed that enable an acceptable level of aid under all foreseeable eventualities. We propose a decision- and goal-oriented approach that uses scenarios to systematically explore future developments that may have a major impact on the outcome of a decision. We discuss to what extent this approach supports robust decision-making, particularly if time is short and the availability of experts is limited. We interlace our theoretical findings with insights from experienced humanitarian decision makers we interviewed during a field research trip to the Philippines in the aftermath of Typhoon Haiyan.

Keywords: Disaster response, humanitarian information management, robust decision support, risk management, preparedness, sensemaking.

1 Introduction

Five weeks after Typhoon Haiyan had made landfall on the Philippines, we lead a small research team to carry out an on-site investigation of the humanitarian response, and in particular of the impact of information on sensemaking and decision making. In the course of our journey, we interviewed 35 decision makers from the United Nations (UN), non-governmental organizations or local government, attended national and local coordination meetings and observed field operations. One compelling finding from this fieldwork was the recognition that humanitarian decision making should be driven by the aim to understand emerging risks and to share information

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about them in due time and accessible format. As Jesper Lund, Head of Office for the UN Office for the Coordination of Humanitarian Affairs (OCHA) in the severely affected town of Tacloban stated:

"*Managing disasters means to understand what the risks are as they emerge: prevent acceleration of trends that can turn into a disaster.*"

In this paper we will outline the challenges for humanitarian information management to support such real-time identification and management of emerging risks by focusing on two questions:

1. *How should an information system be designed for sensemaking and decision support in sudden onset disasters?*
2. *How to steer the exploration of a complex system such that the aims of the information system can be achieved while respecting constraints in terms of time and resources available?*

2 Humanitarian Information Management

In the response to Haiyan, the importance of information management has been widely recognized. In most organizations, information management officers (IMOs) work to collect data and convert it into information products, most often a situation report or a map. These information products by their very nature mostly provide a snapshot of the situation; they do not convey analyses or a deeper understanding of the situation and important trends. IMOs try to keep pace with the requests of a plethora of different policy- and decision-makers to satisfy aid organizations, donors, governments, the military, from international to local levels. The multitude of organizations and decisions, the divergence of needs, information sources, temporal and geographical scales, bandwidth constraints and a virtually unlimited variety of information that were openly shared with the whole world, create a frantic pattern of constant requests, surveys, questionnaires, reports and maps pushed from headquarters to the field and back. Marc McCarthy, a member of the UN Disaster Assessment and Coordination (UNDAC) team and deployed in one of the worst hit areas within days after the Typhoon's landfall expressed the resulting confusion and irritation among responders bluntly and succinctly:

"This is the Information Disaster."

Due to the nature of sudden onset disasters and the ad hoc character of the response, no model can be developed to timely explain and predict the behavior of the disrupted socio-economic system or the consequences of decisions on how and where to intervene (DiMario et al. 2009). Therefore, information management in sudden onset disasters should acknowledge that decisions need to be made in near real-time based on uncertain and lacking information about the impact of the disaster. Instead of seeking optimality, this decision-centered approach aims to prevent that essential goals cannot be reached.

2.1 Decision Support in Humanitarian Disaster Response

How humans approach a decision depends on the information and understanding of the systems that affect the results of decisions. Under stress and pressure, we mostly follow intuitive rules (Gigerenzer et al. 2012), which emphasizes the importance of training and professional experience to avoid the most common judgmental biases. To capture expert knowledge, scientists tend to abstract and model parts of the overall problem. Disasters, however, pose complex problems that largely defy such simplifications.

Complexity and uncertainty are certainly not new aspects of decision-making (Rittel & Webber 1973). Yet as organizations and individuals increasingly rely on models for data processing and on Information Systems to share information, decision-makers operate in circumstances that are more difficult than ever before, while they struggle to maintain oversight and control. Turoff, Chumer, Van de Walle and Yao (2004) presented the Dynamic Emergency Response Management Information System (DERMIS) framework for information system design and development that addresses communication, information and decision-making needs of responders to emergencies. As Turoff et al. (2004) stated, the unpredictable nature of a crisis implies that the exact actions and responsibilities of possibly geographically dispersed individuals and teams cannot be pre-determined. Therefore, an information system should be able to support reassigning decision power to where the action takes place, but also the reverse flow of accountability and status information upward and sideways throughout any responding organization.

2.2 Wicked Problems

In policy-making, the term '*wicked problem*' has been coined to refer to problems that are characterized by fundamental uncertainty about the nature, scope and behavior of the involved systems (Van Bueren et al. 2003; Weber & Khademian 2008). Sudden onset disasters confront decision-makers with wicked problems that are further complicated as a disaster entails a catastrophic event generating dramatic impacts that can propagate rapidly through the system (Rasmussen 1997).

The way to understand and analyze a wicked problem depends on the decision-makers' ideas about issues and possible solutions (Rittel & Webber 1973). In literature, wicked problems have hardly been addressed systematically, as there is no standard solution nor algorithm (Coyne 2005). Some approaches aim at adapting knowledge-based models to consider uncertainty and complexity by decomposing the overall system into sub-systems that are modeled separately (Rasmussen 1997). By neglecting interdependencies, important aspects associated to the emergence and interplay of systems are ignored (Pich et al. 2002) leading to inadequate models and flawed expectations regarding both the actual consequences and the manageability of the problem.

Therefore, approaches need to be developed that embrace the lack of situational awareness, resources and time, particularly in the early phases of a disaster. We propose to support decision-makers to structure information for decisions and explore consequences rather than relying on models. Such 'soft' approaches are considered as '*probe, sense and respond*' to test a system's reaction to an intervention instead of a model-based '*analyze and respond*' (Mingers & Rosenhead 2004).

In the response to sudden onset disasters, information management should be targeted at facilitating collaboration between the many organzations and actors involved. The process should systematically identify and reveal information that has the most significant implications for disaster response – on an individual, organizational and regional level. In the words of UN OCHA Head of Office Jesper Lund:

"*I only look at issues, not at numbers.*"

The ultimate challenge in wicked problems is making good decisions on the basis of lacking or inadequate information. The notion of a 'good' decision must be re-interpreted in this context: plans and projects should not be ranked on the basis of their performance at a given (static) point in time. Typically, the dynamics play an important role, as the evolution of the situation, the information available about the problem and the understanding of it continously change. Re-planning 'en cours de route' is often required (Benjaafar et al. 1995). Therefore, good probing should aim at the identification of drivers that considerably change the performance and ranking of alternatives. Information management should enable monitoring the situation, making sense of it and acting upon the (new) understanding (Pich et al. 2002).

2.3 Risk Accelerators as Basis for Information Management

There is a plethora of definitions of 'risk' depending on the context and purpose of use (Frosdick 1997). Although the term is used frequently in day-to-day language and seems to be understood, risks are perceived and judged very differently. Still, most authors agree that risk addresses the (positive or negative) consequences of a situation, an event, a decision or any kind of combination thereof and the probability of the consequences occurring (Fishburn 1984; Haimes et al. 2002).

The notion of risk is most prominent in financial corporations. Financial risk is usually determined by the variance or volatility of expected returns (Rippel & Teply 2011). Further measures focusing on losses comprise different value-at-risk measures that can be used to describe the extent of uncertainty and its related harm. Following this rationale, international engineering standards such as ISO 14971 define the risk associated to an event as the product of the event's probability and harm (Rakitin 2006).

Most approaches to risk management start with an assessment, i.e., the identification of potential risk sources or events, the assessment of those events' likelihood and consequences (Renn 2005). This leads to a focus on 'frequent' or chronic failures that are part of the annual or quarterly reporting. Emerging risks or outliers are typically not considered, and therefore not monitored, controlled and managed.

Organizations that are operating under high-risk circumstances should be very vigilant on avoiding risks resulting in incidents, because their occurrence would have disastrous consequences for the organization itself or the public. "High Reliability Organizations" (HROs) are organizations that operate under these trying conditions and succeed in having less than their fair share of accidents (Weick & Sutcliffe, 2001). Processes in HROs focus on failure rather than success, inertia as well as change, tactics rather than strategy, the present rather than the future, and resilience as well as anticipation (Weick et al., 1999).

The increasing complexity and uncertainty of socio-economic systems have resulted in increasing losses, and an increasing interest in HROs and the way they manage risk (Rothstein et al. 2006). Traditionally, risk management aims at reducing the likelihood of an event or the harm of its consequence. This approach requires that *all* events that may have harmful consequences can be identified and modeled to determine *all* harmful consequences and derive mitigation strategies. To acknowledge the fact that this is not possible in today's complex systems, the events that are not explicitly considered are classified as 'residual' and managed by a contingency or buffer (Renn 2005). In this manner, important risks, particularly those associated with combined or multi-hazards, may be overlooked or neglected. For instance, the 2010 eruption of the Eyjafjallajökull volcano in Iceland was not judged unlikely by geologists (Leadbetter & Hort 2011), yet it was not among the events that airlines considered. This lack of preparedness and vigilance caused supply chain disruptions and losses in the millions of Euros (Jüttner & Maklan 2011). A disaster of an unprecedented type and magnitude was the Fukushima Daiichi disaster in Japan in 2011, a catastrophic failure at the Fukushima I Nuclear Power Plant, resulting in a meltdown of three of the plant's six nuclear reactors. The failure occurred when the plant was hit by the tsunami triggered by the Tōhoku earthquake – an event of a magnitude that was considered extremely unrealistic by experts and government officials.

3 Managing Disaster Risks - Our Approach

We propose a perspective that analyses the multifaceted concept of risk in terms of potential developments of a system. We start the process by identifying unfavorable consequences or paths of development (scenarios) that need to be avoided. Information management, sensemaking and decision support are used to flag these unfavorable paths. Since it is not possible to manage and process information related to *all* possible scenarios, we focus on those that imply the most relevant consequences in terms of plausibility and harm of consequences.

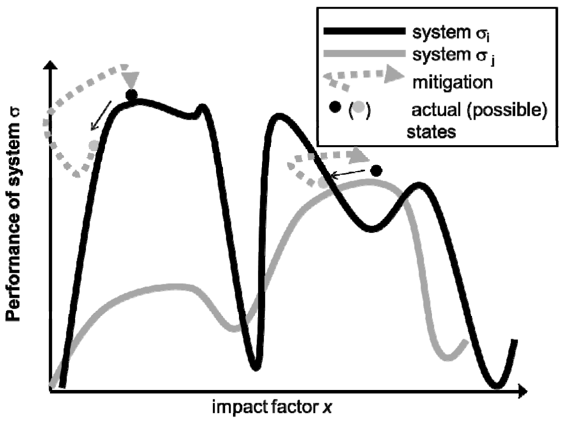

Fig. 1. Risk as a system inherent concept that evolves with changes of the environment

Figure 1 shows the evolution of the performance of a risk system σ as a function of the environment. The performance of the system σ is defined by two characteristics: (i) the potential losses, measured in terms of the performance difference between a satisficing and other potential states; performance can be understood in terms of qualitative and quantitative aims such as economic growth, stability, security, etc.; and (ii) the steepness of decline when the environment changes. As the environment cannot be captured or described in its full complexity, we focus on a set x of *impact factors* x_i that characterize the environment: $x=[x_1,\dots,x_N]$. The impact factors x_i do not necessarily evolve independently or continuously; shocks such as natural hazards may result in jumps or major disruptions. How x's values actually may or might develop over time needs to be modeled and represented in the scenarios.

We now define *risk drivers* as those components x_i of x whose change leads to a steep decrease of the σ's performance. How steep the decline must be to consider x_i to be a risk driver depends on the perception and preferences of decision makers. Ideally, the set of scenarios should enable them to understand and monitor *all* risk drivers, but this is usually not feasible given restrictions in time and resources; and limitations in knowledge. To identify the most relevant risk drivers, we propose to identify factors that are driving or triggering changes in the σ's performance and impact the evaluation of the decision alternatives.

Good risk management should develop strategies to avoid patterns that may (quickly) lead to undesired consequences. As illustrated in Figure 1, system σ_i (in black) requires a mitigation reaction that corresponds to small changes in the environment to avoid potential large losses initiated by risk driver x. For system σ_j (in grey), the consequences of a small deviation are less severe. Depending on x's development there may be more time to recognize the development and act accordingly. Ultimately, it is the aim to change a system's behavior by exerting controls such that it is less prone to failure and substantial loss.

Due to the dynamics of complex systems, it is crucial to understand the patterns and relations that steer the system's behavior *while* these are emerging. When confronted with lacking information, there is a tendency to assume that relations can be controlled and behave similar to what is known about the system. Uncertainty is then simply added by assuming a limited variance (Draper 1995).

Our concept of risk recognizes that it is impossible to describe all possibly relevant components of x and model their consequences with respect to the system's performance. Ergo, 'risk' is largely a relative concept depending on the current knowledge and organizational or societal preferences and goals. Taking a **relevance- instead of likelihood driven perspective**, we advocate to systematically uncover relevant scenarios by using techniques from information management and decision support, such that systems can be designed that are less prone to substantial losses in any situation.

3.1 Exploration of Complexity through Scenarios

Data interpreted in the context of a disaster will result in assumptions about its possible or likely evolution. Systematically constructing *scenarios* that challenge current mind sets supports probing by helping decision-makers to explore the consequences of their actions against events that may happen and are sufficiently plausible to be envisioned (Wright & Goodwin 2009). Scenarios can be used to plan for possible future humanitarian needs, to steer the assessment to the most critical issues and to create common situation awareness among key stakeholders. By their very nature, scenarios represent diverging paths of the disaster's possible evolution, and can hence also be used as a means to build consensus or compare the impact of different assumptions, forecasts or models on the response planning and strategy. In this sense, they can be used as a tool to embrace different opinions rather than aggregating and averaging them, or choosing just one specific opinion.

Scenarios should address the information needs of decision-makers. Especially at the initial phase of a disaster, the need to act is greatest, yet the least information about what has happened is available. Decisions made in these early stages have consequences for months and years. At a recent UN Workshop on information needs of humanitarian decision makers, the information requirements were categorized into seven categories: context and scope; humanitarian needs; capacity and response planning; operational situation; coordination and institutional structures; internal; and looking forward. Within each of these categories specific questions or kinds of required information were provided (Gralla, Goentzel & Van de Walle 2012). As the resulting extensive list of requirements shows, decision-makers prefer to obtain all relevant observations and information that is available in order to make a decision that reflects the reality of the given situation. Once they know they have all relevant information that is available before they have to make a decision, they can move to sensemaking, which allows them to design response scenarios (Turoff et al 2004).

Scenarios are relevant if they represent a development with significant impact on the current strategy or planning and would – if they were true – require a change. Additionally, scenarios need to be credible and understandable. Credibility can be derived by verifiability and reliability of the source (Schoemaker, 1993). To balance timeliness and potential impact versus credibility, precision and granularity, information management should make trade-offs transparent at run-time by explicitly challenging the adequacy of the information and the constraints on the process (Comes, Wijngaards & Van de Walle, 2014).

Disaster responders operate under pressure and strain, including risks for personal safety and well being of responders on-site. Personal experience and trusted social networks play therefore an important role. As trust often is not transmitted across networks, this leads to a plethora of redundant pieces of information that is collected and processed individually, instead of being shared between different responding communities. It is also often difficult to codify and communicate knowledge that is only applicable to very specific situations. That is why scenarios are appropriate for expressing tacit knowledge (Kim 1998). Not everyone has the same experience with respect to a crisis situation since such events are relatively rare (King 2002), resulting in different reactions of professional responders and population affected. Tacit knowledge can be acquired only through experience such as observation, imitation, and practice (Kim 1998). Again, in the words of Jesper Lund:

"*Disaster management is experience. And common sense.*"

Information is typically perceived as credible when it matches the expectations or experiences of decision-makers (Schoemaker, 1993). In case a scenario flags a risk that is emerging and unexpected, it is essential to annotate the information with the source (reliability by expertise) or the process that was used to derive the information (verifiability). Moreover, the information needs to be represented in an understandable way, making potential cause-effect chains explicit (Comes et al., 2012).

3.2 Providing Information, not Data

As Sebastian Rhodes-Stampa stated for the humanitarian response efforts he was coordinating in Tacloban, information needs could be very different depending who requested the information, and for what purpose. Along with the increasing availability of information management, expectations rose about the availability of detailed data. This lead to the need to manage an ever increasing amount of data, maps and situation reports in various levels of temporal and geographical detail. In his words:

"*Granularity is the word of this emergency.*"

Instead of juxtaposing the same information at different levels of detail, scenarios should be tailored for specific decisions and address decision-makers' needs to avoid information overload, redundancies or the wrong level of granularity. A strategic series of scenarios might for instance include the needs of the population as they are and explore the impact of disaster relief supplies as a basis for the planning of humanitarian logistics. On a more operational level, scenarios can support coordination by presenting information about the current projects and the future presence of aid organizations (building on the so-called Who-What-Where or 3W database), and complementing the efforts with numbers of population and potential migration patterns.

To support sensemaking each scenario should present an understandable development of the situation; i.e., processed information including cause-effect chains rather than raw data. The form and type of information depends on the decision-makers' preferences, their access to technology (such as internet connection, bandwidth or printers) and the time available. Distributed techniques for scenario construction (Comes, Wijngaards & Van de Walle, 2014) enable the integration of experts from various agencies and authorities, bringing together local experts, professional responders, volunteers that work onsite or remotely (such as the Digital Humanitarian Network, a global network of volunteers), and scientists with different backgrounds.

3.3 Addressing the Dynamics

It takes time to collect and process data; to share and communicate information; and to derive an understanding of the problem, construct scenarios and make a decision. This is particularly true if a consensus must be found among different responding actors and organizations. In the very initial phase of humanitarian response, information is typically far from complete, yet the urgency of the response necessitates action nevertheless. As André Pacquet from the International Committee of the Red Cross and responsible for operations in the heavily affected town of Guiuan put it:

"*We accept chaos to start operations*."

As time passes, the information about the problem and the perception thereof can change. Hence, continuous revisions and corrections are necessary while considering the scarcity of resources available for sensemaking and to support the decision-makers. Therefore, scenario updates need to be conducted in an efficient and responsive manner (Comes, Wijngaards & Schultmann, 2012).

To this end, two aspects need to be respected: relevance and validity. In the context of updating, relevance is assessed in terms of the potential consequences of neglecting the new information. It is therefore necessary to assess if the new information is '*relevant enough*' to justify the updating effort. Similarly, already collected information that is still '*sufficiently valid'* should be reused. A scenario update can be informational or structural: *information updates* may change the measured or forecasted value of a variable, or its likelihood. A *structural update* requires mechanisms that account for a change in the basis for sensemaking or the evaluation and ranking of alternatives. This is for instance the case, when new impact factors are identified as the understanding about the problem grows, or as expert's previously implicit assumptions become more explicit.

4 Avoid Risk Accelerators: An Agenda for Humanitarian Information Management and Systems

Our approach to manage information and support decision-makers who are facing wicked problems in complex environments can be summarized by answering the two questions posed in the introduction.

Ad 1: Information Systems Design. The behavior of complex systems cannot be predicted and information is imperfect. The difficulty of assessing the consequences of a decision and prioritizing alternatives is compounded by a tendency to simplify the problem and neglect the lack of knowledge (Pathak et al. 2007). To support decision-makers who face complexity, we propose the use of scenarios to systematically explore harmful future developments. This entails continuous sensemaking and seeking to identify risk drivers as they emerge, while evaluating and continuously adapting disaster response strategies. The interpretive information processing mechanisms that are commonly called "intuition" or "experience" need to be supported by appropriate information systems. As Weick (1995) put it, "we need to understand more about Sensemaking Support Systems as well as Decision Support Systems, which means we need to know more about what is being supported". We have referred earlier to the DERMIS design premises as introduced by Turoff et al. (2004) providing a framework for the design of Humanitarian Information Management Systems.

Ad 2: Scenario Construction. Given limitations in time, effort, and resources, scenario construction and design of information products should be guided towards those that most significantly distinguish advantages and drawbacks of promising alternatives or the currently implemented strategies. To understand and detect potential flaws, we use scenarios for probing in a way that is targeted to identify the most critical potential problems while respecting constraints in terms of sufficient plausibility and credibility. To embrace the dynamics of a situation, and potentially swift system changes, information systems need to provide updating procedures to efficiently integrate new information and support sensemaking and decision-making on the basis of the latest understanding of the situation.

Inherent to the complexity of the situation, no method can guarantee to find all critical and loss-prone risks or risk drivers, and to communicate them at the right time to the decision-makers. Yet, in contrast to most modeling and statistical techniques, our method aims at identifying these drivers by referring to professionals, local or remote experts and scientists with different backgrounds to actively challenge current mindsets for critical sensemaking and robust decisions. By referring to different experts per piece of information, we aim at avoiding groupthink and, to some extent, the confirmation bias: experts can creatively think at an individual level about what might go wrong.

To choose and prioritize information products and scenarios, the following questions need to be addressed:

- *Number of information products* to be selected: how can the trade-off be made between a thorough exploration and the constraints on time and resources available?
- *Similarity:* how can the similarity or difference of information products and scenarios be measured in the context of sensemaking and decision support?
- *Reliability:* how can the plausibility and reliability of scenarios, which combine information of different type and quality, be assessed and continuously updated as new information becomes available?
- *Relevance and selection:* how can the most relevant information products be constructed, and how to select a good representative taking into account scenario similarity and reliability?

Each of these questions opens up fields and directions for future research. When designing information systems to answer these questions, it is vital that the decision-makers' needs and the constraints of sudden onset disasters are respected. If the realities of operations are not valued, frustration with the systems may lead to workarounds and the parallel existence of official reporting and information management and direct and direct communications within the respective networks. For instance, Sebastian Rhodes-Stampa expressed his views as follows:

"Provide simple messages, don't overcomplicate stuff. Right now we are victims of our own black magic of sophisticated systems."

The characteristics that need to be taken into account include, among others, the time available before a decision has to be made, and the authority to make it; the requirements of accessibility of information and interoperability of systems; the availability of local experts; the quality of information that local or remote experts, or automated systems can provide; the current workload; and the sensitivity of the experts' assessments to a change in input information. In this manner, future information systems can be designed so that they support decision-makers who are confronted with an increasing number of increasingly complex disasters.

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