Decision Support for Strategic Disaster Management: First Release of a Wiki

Marion Rauner, Helmut Niessner, Lisa Sasse, Kristina Tomic, Karen Neville, Andrew Pope, and Sheila O'Riordan

Abstract For successful emergency management (EM) it is crucial that all stakeholders, especially health care emergency responders, use the same terminology. Throughout the emergency management lifecycle it is necessary for individual agencies to work together, sharing information and resources. Emergency management is already a complex process, but a multi-agency response comes with added difficulties. Each agency has its own organisational cultures, structures, and technologies in place, managed by internal processes and systems. To address some of the challenges associated with a multi-agency response (e.g., lack of coordination, information, and interoperability), standardisation is promoted. By ensuring the use of shared terms, operational inefficiencies and delays can be reduced and a shared vocabulary can be promoted across multiple agencies. For this reason, the S-HELP Strategic Disaster Management wiki has been developed by University of Vienna, Austria (UNIVIE). The wiki provides main glossary terms, definitions, and standards to improve decision making. It is implemented as a part of the FP7-EU S-HELP (Securing Health.Emergency.Learning.Planning) project, which develops a Decision Support (DS) tool for EM and is coordinated by University College Cork (UCC), Ireland.

M. Rauner (✉)
Department of Innovation and Technology Management, University of Vienna, Oskar-Morgenstern-Platz 1, A-1090 Vienna, Austria
e-mail: Marion.Rauner@univie.ac.at

H. Niessner • L. Sasse • K. Tomic
School of Business and Economics, University of Vienna, Vienna, Austria
e-mail: Helmut.Niessner@univie.ac.at; Lisa.Sasse@univie.ac.at; Kristina.Tomic@univie.ac.at

K. Neville • A. Pope • S. O'Riordan
Centre for Security & Emergency Management Research, Cork University Business School, University College Cork, Cork, Ireland
e-mail: KarenNeville@UCC.ie; A.Pope@ucc.ie; Sheila.ORiordan@ucc.ie

© Springer International Publishing Switzerland 2016

H. Dawid et al. (eds.), *Dynamic Perspectives on Managerial Decision Making*, Dynamic Modeling and Econometrics in Economics and Finance 22,
DOI 10.1007/978-3-319-39120-5_23

1 Introduction

Operations Research and Management Science models have successfully supported policy making in disaster management as illustrated by the reviews of Altay and Green (2006), Caunhye et al. (2012), Galindo and Batta (2013), Manopiniwes and Irohara (2014), and Hoyos et al. (2015). For example, Doerner and Hartl (2008) investigated new challenges for routing problems for health care logistics, emergency preparedness, and disaster relief with a focus on the Austrian situation. In addition, distribution of critical goods plays a crucial role in disaster relief such as water (Nolz et al. 2010) or food, shelter, and medicine (Nolz et al. 2009).

Decision support systems are essential in supporting activities undertaken during an emergency response. For example, "spatial decision support systems were used routinely in the rescue and relief operations in the World Trade Center disaster. These ranged from micro-level risk assessments (shifts in the debris pile and temperature hot spots at the site) to the spatial status of lifelines (electric, water, telephone, transportation networks), all of which changed almost daily" (Cutter 2003, p. 441). For emergency management, these systems need to integrate advanced computer and communication technologies with components such as Geographic Information Systems (GIS), storm tracking tools, damage projection and flooding models, and models for evacuating an affected population (Tufekci 1995), to name a few. These systems help emergency responders to make better decisions based on real-time data and the use of modelling tools. Using the evacuation scenario as an example, various decisions must be made based on how many people are at risk, where people can be evacuated to, how casualties can be transported, and deciding on how the process can be managed (Carver and Turoff 2007). As a result, integrated real-time decision support needs to be effective under complex and changing conditions (Tufekci 1995), as well as provide easy to understand displays that do not 'overload' the end-users with too much information and ultimately reduce an agency's ability to find information when it is needed (French and Turoff 2007; Manoj and Baker 2007).

In order to address these challenges, and the challenges associated with emergency management, the FP7-EU S-HELP (Securing Health.Emergency.Learning.Planning) is developing a decision-support tool-set with function-specific modules that integrate with existing tools and systems. S-HELP is coordinated by University College Cork (UCC), Ireland (http://www.fp7-shelp.eu/). As agencies that respond to emergencies already have legacy systems in place, it is vital that new solutions can be integrated with old, as well as add value through new capabilities and functionalities. Hence, the S-HELP project seeks to create a tool-set to support rapid and effective decision making across all stages of an emergency lifecycle (i.e. mitigation, preparation, response, and recovery), which can be effectively implemented for a cross-border multi-agency response. To achieve this, a holistic framed approach has been developed that integrates a number of components for consideration in the development of an EM decision support system. Such components include interoperability standards (cf. Waugh and Streib 2006), modular end-user focused

tool development (cf. Carver and Turoff 2007), real-life emergency scenarios (cf. Reznek et al. 2003), end-user training in decision making (cf. Alexander 2003; Kowalski-Trakofler et al. 2003), as well as risk communication through information communication technologies and social media (cf. Sutton et al. 2008; Veil et al. 2011). Furthermore, for the design of the decision support tool-set, concepts such as spatial modelling and mapping (cf. Cutter 2003), psychological frameworks and information processing for user interface design have been investigated and incorporated (cf. Chen and Lee 2003).

Consequently, S-HELP enhances the protection of public health and common grounds for interoperability by significantly advancing the existing knowledge base required for the development of a user-centred decision support (DS) tool-set for the management of emergency situations. By gathering the collective knowledge of industry and research practice to identify current constraints in the development of emergency management solutions, S-HELP addresses the capability gaps that exist in currently available commercial tool-sets. Literature has highlighted gaps in the activities undertaken by emergency managers and the capabilities of commercially available tools, as well as a lack of focus and integration between the complimentary phases of the emergency management (EM) lifecycle (Altay and Green 2006). Hence, S-HELP seeks an advantage over other projects and tools, by developing a solution that accounts for the interplay among the entire EM lifecycle and that addresses the capability gaps identified in the literature and by EM end-users. S-HELP will define an interoperability standard to enable communication and coordination of multi-agencies across different geographical areas and cultural settings and facilitate a collaborative end-user driven solution to meet the needs of these varied users and countries. In addition, S-HELP advances the design and application of currently available solutions, to improve preparedness, response and recovery in emergency situations and provide a decision support tool-set that has been tested, evaluated, and enhanced through quality, end-user designed emergency scenarios.

For EM stakeholders, it is of highest importance to obtain a list of a controlled vocabulary and general structure for the main areas of strategic disaster management. Hereby, a glossary of terms and definitions with common grounds and standards for interoperability are essential. For this reason, we have provided a taxonomy for strategic disaster management in the form of a wiki. Main glossary terms for emergency management are incorporated based on international standard terms, scientific literature, and practice. Furthermore, main stakeholder groups and associated common grounds are considered. For the specific disaster examples, we focus on the three disaster policy scenarios of S-HELP (flooding, chemical explosion, and biological hazard).

Taxonomies or systems of classification are often used in the natural sciences (e.g., the Periodic Table, International Classification of Diseases) to apply order to "an apparently perplexing variety of elements of a scientific field or specialty" (Heidenberger and Roth 1998). In addition, taxonomies may help stakeholders "in a systematic search for hitherto unknown, and hopefully better" components, structures, and systems of a certain area (Heidenberger and Roth 1998, p. 337).

The taxonomies can be "extracted or identified along multiple dimensions and ordered to result in a coherent frame of reference. This frame of reference facilitates the recombination of the essentials of previous approaches and may result in new approaches of enhanced analytical power" (Heidenberger and Roth 1998, p. 337).

Our taxonomy hierarchically structures both controlled terms and the main areas of strategic disaster management by creating a visual representation (cf. Zarate 2013). For certain areas, thesaurus terms are provided if needed. Furthermore, it is very useful for education and training purposes for emergency responders. Please note, that the main content of this taxonomy is implemented in the S-HELP DSS.

The development of wiki for the strategic disaster management glossary and taxonomy was deemed most appropriate. As a wiki has a "significant potential to improve knowledge work and information sharing within organizations" (Jackson and Klobas 2013). A wikis' advantage of usability and simplicity are useful and appropriate to support the decision making of EM stakeholders. The wiki platform provided by University of Vienna, Austria was used for the implementation by UCC. The strategic disaster management wiki can be accessed via https://wiki.univie.ac.at/display/SHELP/ Please note that this is the first release of the strategic disaster management wiki that is planned to be further expanded.

In Sect. 2, we explain the taxonomy for strategic disaster management in detail and refer to related work. Examples for glossary terms are discussed in Sect. 3. Section 4 concludes the paper and outlines further research.

2 Taxonomy for the Strategic Context of Disaster Management[1]

Figure 1 contains the top level of the *taxonomy for strategic context of disaster management* that includes both external and internal components/criteria. This taxonomy and the related glossary terms serve as an essential part of the S-HELP DSS for disaster management policy makers. The first release's structure of the taxonomy contains 29 Figures and 806 glossary terms as explained before and can be expanded if needed.

For EM decision makers who use the S-HELP DSS, it is essential to understand the external *emergency management environment* influence on policy making (cf. Sect. 2.1). Next, EM decision makers need to know what can happen and how disasters can be defined (cf. Sect. 2.2), which is a key component of the strategic management. *Disasters* also impact the *emergency management environment*. This knowledge is incorporated in the S-HELP DSS and is needed for training of

[1]This section is based on University of Vienna, Austria (UNIVIE): Rauner, M., Niessner, H., Sasse, L., Tomic, K. (2014) Securing Health Emergency Learning Planning, S-H.E.L.P., Collaborative Project FP7-SEC-2013-1, Project no. 607865, Deliverable No. 2.1, Glossary of terms and definitions & common grounds and standards for interoperability.

Fig. 1 Taxonomy for the Strategic Context of Disaster Management

emergency responders with a special focus on health care responders (*stakeholders*) who are responsible for coping with different disaster policy scenarios (*disaster definition*).

Once this external information is gathered, the internal *decision making* can take place by EM *stakeholders.* First, we analyse the decision making process (*stakeholders, decision making levels, decision support systems, command and control systems*) in Sect. 2.3. EM policy makers have to decide what has to be done (*emergency management cycle*, *related interventions*) [cf. Sect. 2.4], which staff and material are needed (*resources*) [cf. Sect. 2.4]. Note that *decision making* will also impact the *emergency management environment*. These logically-clustered taxonomy components can be easily expanded by further taxonomies. Pease note that a main focus is given on disasters in the field of flooding, chemical explosion, and biological hazards because of the S-HELP project. This information is the basis for emergency responder (*stakeholder*) training depending on the disaster scenarios (*disaster definition*). These disaster scenarios also impact on the *related interventions* initialized by EM decision makers and the required *resources*.

On the left-hand side of our strategic disaster management wiki, EM policy makers can:

1. search for specific glossary terms,
2. look-up figures and glossary terms related to certain chapters of the *taxonomy for strategic context of disaster management* (cf. Sect. 2),
3. select definitions of glossary terms listed in alphabetical order (cf. Sect. 3), and
4. display the literature of the strategic disaster management wiki.

Main figures for classification are developed and linked to the definitions (glossary terms). Each section of the taxonomy contains at least one figure and a further set of the topic related-terms, either below each figure or below the chapter heading on the left-hand side in the wiki. We included general terminology used by international EM Organizations such as the World Health Organization (WHO) or specialized health care agencies such as the Centers for Disease Control and Prevention (CDC).

During the performance of the literature research and interviews of policy makers as well as consideration of end-user requirements, a decision was taken to restrict the strategic disaster management wiki to key topics on a general non-country specific level based on general international standards and guidelines for disaster management to enhance interoperability and cross-border communication. Restricting the wiki to essential topics was necessary due to a limited development timeframe (9 months). Furthermore, by restricting the wiki to essential topics the first release could easily be incorporated into the S-HELP DSS which is highly essential for end-user training. It is envisaged that this strategic disaster management wiki will become a living repository of core EM terms. The use of wiki technology ensures that this resource can extended over time.

The research was performed as a desktop research of academic literature (books, journal articles, and conference papers), the EU, other EU projects, and existing domain-specific skill descriptions in practice. Furthermore, domain-specific skills of paramedics were investigated in detail at the Enquete "Paramedics: International Education Concepts" at the University of Applied Sciences, St. Pölten (October 2014). UNIVIE presented the S-HELP project and conducted three interviews with Austrian end users regarding the functionality of the S-HELP Decision Support System: (1) deputy head of Division Operation, Innovation, and Subsidiaries of the Austrian Red Cross, (2) head of special course of studies on "Ambulance Service Management", Danube University of Krems, and (3) policy makers at the Coordination Center for Emergency Calls, Lower Austria. The academic and practitioner literature was supplemented with other sources including:

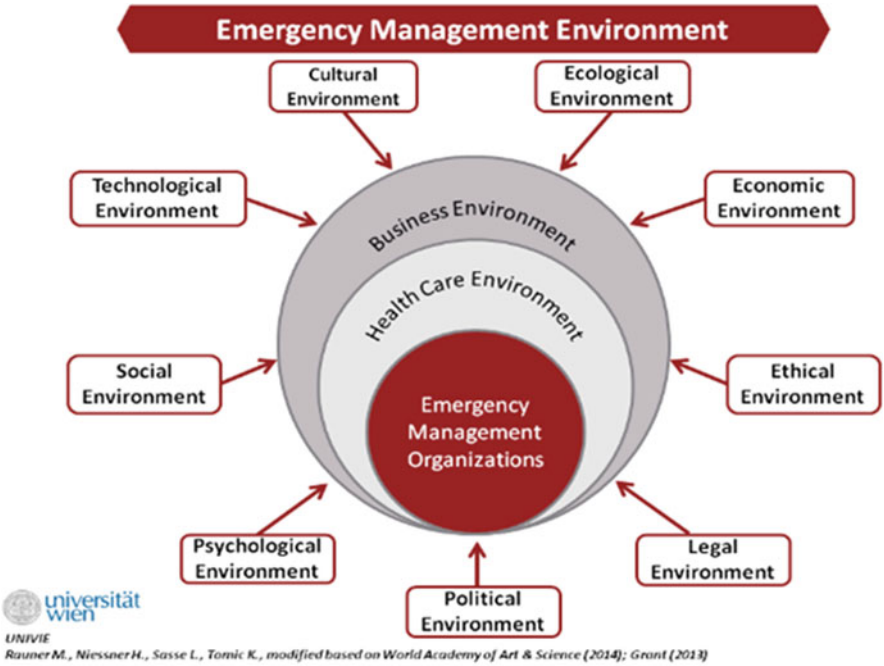
- Centers for Disease Control and Prevention, CDC,
- Centre for Research on the Epidemiology of Disaster, CRED,
- Digital Humanitarian Network, DHN,
- Emergency Response Coordination Centre, ERCC,
- European Commission, Flood Risk Management,
- United Nations Office for the Coordination of Humanitarian Affairs, OCHA, and
- World Health Organization, WHO.

The project builds on widely accepted international standards for interoperability based on ISO norms and EU guidelines such as:

- European Union Civil Protection Modules, EU CP Modules,
- International Organization for Standardization, ISO, and
- Interoperable Delivery of European eGovernment Services to Public Administrations, Businesses, and Citizens, IDABC.

2.1 Emergency Management Environment

The general *emergency management environment* is defined in Fig. 2 which was modified based on World Academy of Art and Science (2014) and Grant (2013). Please note that *disasters, decision making*, and the *emergency management environment* influence each other. For example, improved decision making such as the S-HELP DS tool can lower the *extent of an event* and the *vulnerability* of a society to disasters.



- Business Environment
- Cultural Environment
- Ecological Environment
- Economic Environment
- Emergency Management Organizations
- Ethical Environment
- Health Care Environment
- Legal Environment
- Political Environment
- Psychological Environment
- Social Environment
- Technological Environment

Fig. 2 Emergency Management Environment

Cultural, *ecological, economic*, *ethical*, *legal*, *political*, *psychological*, *social*, and *technological environments* are sub-environments that impact on the *business environment* and further on the *health care environment* up to the *emergency management organizations*. For example, the *technological environment* is defined as the surrounding field "resulting from improvements in technical processes that increase productivity of machines and eliminates manual operations or operations done by older machines" (Merriam-Webster Dictionary 2014). Of highest importance are the *emergency management organizations* that are responsible for "the organization and management of resources and responsibilities for addressing all aspects of emergencies, in particular preparedness, response and rehabilitation" (United Nations Office for the Coordination of Humanitarian Affairs 2008). These emergency management organizations are also part of the *stakeholders* who make decisions in EM situations (cf. Sect. 2.3.1).

A list of the components (i.e., sub-environments) for the *emergency management environment* is explained below the related figure in the wiki, as displayed in Fig. 2. All related definitions are linked to the glossary.

Health care organizations/individuals (cf. Ginter et al. 2013) comprise (cf. Fig. 3): (1) *organizations that regulate primary and secondary providers*, (2) *secondary providers (resources)*, (3) *primary providers (health services)*, (4) *organizations that represent primary and secondary providers*, and (5) *individuals and patients (consumers)*. For example, patients and consumer groups are consumers of health care services. Thus, they are an essential part of the external health care

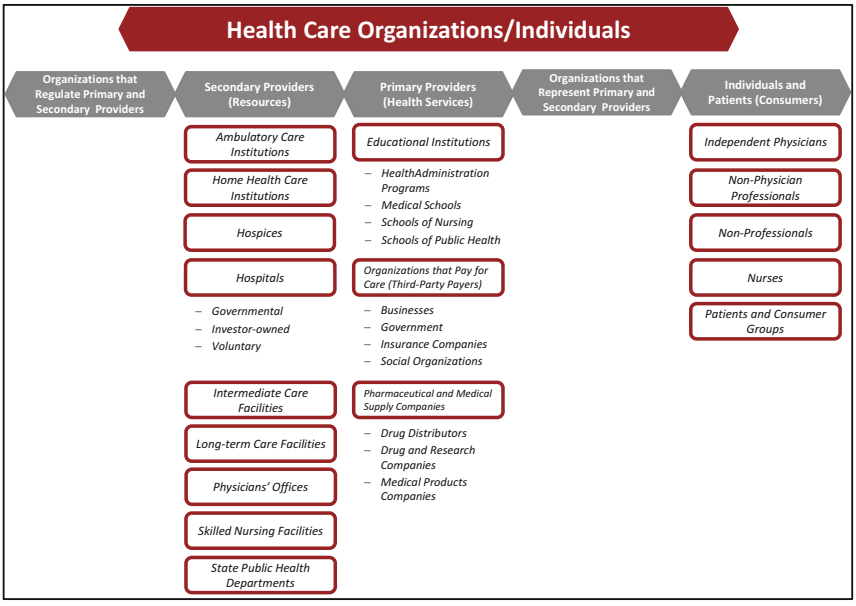


Fig. 3 Health Care Organizations/Individuals

environment. All of the groups mentioned above influence technological, social, regulatory, political, economic, and/or competitive issues within the health care sector. Note that *health care organizations/individuals* might also be part of the *stakeholders* in the EM environment (Sect. 2.3.1). Especially the primary and secondary providers that are involved in care and treatment of injured people by using their staff and material (*resources*).

2.2 Disaster Definition

For EM *stakeholders* it is of highest importance to first categorize a disaster according to Fig. 4 (cf. Birkmann 2007): (1) *disaster types* (Sect. 2.2.1), (2) *extent of event* (Sect. 2.2.2), (3) *vulnerability* (Sect. 2.2.3), and (4) *disaster risk* (Sect. 2.2.4). The *disaster risk* is dependable on *disaster types*, *extend of event*, and *vulnerability*.

In addition, the wiki provides the main general *disaster definitions* by international EM agencies:

1. "A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources" (Office for the Coordination of Humanitarian Affairs 2008).

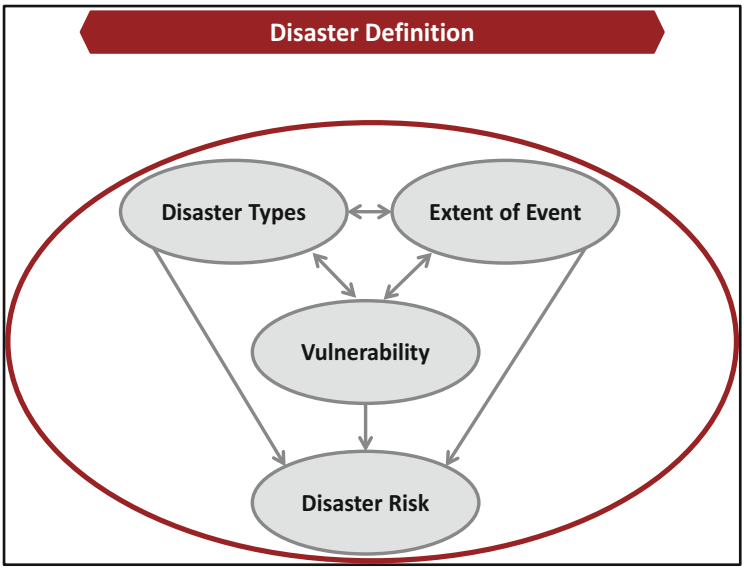


Fig. 4 Disaster Definition

Comment: Disasters are often described as a result of the combination of a natural hazard, the conditions of vulnerability, and insufficient capacity or measures to reduce or cope with the potential negative consequences. A disaster also may be seen as an outcome of the 'risk process', the interactions of the above three factors over time that lead to the development of disaster risks and the expression of that risk through disaster events (Office for the Coordination of Humanitarian Affairs 2008).

2. "Situation or event, which overwhelms local capacity, necessitating a request to national or international level for external assistance (definition considered in EM-DAT); An unforeseen and often sudden event that causes great damage, destruction and human suffering. Though often caused by nature, disasters can have human origins. Wars and civil disturbances that destroy homelands and displace people are included among the causes of disasters. Other causes can be: building collapse, blizzard, drought, epidemic, earthquake, explosion, fire, flood, hazardous material or transportation incident (such as a chemical spill), hurricane, nuclear incident, tornado, or volcano (Disaster Relief)" (The International Disaster Database, EM-DAT 2014).

The wiki also describes the criteria for a *disaster*—and at least one of the following criteria must be fulfilled (The International Disaster Database, EM-DAT 2014):

- "Ten (10) or more people reported killed.
- Hundred (100) or more people reported affected.
- Declaration of a state of emergency.
- Call for international assistance."

2.2.1 Disaster Types

The *disaster types* can be categorized into *natural*, *man-made*, and *hybrid disasters* that can also cause *subsequent disasters* (cf. Fig. 5) which are modified based on the international disaster database (EM-DAT 2014; Shaluf 2007).

Natural disasters contain *biological*, *cosmological*, *geophysical*, and *hydro-meteorological disasters*, while *man-made disasters* include *socio-technical disasters* and *human conflicts*.

For example, *biological disasters* might be an *epidemic*. *Epidemics* can be categorized by: (1) *types of epidemics*, (2) *chain of infection*, (3) *infection disease stages of individuals*, and (4) *evolution of epidemics*.

Types of epidemics include *bacterial*, *fungal*, *parasitic*, *prion*, or *viral infections* (*infectious diseases*). The wiki defines infectious diseases as "diseases that can be spread, directly or indirectly, from one person to another" (WHO 2014). "Zoonotic diseases are infectious diseases of animals that can cause disease when transmitted to humans" (WHO 2014). Examples of viral infectious diseases are listed in the wiki such as hepatitis and Marburg virus based on WHO (2014). Several diseases are further exemplarily explained.

To fight against certain diseases by selecting related interventions, policy makers must understand the *chain of infection* by identifying the mode of transmission, portal of entry/exit, as well as the reservoir, infectious agent, and susceptible host as illustrated by Fig. 6 (cf. Krämer et al. 2010).

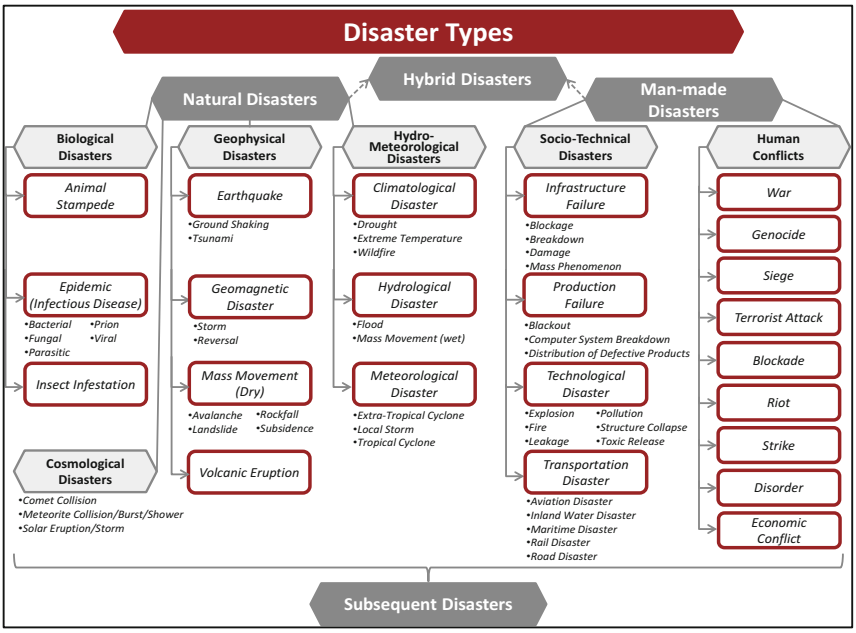


Fig. 5 Disaster Types

The main *infectious disease stages of an individual* are represented in Fig. 7 (cf. Anderson and May 1991). Please note, that there are several infectious diseases such as HIV/AIDS from which an individual cannot recover from yet. In addition, a recovery from a certain disease does not automatically result in immunity.

Figure 8 (cf. Institute of Medicine 2009) displays the *evolution of epidemics* for infection diseases from the initial *exposure* to a population (level 1) up to an *epidemic spread* (level 4). Policy makers can fight against the spread of *epidemics* by initiating *interventions* using *resources* (staff and material).

2.2.2 Extent of Event

The *extent of event* is most crucial for EM *stakeholders* as it highly impacts *disaster risk* (cf. Fig. 9). The main components of the extent of event cover (modified based on De Smet et al. 2012): (1) *forewarning*, (2) *time*, (3) *location & size*, (4) *level*, (5) *intensity*, and (6) *duration*.

For example, the *intensity* of a disaster can be measured by established standards, depending on the disaster type. The *discharge* or *stage* can be used to measure the severity for *floods* (The Science Education Resource Center at Carleton College, SERC 2014).

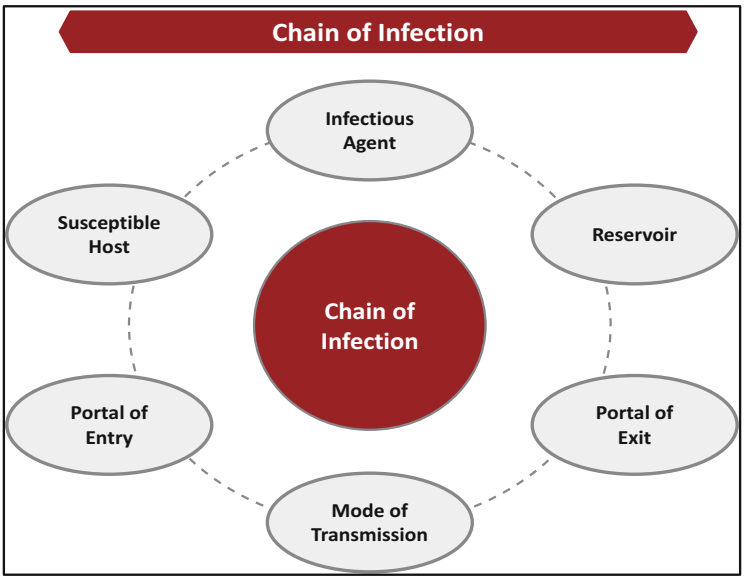


Fig. 6 Chain of Infection

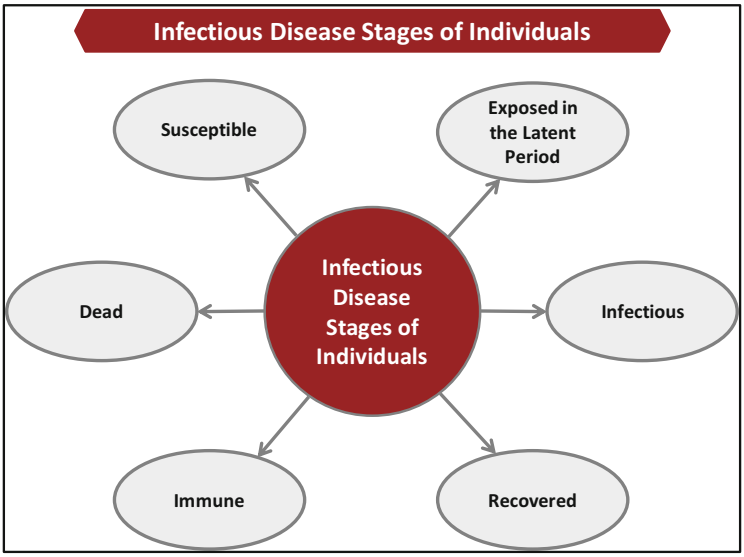


Fig. 7 Infectious Disease Stages of Individuals

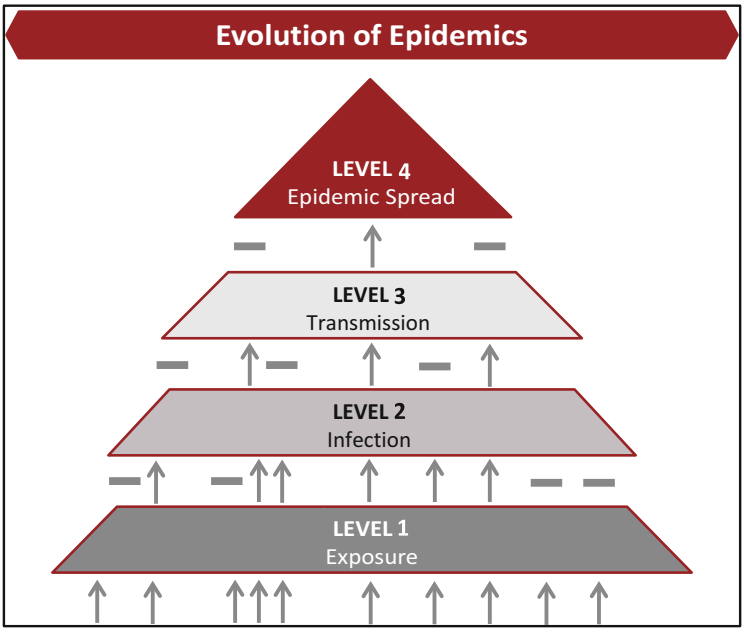


Fig. 8 Evolution of Epidemics

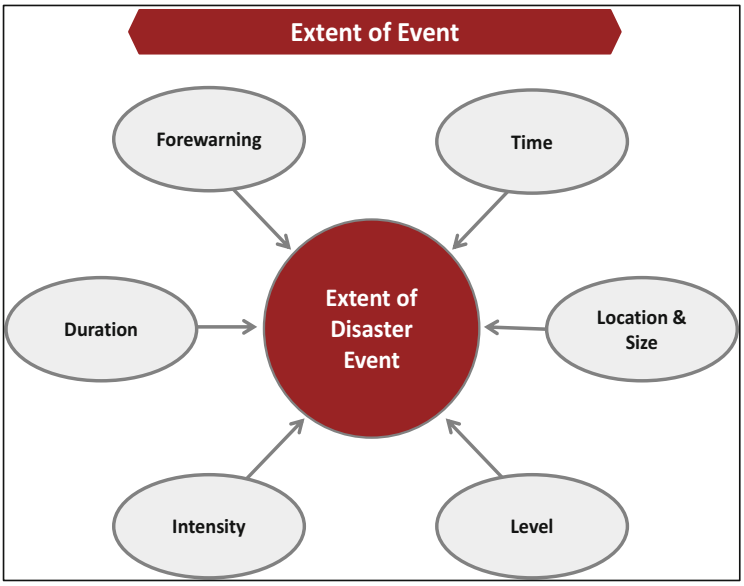


Fig. 9 Extent of Event

An emergency incident can happen on five levels based on the regional extent: (1) *local*, (2) *regional*, (3) *national*, (4) *cross-border*, and (5) *international level* (Irish National Steering Group 2006). Especially, a biological-hazard scenario or a chemical explosion policy scenario might be at a cross-border or even international level.

2.2.3 Vulnerability

The *disaster types* (cf. Sect. 2.2.1), the *extent of event* (cf. Sect. 2.2.2), and the *vulnerability* (cf. Fig. 10) influence each other, and together define the *disaster risk* (cf. Sect. 2.2.4).

The *vulnerability* is "determined by *physical*, *social*, *economic* and *environmental factors* or processes, which increase the *susceptibility* of a community to the impact of hazards (Office for the Coordination of Humanitarian Affairs 2008). It is dependent on the *exposure*, *susceptibility & fragility*, and *lack of resilience* (Birkmann et al. 2013). EM stakeholders need to increase the *resilience* capabilities and thus lower the *susceptibility* and *fragility* of societies by using *DSS*.

Exposure is defined as "the extent to which a unit of assessment falls within the geographical range of a hazard event. Exposure extends to fixed physical attributes of social systems (infrastructure) but also human systems (livelihoods, economies,

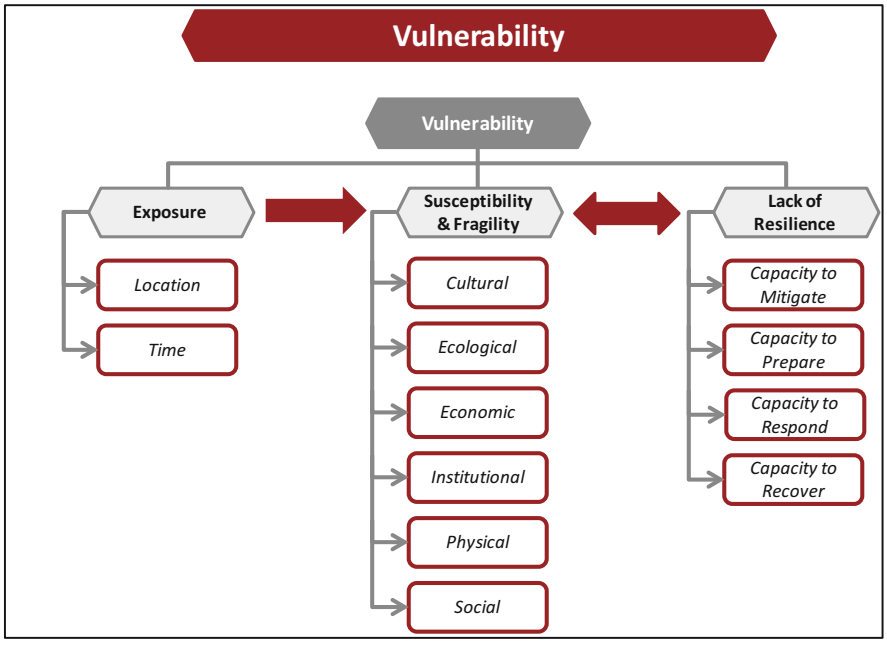


Fig. 10 Vulnerability

cultures) that are spatially bound to specific resources and practices that may also be exposed. Exposure is then qualified in terms of spatial and temporal patterns" (Birkmann et al. 2013, p. 200).

Exposure then affects the *susceptibility/fragility*, the "predisposition of elements at risk (social and ecological) to suffer harm—often independent of exposure" (Birkmann et al. 2013, p. 200). It has a *cultural*, *economic*, *environmental*, *institutional*, *physical,* and *social* component. For example, with respect to the *cultural dimension*, policy makers want to protect the "potential for damage to intangible values including meanings placed on artefacts, customs, habitual practices and natural or urban landscapes" (Birkmann et al. 2013, p. 200).

The *lack of resilience* and the *susceptibility/fragility* interact. *Resilience* is "the capacity of a system, community, or society potentially exposed to hazards to resist, adapt, and recover from hazard events, and to restore an acceptable level of functioning and structure" (Office for the Coordination of Humanitarian Affairs 2008). Comment: "Resilience means to 'resile from' or 'spring back' after a shock. The resilience of a social system is determined by the degree to which the system has the necessary resources and is capable of organizing itself to develop its capacities, to implement disaster risk reduction and to institute means to transfer or manage residual risks" (Office for the Coordination of Humanitarian Affairs 2008). The *lack of resilience* can be divided into the four elements of the emergency management cycle (cf. Sect. 2.4): (1) *lack of capacity to mitigate*, (2) *to prepare*, (3) *to respond*, and (4) *to recover* (Birkmann et al. 2013).

2.2.4 Disaster Risk

Disaster risk is affected by the *disaster types* (cf. Sect. 2.2.1), the *extent of event* (cf. Sect. 2.2.2), and the *vulnerability* (cf. Sect. 2.2.3).

Disaster risk is "the magnitude of potential disaster losses, in lives, livelihoods and assets, which could occur to a particular community or group, arising from their exposure to possible future hazard events and their vulnerability to these hazards" (Office for the Coordination of Humanitarian Affairs 2008). Comment: "The concept of disaster risk shifts the viewpoint from disasters as events randomly affecting places, to that of negative potential conditions continuously affecting all areas. Disaster risk encompasses several different types of potential losses—in lives, livelihoods and financial and other assets—and is often difficult to quantify. Nevertheless, with knowledge of the prevailing hazards and the patterns of population and socio-economic development, it can be assessed and mapped, in broad terms at least, and the factors contributing to the risks can be made subject to public and private risk-reducing actions" (Office for the Coordination of Humanitarian Affairs 2008). Thus, *humans*, *fauna*, *flora*, and the *infrastructure* might be impacted/harmed by a potential disaster.

For policy makers it is of highest importance to protect the *critical infrastructure* against disasters and to restore destroyed *critical infrastructure* as soon as possible

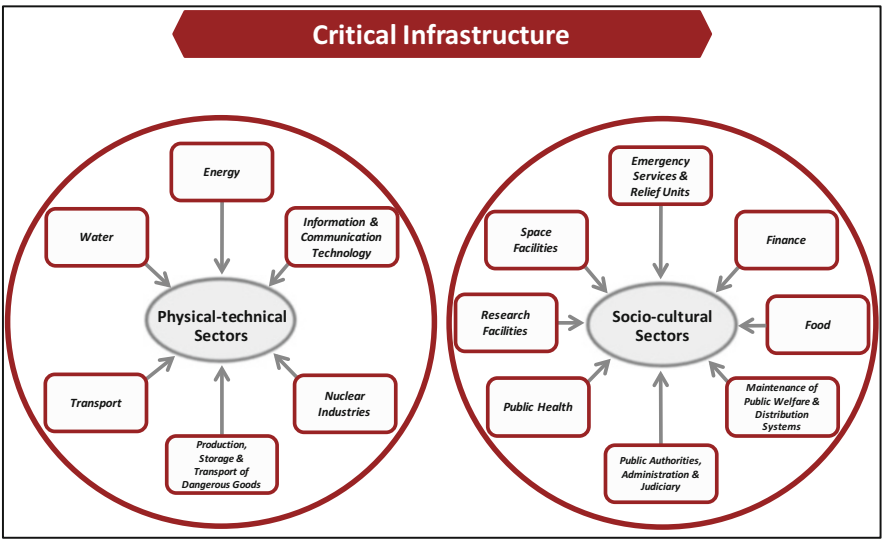


Fig. 11 Critical Infrastructure

after a disaster (cf. Fig. 11). The magnitude of the material destruction and/or contamination after an impact of an event can be divided into four categories:

1. "**Small**: one destructed or contaminated site (e.g., plant, building)
2. **Medium**: more than one destructed or contaminated site, partial destruction of a village, small town or small region (<50 km^2)
3. **Big**: partly destruction or contamination of more than one town
4. **Very big**: destruction or contamination of a large region (several towns are heavily disrupted or affected)" (De Smet et al. 2012, p. 143).

The *critical infrastructure* (cf. Fig. 11) can be categorized into *physical-technical sectors* (*energy, information & communication technology, nuclear industries, production, storage & transport of dangerous goods, transport, water*) and *socio-cultural sectors (emergency services & relief units; finance; food; maintenance of public welfare & distribution systems; public authorities, administration & judiciary; public health; research facilities; space facilities*) (Stangl et al. 2012).

From the *physical-technical sectors*, the *water sector* plays a key role. According to WHO (2014), "safe and readily available water is important for public health, whether it is used for drinking, domestic use, food production or recreational purposes". Kleiner (1999) suggests that "the average male should consume a minimum 2.9 litres per day and the average female 2.2 litres Approximately one-third of this fluid was considered likely to be derived from food" (Howard and Bartram 2003, p. 5). WHO (2014) summarizes that "a minimum of 15 litres per person per day should be provided as soon as possible after a disaster. During emergencies, people may use untreated water for laundry or bathing". In the S-

HELP flooding policy scenario, the flooding might reduce both the quality and quantity of potable water resulting in dehydration of humans and animals, damage to agriculture, impairment of hygienic measures, and occurrence of infectious diseases etc. (Stangl et al. 2012).

From the *socio-cultural sector*, the *public health sector* (e.g., hospitals, health care facilities, laboratories, drugs, search and rescue services, emergency services) is most important for the S-HELP project, especially for the biological-hazard policy scenario. Not only infected people are treated by the health sector but also a strong effort must be made to contain emerging epidemics by keeping in mind that the workforce for all critical infrastructures has to be provided and protected against infection.

2.3 Decision Making

Stakeholders (Sect. 2.3.1) perform *decision making* on certain *levels* (Sect. 2.3.2) applying *decision support systems* (Sect. 2.3.4). EM organizations use *command and control systems* (Sect. 2.3.3) to accomplish their command and control duties for disaster management. Generally, a *decision* "is a choice among options" (Power 2014). For interoperability in disaster management it is of highest importance to explore in detail the decision making for disaster management of EM *stakeholders*.

2.3.1 Stakeholders

Digital Humanitarian Network (2014) defines EM *stakeholders* to include "all those – from agencies to individuals – who have a direct or indirect interest in the humanitarian intervention, or who affect or are affected by the implementation and outcome of it. Within the context of the Quality Pro Forma, primary stakeholders refers to both beneficiaries and non-beneficiaries within the affected population."

Digital Humanitarian Network (2014) provides a comprehensive overview on different Humanitarian Stakeholders which is displayed in Fig. 12. We have included this categorization into our taxonomy. First, we displayed the main *stakeholder* groups (cf. Fig. 12): *donors, individuals, international organizations, media, military, non-governmental organizations, private sector*, and *public sector*. Next, we developed one sub-Figure for each of the eight EM *stakeholder* categories of the Humanitarian Decision Makers Taxonomy (Digital Humanitarian Network 2014). These eight sub-Figures are displayed in detail in the wiki. As the Digital Humanitarian Network (2014) does not provide any explanations for the stakeholders illustrated in at http://digitalhumanitarians.com/content/decision-makers-needs, we explain all main EM *stakeholders* listed for EM policy makers in the strategic disaster management wiki. In addition, this classification could also be improved. Please note that we are currently expanding this taxonomy for stakeholders to include all essential emergency responder categories for the S-HELP

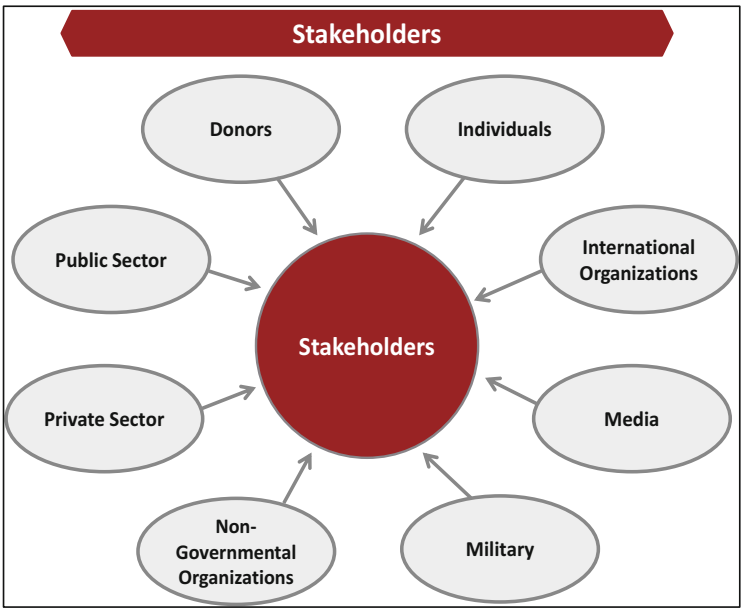


Fig. 12 Stakeholders

project regarding the three emergency scenarios (flooding, chemical explosion, and biological hazard). This expanded classification will be included in the second release of the strategic disaster management wiki in Spring 2016 as discussed in the conclusion section.

2.3.2 Decision Making Levels

Decision Making can be performed on a *strategic*, *tactic*, and *operational level* (Mintzberg 1994) by EM *stakeholders* (cf. Sect. 2.3.1).

The *strategic level* "is concerned with the broader and long-term implications of the emergency and which establishes the policies and framework within which decisions at the tactical level are taken" (Irish National Steering Group 2006).

At the *tactical level* "the emergency is managed, including issues such as, allocation of resources, the procurement of additional resources, if required, and the planning and co-ordination of ongoing operations" (Irish National Steering Group 2006).

The *operational level* is "the level at which the management of hands-on work is undertaken at the incident site(s) or associated areas" (Irish National Steering Group 2006).

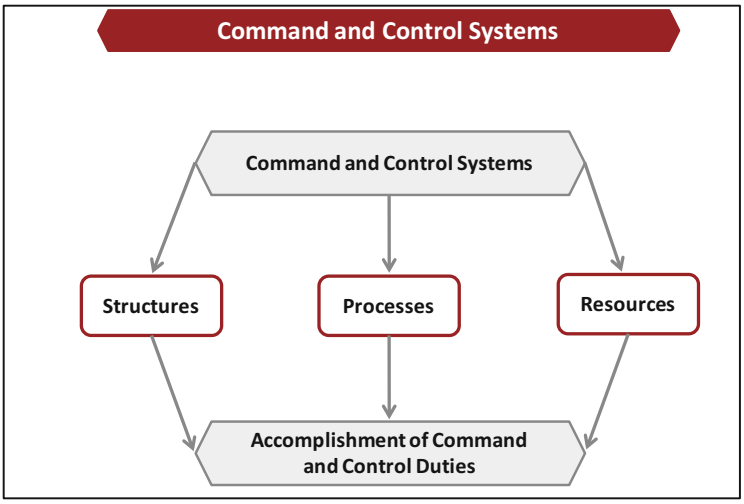


Fig. 13 Command and Control Systems

2.3.3 Command and Control Systems

Command and control systems (cf. Fig. 13) are highly essential for the decision making of EM *stakeholders* and are defined as "systems that support effective emergency management of all available assets in a preparation, incident response, continuity and/or recovery process" (International Organization for Standardization 2011).

For interoperability in disaster management, it is of highest importance to compare different command and control systems (structure, process, and resources) among selected countries. This feature of the wiki could be expanded in the future.

2.3.4 Decision Support Systems

In the wiki, general glossary terms/definitions of *decision support systems* are explained based on Power (2014) to support EM *stakeholders* to generally understand DSS. Power (2014) classifies *decision support systems* as follows: "A DSS is an interactive computer-based system or subsystem intended to help decision makers use communications technologies, data, documents, knowledge and/or models to identify and solve problems, complete decision process tasks, and make decisions. DSS is a general term for any computer application that enhances a person or group's ability to make decisions and also refers to an academic field of research that involves designing and studying DSS and their context of use."

In general, DSS are a class of computerized information system that support decision-making activities. The five more specific DSS types (cf. Power 2014) are

included and explained in the wiki:

1. *Communications-driven DSS*
2. *Data-driven DSS*
3. *Document-driven DSS*
4. *Knowledge-driven DSS*
5. *Model-driven DSS*

2.4 Emergency Management Cycle

The *emergency management cycle* "includes sum total of all activities, programmes and measures which can be taken up before, during and after a disaster with the purpose to avoid a disaster, reduce its impact or recover from its losses" (Vasilescu et al. 2008, p. 46). The *emergency management* cycle consists of two phases, namely a *pre-disaster phase* and a *post-disaster phase* (cf. Alexander 2012), which are further divided into *mitigation* and *preparedness (pre-disaster) as well as response* and *recovery* (post-disaster).

Mitigation "involves reducing or eliminating the likelihood or the consequences of a hazard. It is used to treat the hazard and resulting incident in order to reduce its impact on society" (cf. Coppola 2011). Vaccination of individuals against diseases might be a *mitigation* measure in the biological-hazard policy scenario of S-HELP.

Preparedness can be explained as "the readiness of an organization and/or community to respond to an emergency/disaster/crisis in a coordinated, timely, effective, and efficient manner. It involves equipping responders, decision-makers, and the public with the tools and mechanisms necessary to increase their chance of survival and to minimize losses" (Coppola 2011). The DSS developed by S-HELP and the training of EM stakeholders might be such an example for preparedness.

Response covers the "sum of decisions and actions taken during and after the event of an emergency/disaster/crisis to reduce or eliminate the impact of the disaster in order to prevent further health suffering, financial loss, or a combination of both" (Coppola 2011). Isolation of infected individuals might be a *response* measure in the biological-hazard policy scenario of S-HELP.

Recovery "involves returning victim's lives back to the normal state they were before the disaster. This usually begins immediately after the incident but it can last for months or even years" (Coppola 2011). The reconstruction of critical infrastructure after a major disaster might be such an example (e.g., chemical explosion policy scenario).

2.5 Related Interventions and Resources

The related *interventions* that EM *stakeholders* select using their given *resources* (*staff* and *material*) are not yet incorporated in the first release of the wiki.

In the S-HELP project, we developed a skills taxonomy template to interlink emergency interventions/tasks and emergency responders/skills. Furthermore, we provided an overview which emergency interventions/tasks can be covered by EU Civil Protection Modules by incorporating availability, start of operation, self-sufficiency, and operation time (cf. University of Vienna, Austria, UNIVIE 2015a). Next, the resource taxonomy template contained the linkage of emergency interventions/tasks and emergency responders/skills to emergency equipment/materials needed (cf. University of Vienna, Austria, UNIVIE 2015b). The skills and resource taxonomy templates considered the complex and multi-disciplinary nature of health services in emergency preparedness, response, and recovery. They are included in the DSS of S-HELP. In addition, they might be also included in the strategic disaster management wiki in a future release.

3 Glossary Terms for the Strategic Context of Disaster Management[2]

In the following, we illustrate how EM *stakeholders* can use our wiki for looking up definitions (glossary terms). Our taxonomy currently consists of 29 figures and 806 glossary terms that further explain the entire structure of our taxonomy and the essential terminology used based on 136 references to the literature. A glossary term can be entered or selected from the list of 806 definitions at the left hand side of the wiki screen which is displayed in Fig. 14. For each glossary term, a title,

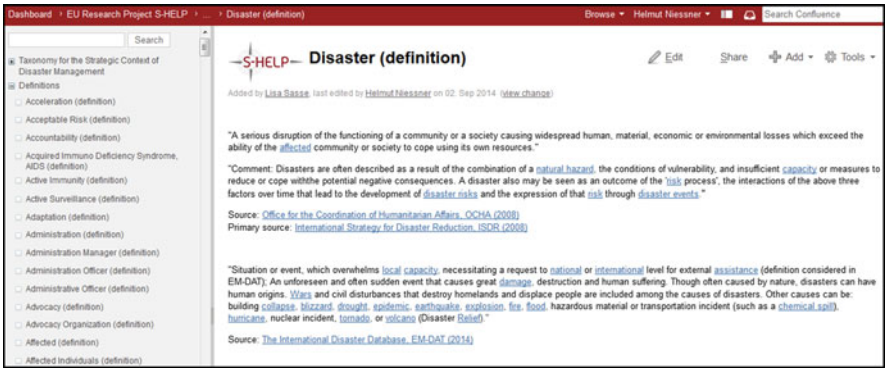


Fig. 14 Screenshot of the Wiki for Glossary Term "Disaster". *Source*: https://wiki.univie.ac.at/display/SHELP/

[2]This section is based on University of Vienna, Austria (UNIVIE): Rauner, M., Niessner, H., Sasse, L., Tomic, K. (2014) Securing Health Emergency Learning Planning, S-H.E.L.P., Collaborative Project FP7-SEC-2013-1, Project no. 607865, Deliverable No. 2.1, Glossary of terms and definitions & common grounds and standards for interoperability.

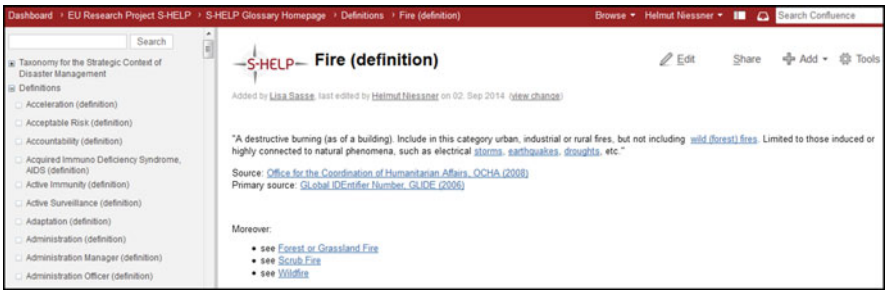


Fig. 15 Screenshot of the Wiki for Glossary Term "Fire". *Source*: https://wiki.univie.ac.at/display/SHELP/

Fig. 16 Screenshot of the Wiki for a Selected Literature Source. *Source*: https://wiki.univie.ac.at/display/SHELP/

description, and references to the literature is provided (i.e., source, primary source). In the description field, several terms are highlighted which are hyperlinks to other glossary terms in our wiki.

Figure 14 shows how the glossary term "Disaster" is explained in the wiki. We used standard definitions provided by international organizations/institutions such as the Office for the Coordination of Humanitarian Affairs (2008) and The International Disaster Database, EM-DAT (2014). If other glossary terms of our wiki are used for the explanation of a certain glossary term, links will be provided to these terms (e.g., collapse, fire, flood).

If an EM policy maker wants to get further information on certain glossary terms such as "fire" by clicking on the glossary term, the following explanation for the glossary term "fire" will appear (cf. Fig. 15).

Next, if a policy maker is interested in the source of the explanation for the glossary term "fire" (Office for the Coordination of Humanitarian Affairs 2008) they can click on the related source link, which opens the following wiki window (cf. Fig. 16).

For all sources, the full reference is given. For several sources, the entire source as a pdf-File is provided and the link to the related web-site is displayed.

4 Conclusion and Further Research

EM stakeholders are supported by a glossary/taxonomy of strategic management disaster terms and definitions & common grounds and standards for interoperability. For this reason, we developed a strategic disaster management wiki using the platform provided by University of Vienna, Austria: https://wiki.univie.ac.at/display/SHELP/

The main parts of this strategic disaster management wiki are incorporated into the DSS of S-HELP (http://www.fp7-shelp.eu/). The wiki contains 29 figures and 806 glossary terms for strategic disaster management limited to the following topics, which can be further expanded in the future:

- Disaster Definition (What can happen?)
- Decision Making
  - Stakeholders (Who makes the decisions?)
  - Decision Making Levels & Command and Control Structures (How are the decisions made?)
  - Decision Support Systems (How are decisions supported?)
- Emergency Management Cycle
- Emergency Management Environment

In the S-HELP project, we developed a skills taxonomy template to interlink emergency interventions/tasks and emergency responders/skills (University of Vienna, UNIVIE 2015a). Furthermore, we provided an overview which emergency interventions/tasks can be covered by EU Civil Protection Modules (European Commission, EC 2014) by incorporating availability, start of operation, self-sufficiency, and operation time. Next, the resource taxonomy template contained the linkage of emergency interventions/tasks and emergency responders/skills to the required emergency equipment/materials (University of Vienna, UNIVIE, 2015b). The skills and resource taxonomy templates take into account the complex and multi-disciplinary nature of health services in emergency preparedness, response, and recovery. The main parts are implemented in the DSS of S-HELP by University College of Cork which also might be included in the strategic disaster management wiki in the future.

Moreover, the content on command and control systems for disaster management might be expanded to help decision makers compare different approaches among countries (University of Vienna, UNIVIE 2015c). For example, the international EM guidelines (e.g., ISO 22320—International Organization for Standardization 2011; ISO 22300—International Organization for Standardization 2012) play an important role. In addition, further interoperability standards are investigated by the European Interoperability Framework for Pan-European eGovernment Services that are published by the Interoperable Delivery of European eGovernment Services

to Public Administrations, Businesses and Citizens (2004). The current strategic disaster management wiki focus on organisational and semantic interoperability, while the technical interoperability (data-sets and data exchange) might be essential for implementing DSS based on standards such as the international EM guideline ISO 22351 (International Organization for Standardization (under development)).

For the second release of the strategic disaster management wiki for S-HELP in spring 2016, the team will include the following additional content (glossary terms, figures, and tables) based on essential parts of the skills taxonomy template (University of Vienna, UNIVIE 2015a), resources taxonomy template (University of Vienna, UNIVIE 2015b), and the interoperability model (University of Vienna, UNIVIE 2015c):(1) main emergency interventions, (2) main emergency resources, (3) main human emergency resources (emergency responders): (a) national emergency responders, (b) incident command-related emergency responders, and (c) international emergency responders, (4) main non-human emergency resources, and (5) EU Civil Protection Modules (including the general EU Emergency and Crisis Coordination Arrangements). This additional content may prove essential for policy makers to better plan skills and resources needed for emergencies under consideration of interoperability.

To conclude, this work contributes to both research and industry practitioners. By putting forth a strategic disaster management wiki that includes a taxonomy of terms and definitions, it addresses some of the issues identified in the literature that are critical in cross-border multi-agency response. As our susceptibility to hazards and related disaster scenarios increases due to urbanisation and increasing populations, it is more crucial than ever to address interoperability issues like standardisation in advance of emergency situations. By providing this work, S-HELP is helping to reduce some of the operational inefficiencies and delays associated with not having a shared vocabulary across agencies. In addition, the findings can be used to extend the current knowledge base on emergency management interoperability. Emergency responders have been provided with an extensive glossary of emergency management terms, which are being applied for use in the S-HELP DSS solution. This solution addresses the challenges of interoperability while providing a set of tools that can integrate with legacy systems and afford essential capabilities and functionalities in the management of cross-border emergency situations. It is envisaged that this strategic disaster management wiki will become a living repository of core EM terms. The use of wiki technology ensures that this resource can extended over time.

Acknowledgement This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement N607865 (http://www.fp7-shelp.eu/).

References

Alexander, D. (2003). Towards the development of standards in emergency management training and education. *Disaster Prevention and Management: An International Journal, 12*(2), 113–123.

Alexander, D. (2012). *Principles of emergency planning and management* (6th ed.). Oxford: Oxford University Press.

Altay, N., & Green, W. G. (2006). OR/MS research in disaster operations management. *European Journal of Operational Research, 175*(1), 475–493.

Anderson, R. M., & May, R. M. (1991). *Infectious diseases of humans*. Oxford: Oxford University Press.

Birkmann, J. (2007). Risk and vulnerability indicators at different scales: Applicability, usefulness and policy implications. *Environmental Hazards, 7*(1), 20–31.

Birkmann, J., Cardona, O. D., Carreno, M. L., Barbat, A. H., Pelling, M., Schneiderbauer, S., Kienberger, S., Keiler, M., Alexander, D., Zeil, P., & Welle, T. (2013). Framing vulnerability, risk and societal responses: The MOVE Framework. *Natural Hazards*, *67*(2), 193–211.

Carver, L., & Turoff, M. (2007). Human-computer interaction: The human and computer as a team in emergency management information systems. *Communications of the ACM, 50*(3), 33–38.

Caunhye, A. M., Nie, X., & Pokharel, S. (2012). Optimization models in emergency logistics: A literature review. *Socio-Economic Planning Sciences, 46*(1), 4–13.

Chen, J. Q., & Lee, S. M. (2003). An exploratory cognitive DSS for strategic decision making. *Decision Support Systems, 36*(2), 147–160.

Coppola, D. (2011). *Introduction to disaster management* (2nd ed.). Oxford: Butterworth-Heinemann.

Cutter, S. L. (2003). GI science, disasters, and emergency management. *Transactions in GIS, 7*(4), 439–446.

De Smet, H., Lagadec, P., & Leysen, J. (2012). Disasters out of the box: A new ballgame? *Journal of Contingencies and Crisis Management, 20*(3), 138–148.

Digital Humanitarian Network (2014). Humanitarian Decision Makers Taxonomy. http://digitalhumanitarians.com/content/decision-makers-needs

Doerner, K. F., & Hartl, R. F. (2008). Health care logistics, emergency preparedness, and disaster relief: new challenges for routing problems with a focus on the Austrian situation. In B. Golden, R. Raghavan, & E. Wasil (Eds.), *The vehicle routing problem: Latest advances and new challenges, Operations Research/Computer Science Interfaces Series*, (Vol. 43, pp. 527–550). Berlin: Springer.

European Commission, EC (2014). Commission Implementing Decision of 16.10.2014 laying down rules for the implementation of Decision No 1313/2013/EU – Annex II- C(2014) 7489 final.

French, S., & Turoff, M. (2007). Decision support systems. *Communications of the ACM, 50*(3), 39.

Galindo, G., & Batta, R. (2013). Review of recent developments in OR/MS research in disaster operations management. *European Journal of Operational Research, 230*(2), 201–211.

Ginter, P. M., Duncan, W. J., & Swayne, L. E. (2013). *Strategic management of health care organizations* (7th ed.). Chichester: Wiley.

Grant, R. M. (2013). *Contemporary strategy analysis, text and cases* (8th ed.). Chichester: Wiley.

Heidenberger, K., & Roth, M. (1998). Taxonomies in the strategic management of health technology: The case of multiperiod compartmental HIV/AIDS policy models. *International Journal of Technology Management*, *15*(3/4/5), 336–358.

Howard, G., & Bartram, J. (2003). *Domestic water quantity, service level, and health*. Geneva: World Health Organization.

Hoyos, M. C., Morales, R. S., & Akhavan-Tabatabaei, R. (2015). OR models with stochastic components in disaster operations management: A literature survey. *Computers & Industrial Engineering, 82*, 183–197.

Institute of Medicine. (2009). *Microbial evolution and co-adaptation: A tribute to the life and scientific legacies of Joshua Lederberg*. Washington, DC: National Academies Press.
International Organization for Standardization. (2011). ISO 22320 Societal Security - Emergency Management - Requirements for Incident Response. http://www.iso.org/iso/home.htm
International Organization for Standardization. (2012). ISO 22300 Societal Security – Terminology. http://www.iso.org/iso/home.htm
International Organization for Standardization. (under development). ISO 22351 Societal Security - Emergency Management - Message Structure for Exchange of Information. http://www.iso.org/iso/home.htm
Interoperable Delivery of European eGovernment Services to public Administrations, Businesses and Citizens. (2004). European Interoperability Framework for Pan-European eGovernment Services. http://ec.europa.eu/idabc/
Irish National Steering Group. (2006). A Framework for Major Emergency Management. http://www.mem.ie/framework.htm
Jackson, P., & Klobas, J. (2013). Deciding to use an enterprise wiki: The role of social institutions and scripts. *Knowledge Management Research & Practice, 11*(4), 323–333.
Kleiner, S. M. (1999). Water: An essential but overlooked nutrient. *Journal of the American Dietetic Association, 99*(2), 200–206.
Kowalski-Trakofler, K. M., Vaught, C., & Scharf, T. (2003). Judgment and decision making under stress: An overview for emergency managers. *International Journal of Emergency Management, 1*(3), 278–289.
Krämer, A., Akmatov, M., & Kretzschmar, M. (2010). *Principles of infectious disease epidemiology*. New York, NY: Springer.
Manoj, B. S., & Baker, A. H. (2007). Communication challenges in emergency response. *Communications of the ACM, 50*(3), 51–53.
Manopiniwes, W., & Irohara, T. (2014). A review of relief supply chain optimization. *Industrial Engineering & Management Systems, 13*(1), 1–14.
Merriam-Webster Dictionary. (2014). www.merriam-webster.com
Mintzberg, H. (1994). *The rise and fall of strategy planning*. London: Prentice Hall.
Nolz, P. C., Doerner, K. F., Gutjahr, W. J., & Hartl, R. F. (2009). A bi-objective metaheuristic for disaster relief operations planning. In C. A. Coello Coello, C. Dhaenens, & L. Jourdan (Eds.), *Advances in multi-objective nature inspired computing* (pp. 167–187). Berlin: Springer.
Nolz, P. C., Doerner, K. F., & Hartl, R. F. (2010). Water distribution in disaster relief. *International Journal of Physical Distribution & Logistics Management, 40*(8/9), 693–708.
Power, J. D. (2014). Decision Support Systems Glossary. www.DSSResources.COM/glossary
Reznek, M., Smith-Coggins, R., Howard, S., Kiran, K., Harter, P., Sowb, Y., Gaba, D., & Krummel, T. (2003). Emergency medicine crisis resource management (EMCRM): Pilot study of a simulation-based crisis management course for emergency medicine. *Academic Emergency Medicine*, *10*(4), 386–389.
Shaluf, I. M. (2007). An overview on disasters. *Disaster Prevention and Management, 16*(5), 687–703.
Stangl, R., Siedschlag, A., Silvestru, D., Fritz, F., & Jerkovic, A. (2012). Comprehensive security research to contribute to critical infrastructure protection. Contributions to security governance in disaster risk reduction. In: *12th Congress INTERPRAEVENT*, Grenoble, France.
Sutton, J., Palen, L., & Shklovski, I. (2008). Backchannels on the front lines: Emergent uses of social media in the 2007 southern California wildfires. In: *Proceedings of the 5th International ISCRAM Conference* (pp. 624–632.) Washington, DC.
The International Disaster Database, EM-DAT - Centre for Research on the Epidemiology of Disaster, CRED. (2014). www.emdat.be/glossary/9#letter
The Science Education Resource Center at Carleton College, SERC. (2014). Floods and Flooding. http://serc.carleton.edu/quantskills/methods/quantlit/floods.html
Tufekci, S. (1995). An integrated emergency management decision support system for hurricane emergencies. *Safety Science, 20*(1), 39–48.

United Nations Office for the Coordination of Humanitarian Affairs. (2008). Glossary of Humanitarian Terms. ReliefWeb. http://reliefweb.int/report/world/reliefweb-glossary-humanitarian-terms

University of Vienna, Austria, UNIVIE. (2014). Securing Health Emergency Learning Planning, S-H.E.L.P., Collaborative Project FP7-SEC-2013-1, Project no. 607865, Deliverable No. 2.1, *Glossary of terms and definitions & common grounds and standards for interoperability*.

University of Vienna, Austria, UNIVIE. (2015a). Securing Health Emergency Learning Planning, S-H.E.L.P., Collaborative Project FP7-SEC-2013-1, Project no. 607865, Deliverable No. 2.4, *Draft Skills Taxonomy Template.*

University of Vienna, Austria, UNIVIE. (2015b). Securing Health Emergency Learning Planning, S-H.E.L.P., Collaborative Project FP7-SEC-2013-1, Project no. 607865, Deliverable No. 2.7, *Draft Resources Taxonomy Template.*

University of Vienna, Austria, UNIVIE. (2015c). Securing Health Emergency Learning Planning, S-H.E.L.P., Collaborative Project FP7-SEC-2013-1, Project no. 607865, Deliverable No. 2.8, *Draft of the S-HELP Interoperability Model.*

Vasilescu, L., Asmatullah Khan, A., & Khan, H. (2008). Disaster management cycle – a theoretical approach. *Management & Marketing-Craiova, 1*, 43–50.

Veil, S. R., Buehner, T., & Palenchar, M. J. (2011). A work-in-process literature review: incorporating social media in risk and crisis communication. *Journal of Contingencies and Crisis Management, 19*(2), 110–122.

Waugh, W. L., & Streib, G. (2006). Collaboration and leadership for effective emergency management. *Public Administration Review, 66*(S1), 131–140.

World Academy of Art & Science. (2014). Strategic Planning Committee Program Framework. http://www.worldacademy.org/content/strategic-planning-committee-program-framework

World Health Organization. (2014). www.who.int/en

Zarate, P. (2013). Building controlled vocabularies for metadata harmonization. *Bulletin of the American Society for Information Science and Technology, 39*(2), 39–42.