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Estimating needs in disasters

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Avhandlingen finns här:

https://www.uib.no/en/cih/137129/anneli-eriksson-estimating-needs-disasters Anneli kan nås på anneli.eriksson@ki.se

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Abstract

Introduction: In the last decade an annual average of 200–300 million people were affected by disasters caused by natural, man-made or mixed hazardous events that overwhelmed local capacity, necessitating international humanitarian assistance. Such assistance is predominantly funded by governmental agencies and should, according to international agreements, be based on needs. However, as needs are greater than available funding, donors must rationalise funding in proportion to the scale of needs. To date, there is no commonly accepted tool to guide needs-based funding of humanitarian assistance.

The aim: This thesis aimed to increase the understanding of what factors contribute to disaster severity and how they can be measured in order to estimate the scale of needs in disasters, focusing on complex emergencies and earthquakes.

Main results and conclusions: Data on vulnerability and exposure can be used to estimate severity and the scale of needs in conflicts and other types of complex emergencies. The required data were largely available and able to discriminate between levels of severity and needs among countries. However, out of the selection of indicators from commonly used disaster indexes, none are able to predict the scale of needs after earthquakes.

Background

Throughout the history of mankind, we have been accompanied by disasters (Anderson & Gerber, 2018). While we may think of epidemics, floods, earthquakes and wars as unusual or rare events, they are in fact common and affect hundreds of millions of people, every year. Disasters cause damage, suffering and death and leave people in need of life-saving assistance (Anderson & Gerber, 2018; CRED, 2019; UNOCHA, 2019a).

A disaster disrupts the functioning of a society, leading to human, material, economic and environmental losses that overwhelm local capacity and necessitate national or international assistance (CRED, 2018b; UNISDR, 2009; UNDRR, 2017; WHO, 2008). Disasters risk to seriously disrupt sustainable development in affected societies and countries (Samman et al., 2018).

Categorisation of disasters

Disasters are caused by hazards. A hazard is phenomenon that may lead to loss of life, injury and other health impacts, as well as cause damage, social disruption and environmental destruction (Sundnes & Birnbaum, 2003; UNISDR, 2009). Hazards may be classified as either natural, man-made or mixed (Table 1) (CRED, 2018b; Sundnes & Birnbaum, 2003).

Table 1. Classification of hazards after Sundnes and Birnbaum's hazard classification (Sundnes & Birnbaum, 2003)

Type	Subtype	Manifestation
Natural hazard	Seismic	Earthquake, tsunami, Volcanic eruption, Celestial collision
	Climatic, meteorological	High winds, precipitation, lightning – fire, extreme temperatures, flood, drought, avalanches, etc.
Mixed: natural and man-made		Drought, desertification, flood, erosion, landslide, fire, health-related, such as epidemic outbreaks
Man-made	Technological	Release of: chemical, biological or nuclear substances, structural failure, explosions, etc.
	Conflict	Armed conflict: war, complex emergencies, terrorism, etc. Non-armed conflict: sanctions, embargo

Disasters are mainly categorised in three different ways: a) type of hazard causing them, b) speed of onset and duration, as well as c) their social or health impact. (M. L. Birnbaum, Daily, O'Rourke, & Loretti, 2015; CRED, 2018a). Table 1 lists types of hazards (natural, man-made and mixed).

The speed of onset categorisations include sudden-onset disasters that occur within a short time span, leaving destruction and urgent needs behind. Among sudden-onset natural disasters, earthquakes tend to cause the highest number of injured and most urgent needs (CRED, 2018a; PAHO, 2002; Al-Jazairi, 2018). Slow-onset disasters, such as droughts and desertification, may take years or even decades to develop (Perry, 2007). A protracted disaster is a disaster that due to complicating factors, such as conflict or political turmoil, has a long duration, often years, also referred to as a complex emergency (FAO, 2011). A complex emergency is classified as man-made (Table 1), but it is also defined based on the impact that it has on people's lives and livelihood (Perry, 2018; Salama, Spiegel, Talley, & Waldman, 2004; WHO, 2008). A complex emergency develops through the interaction between different hazardous events (Spiegel, Le, Ververs, & Salama, 2007). In an armed conflict, a drought that affects an agriculture-dependent population may lead to prolonged violence and a worsening of the situation (von Uexkull, Croicu, Fjelde, & Buhaug, 2016). The long duration and extent of the Ebola outbreak in eastern Democratic Republic of Congo (DRC), detected in August 2018, is to a large extent explained by the ongoing armed conflict in the same region (Cohen, 2019). Conflicts and other types of man-made complex emergencies receive the absolute majority of international assistance (Development Initiatives, 2019).

Affected by disasters

The number of people who are affected by a disaster is often referred to as a way to measure or quantify disaster severity (CRED, 2018a; Darcy & Hoffman,

2003; UNOCHA, 2019a). The number of affected does not in itself provide information about overstretched resources or the need for assistance, but it gives an indication of the magnitude of a hazardous event and of the damage that it has caused (Marvin L. Birnbaum, Daily, O'Rourke, & Loretti, 2014; Darcy & Hoffman, 2003). This information can, in turn, indicate the severity and the scale of needs (CRED, 2018a; Darcy & Hoffman, 2003; UNOCHA, 2019a).

The term "affected" is, however, not well defined; its definition varies between agencies and it remains unclear who to label as affected. In general, affected people are described as those who are directly or indirectly affected by a disaster (Darcy & Hoffman, 2003). Directly affected are those with injuries or health effects caused by the hazardous events, and also includes displaced or evacuated persons (CRED, 2018b; UNISDR, 2009). Indirectly affected are more loosely described as those affected through increased poverty, vulnerability, or loss of social services in the aftermath of hazardous events (Checchi, Gayer, Grais, & Mills, 2007; Darcy & Hoffman, 2003).

The Centre for Research on the Epidemiology of Disasters at the Université Catholique de Louvain (CRED) states that an average of 200 million people annually are directly affected by disasters caused by **natural hazardous events** (CRED, 2018, 2019; UNOCHA, 2018; Wallemacq, Below, & McLean, 2018). The number fluctuates yearly, but there is a decreasing trend (CRED, 2018, 2019; UNOCHA, 2018; Wallemacq et al., 2018). With the tendency towards more severe hazardous events, including tropical storms, floods, heat waves and droughts, the trend may turn (AghaKouchak et al., 2018; Bakkensen & Mendelsohn, 2019; Dottori et al., 2018; Stäubli et al., 2018).

In 2019, United Nations' Office for Coordination of Humanitarian Assistance (UNOCHA) estimated that more than 130 million people were directly or indirectly affected by **conflicts and other types of complex emergencies** to the extent that they were in need of international humanitarian assistance

(UNOCHA, 2019a). This is an increase compared to the previous five years in terms of both the number of people affected and the number of disasters, explained by an increase in protracted man-made complex emergencies (Development Initiatives, 2019; UNOCHA, 2019a).

Humanitarian assistance

International assistance to people affected by disasters is referred to as international humanitarian assistance. It should be guided by humanitarian principles and, thus, be provided in accordance with needs (ICRC and IFRC, 1994; The good humanitarian donorship initiative (GHD), 2003b). Humanity, impartiality, neutrality and independence are core humanitarian principles (Textbox 1) (FRC and ICRC, 2015; UNOCHA, 2012). The principles have ancient origin but are in modern times associated with the creation of the International Committee of the Red Cross (ICRC) and its founder, Henry Dunant, in the second part of the 19th century (Finnemore, 1999). The principles are agreed on by 500 organisations, as part of "the code of conduct for the International Red Cross and Red Crescent movement and non-governmental organisations in disaster relief" (ICRC and IFRC, 1994). The UN General Assembly has since 1991 endorsed these four principles as core principles (Rysaback-Smith, 2015).

Humanity and impartiality are sometimes referred to as fundamental humanitarian principles while neutrality and independence are tools to implement the fundamental principles (IFRC and ICRC, 2015).

Textbox 1. The core humanitarian principles (IFRC and ICRC, 2015; UNOCHA, 2012)

- **Humanity** postulates that suffering must be addressed wherever it is found with the purpose to protect life and health and ensure respect for human beings.
- **Impartiality** implies that assistance should be provided on the basis of needs alone.
- **Independence** refers to humanitarian action as autonomous from political, economic, military or other agendas and objectives.
- **Neutrality** refers to the necessity for a humanitarian actor to not take side in armed conflicts.

From an ethical perspective, the provision of humanitarian assistance can be understood as deontological: people suffer, therefore, we – the bystanders – have an obligation or a duty to help. The intention to do something is most important. However, the dutiful attitude needs to be interlinked with an ethics based on virtue: assistance should be provided in a way that protects people's humanity and dignity (Gunner Göran, 2005; Helgesson, 2015; Slim, 2015). The moral obligations to assist also relates to the universal ethics of humans as equal in value and rights (the basis for human rights), where duties and rights are two sides of the same coin (Donini, 2012; Gibbons, Roughneen, McDermott, & Maitra, 2019; Gunner Göran, 2005; Slim, 2015).

Humanitarian principles may seem unambiguous on paper, but the harsh reality makes upholding them far less simple (Donini, 2018; Slim, 2015). Implementers and funders of humanitarian assistance often find themselves in situations where the principles collide (Bennett, Foley, & Pantuliano, 2016; Donini, 2012, 2018; Quack, 2018; Spiegel, 2017). The fundamental idea that all

assistance to disaster-affected people should be needs-based unifies funding agencies, organisations and actors, regardless of other motivations (Bennett et al., 2016; Donini, 2018; UNSG, 2016).

A needs-based approach is challenged by the fact that resources in disasters are insufficient to meet even the most basic needs of all affected in the world (Development Initiatives, 2019; Miliband & Tessema, 2018). Therefore, in contrast to the deontological and universal ethics above, consequential considerations are inevitable (Darcy & Hoffman, 2003; Slim, 2015), and a utilitarian approach is required. Help should be provided where it is most needed or where it will create most benefit (Helgesson, 2015). It is accepted that humanitarian assistance should be provided based on the scale of needs (Bennett et al., 2016; Quack, 2018).

Components of needs-based humanitarian assistance

There is no commonly accepted definition for "needs" following disasters. Maslow's pyramid categorises human needs in a hierarchy where physical needs for survival are at the base, followed by safety, social needs, esteem and, finally, self-actualization (Maslow, 1943). It is beyond the scope of humanitarian assistance to meet all human needs. Instead, such assistance is focused on a narrow range of basic needs of services for a community (Darcy & Hoffman, 2003; Sphere Association, 2018).

The assistance aims to ensure that people affected by disasters have access to the assets necessary for their survival and for a healthy life, such as food, water, sanitation, shelter, health-care and disease prevention services, school services for children as well as protection from violence and other hazards (Sphere Association, 2018). Humanitarian assistance can also include efforts for early recovery, risk management and the building of resilience and risk reduction (Bennett et al., 2016; Spiegel, 2017; UNSG, 2016; WHO, 2019).

Defining needs

Needs-based assistance entails addressing the specific needs in each disaster. It is therefore necessary to assess the needs in order to plan and implement assistance in accordance with the needs (IASC, 2007; UNOCHA, 2019b). Humanitarian responders have heavily invested in needs-assessments in order to ensure a needs-based focus in all humanitarian assistance (IASC, 2007; and 2015; UNOCHA, 2012, 2015, 2019c; UNOCHA & IASC, 2016; UNSG, 2016). The amount of data on needs produced in disasters is increasing but despite the many reports, systematic comparison between disasters is lacking (ACAPS, 2020). Variation in the scale of needs in different disasters as well as in how responses are matched to needs are largely overlooked (Donini, 2018; Spiegel, 2017).

Critics highlight that needs in disasters are defined based on the response that international actors are able to provide (Bennett et al., 2016; UNSG, 2016). In disasters where few or no international actors are present - be it due to lack of funding, security or other reasons - needs risk being overlooked and thereby not responded to (Bennett et al., 2016; Donini, 2018; Spiegel, 2017; UNOCHA & IASC, 2016; UNSG, 2016).

In addition, timeliness of assistance is important, especially in sudden-onset disasters, as needs often are urgent (IFRC, 2018). The delay of, or even non-existence of, real-time data, particularly in the first phase of sudden-onset disasters risks delaying funding decisions and responses (IFRC, 2018; Stoddard, Poole, Taylor, & Willitts-King, 2017)

There is, therefore, an inconsistency between the accepted needs-based approach and the principle of impartiality that also requires proportional assistance between disasters. Responders and funding agencies are criticised for not sufficiently taking the scale of needs into account (Narang, 2016; Quack, 2018; Vaux, 2005).

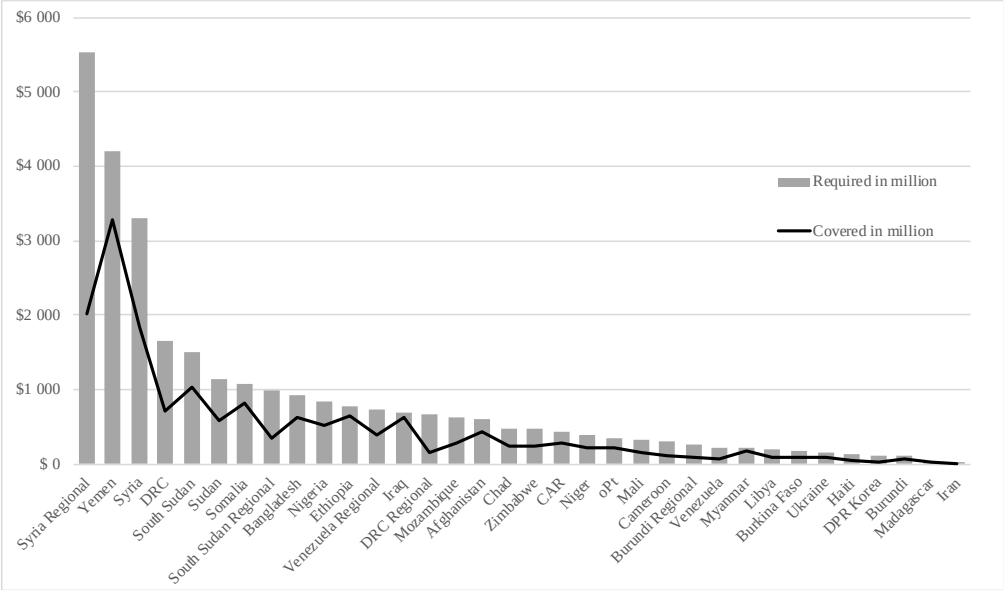
Funding of humanitarian assistance

The UN-system consolidates appeals for funding response plans of UN organisations and other organisations in disasters. The appeals are divided into a humanitarian needs-overview (HNO) and a humanitarian response plan (HRP) (UNOCHA, 2019a). In addition, consolidated flash appeals are assembled for major natural disasters and the UN Central Emergency Fund (CERF) channels funds for smaller emergencies.

In 2018, an estimated 29 billion USD was allocated to international humanitarian assistance. This is an increase of 30 percent over the previous six-year period (Developmen Initiatives, 2012, 2014, 2015 and 2018). 80 percent of the funding was allocated from governmental funding agencies, predominantly through the UN consolidated appeals (Development Initiatives, 2019) and mainly to complex emergencies (UNOCHA, 2019a). Considerably lower amounts were allocated through UN flash appeals for sudden-onset disasters and through CERF (Development Initiatives, 2012, 2018 and 2019).

Both the request for and funding of humanitarian assistance have increased. For the UN consolidated appeals, this has led to constant underfunding. During the last five years, only 60 percent of funding requests were covered, with considerable variations (1) (Development Initiatives, 2018 and 2019).

Figure 1. UN appeals and donor coverage for 2019 as of December 2019.Source: Global humanitarian overview 2020, funding update by 4 December (Humanitarian Insight, 2019)



Funding according to the scale of needs

Governmental funding agencies of humanitarian assistance (donors) have long been criticised for not funding according to needs (Darcy & Hoffman, 2003; Olin & von Schreeb, 2014; Schaar, 2008; J von Schreeb, Unge, Brittain-Long, & Rosling, 2008). In an effort to address this critique, a group of donors convened in 2003 to formulate "The good humanitarian donorship principles" (GHD principles) to ensure more needs-based and transparent funding for humanitarian assistance (Schaar, 2008; The good humanitarian donorship initiative, 2003b). Since then, a majority of governmental donors have signed on to the principles. The GHD emphasise the importance of needs assessments as a tool to ensure needs-based funding. The principles further state that

funding should be proportional and, thus, be allocated in accordance with the scale of needs.

Despite the GHD initiative efforts, criticism of donors remains for not allocating funds according to the scale of need (Donini, 2018; Miliband & Tessema, 2018; IFRC, 2018). Some disasters receive less funding compared to some other disasters of seemingly higher strategic interest, regardless of size of appeals and unmet needs (Bennett et al., 2016; Clarke et al., 2014; Olin & von Schreeb, 2014; Spiegel, 2017).

On the other hand, there is no recognised mechanism to validate that the amounts requested in UN-appeals reflect the scale of needs in the different disasters, nor to validate that the funding of assistance is provided according to the scale of needs (EBA, Swithern S, 2018; Olin & von Schreeb, 2014). Moreover, studies have documented the absence of a systematic approach in defining and quantifying the scale of needs in disasters (Olin & von Schreeb, 2014; J von Schreeb et al., 2008). Moreover, to add to the problem of needs-based funding, there are no commonly accepted indicators to define and quantify the scale of needs nor any standardised methods to collect and compare such data (Olin & von Schreeb, 2014).

Quantifying the scale of needs?

Needs-based funding require clearly defined and quantifiable indicators that capture the scale of needs. Such indicators could, if populated with numerical data, form the basis for needs-based decisions of funding and thereby contribute to alignment to the principles defined in the GHD initiative.

To be useful for needs-based funding, an indicator should be sensitive to changes over time, easy to measure on a routine basis and to interpret, and have a baseline (Darcy & Hoffman, 2003; Pelling et al., 2004). Several indicators could be combined into a model or index that captures measurements of the different

factors contributing to the scale of needs in disasters (UNDP, 2018). Such a model could be useful to understand the bigger picture and enable comparisons of the scale of needs between disasters (Dervis & Klugman, 2011).

The UN system and several organisations have developed staged emergency and disaster thresholds, with three-tiered scales where emergency level 3 is the most severe. However, there are variations in what this entails between UN agencies (WFP, 2018; WHO, 2008). The Integrated Food Security Phase Classification (IPC) for malnutrition and food insecurity uses thresholds based on the level of food insecurity in emergencies and disasters (IPC, 2008) but of course falls short of quantifying other needs. There are several other indexes that assess vulnerability, risk or crisis severity at a more global level (ECHO), 2014; Inter Agency Standing Committee, European Commission, & Joint Research Centre; The Assessment Capacities Project (ACAPS), 2019; UNOCHA, 2013). However, these indexes often fall short of differentiating the scale of needs in complex emergencies. They fail to provide enough granularity on the scale of needs to guide needs-based funding, as many complex emergencies fall into a worst off category, without any distinction between them. Moreover, the components and indicators in the indexes tend to change frequently, as does the logic that they are based on. This makes them difficult to use systematically (Beccari, 2016). Finally, there are, to my knowledge, no studies that validate the indicators or the index results against the actual scale of needs in disasters.

Rationale

The need for humanitarian assistance is increasing, while international funding is insufficient. At the World Humanitarian Summit in 2016, the world's leader stated that no one should be left behind and that vulnerability should guide assistance (Bennett et al., 2016; Donini, 2018; Spiegel, 2017; UNOCHA & I

IASC, 2016; UNSG, 2016). To ensure that limited funding is allocated in accordance with the scale of needs should therefore be high on the agenda.

The efforts to improve and increase information-sharing in disasters are growing, for instance through joint needs assessments and the establishment of new information sharing- and coordination platforms (Bjerge, Clark, Fisker, & Raju, 2016; ACAPS, 2020). As a result, the amount of information collected and the number of reports produced in disasters increases steadily. Nevertheless, the scale of needs in different disasters remains largely overlooked and severe needs are unmet (Development Initiatives, 2019; Donini, 2018; Miliband & Tessema, 2018; Poole, 2014; Spiegel, 2017; ACAPS, 2020).

Donors have agreed to fund according to needs yet other considerations such as geopolitical interest, media attention, principles of proximity, complexity and donor fatigue in protracted disasters compete with the principle to let the scale of needs guide funding decisions (Donini, 2018; Miliband & Tessema, 2018). To improve needs-based allocations and ensure alignment with the GHD, governmental donors must be able to conduct independent and objective analyses of the scale of needs in disasters. There is a need for practical analytical tools, based on the best possible indicators, that make use of available information to systematically estimate the scale of needs in disasters. To allow this, a better understanding of the factors that influence disaster severity is needed. It is moreover important to understand how they can be measured.
This thesis applies a systematic approach combining theoretical research with an understanding of the practical challenges of defining the needs of populations affected by sand rapidly taking decisions to fund needs-based humanitarian assistance. The thesis focuses on man-made complex emergencies that render most people in need of assistance, but it also attempts to develop tools to rapidly predict needs following earthquakes, which are the deadliest natural disasters that also generate a significant number of people in urgent need of life-saving humanitarian assistance.

Research aims and objectives

The aim of this thesis was to increase the understanding of what factors contribute to disaster severity and how they can be measured in order to estimate the scale of needs in disasters.

The specific objectives were:

For complex emergencies:

1 to define indicators that approximate severity and the scale of needs (Paper I)

2 to develop a severity- and needs-scoring model (Paper I)

3 to test the usefulness of the developed model based on: a) the availability of the indicator data, and b) variations between countries and over time (Paper II)

4 to assess the validity of the developed model (Paper II)

For earthquakes:

5 to define predictors for the scale of needs (Paper III)

The research framework and methods overview

The research framework builds on a disaster framework, adapted from Sundnes and Birnbaum, 2003 and Birnbaum et al., 2015, where the development from hazard to disaster is conceptualised (Marvin L. Birnbaum et al., 2014; M. L. Birnbaum et al., 2015; Sundnes & Birnbaum, 2003). The highlighted areas in Figure 2 illustrate the factors studied in the thesis.

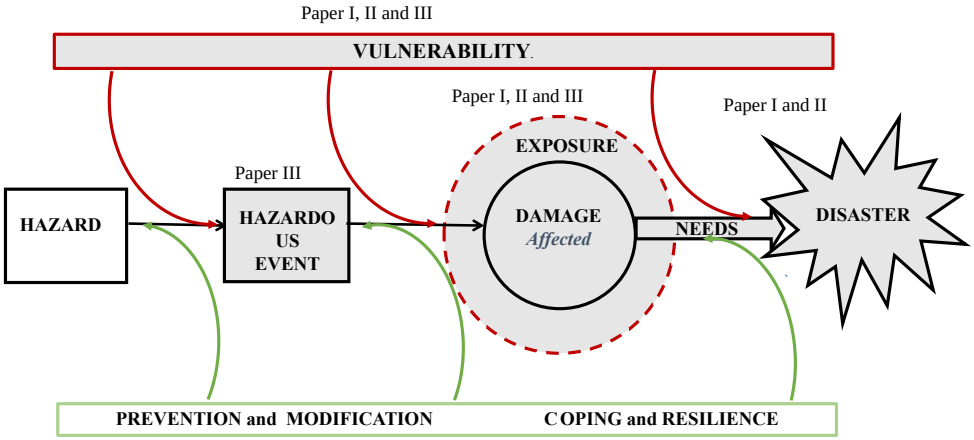


Figure 2. Disaster framework, that conceptualises factors affecting the development from a hazard to a disaster. Adapted from Sundnes and Birnbaum, 2003 and Birnbaum et al., 2015 (Marvin L. Birnbaum et al., 2014; M. L. Birnbaum et al., 2015; Sundnes & Birnbaum, 2003). The highlighted parts illustrate the factors researched in the different papers that this thesis builds on.

Whether a hazard actually occurs as a hazardous event and whether it develops into a disaster or not depend on several interlinked factors. The magnitude of a **hazardous event** will influence the **damages** it causes and the impact it has on a society's functioning (Sundnes & Birnbaum, 2003). The people **exposed** to and, in turn, people who are negatively **affected** by the hazardous event can both be understood as dimensions of damage (Sundnes & Birnbaum, 2003; Banwell, Rutherford, Mackey, Street, & Chu, 2018; Marulanda & Salgado-Gálvez, 2017; Peduzzi, Dao, Herold, & Mouton, 2009; Sena et al., 2018; Strader, Ashley, Pingel, & Krmenec, 2017) .

The hazard can be **prevented** from occurring or the damage of a hazardous event can be reduced through **modification**. This serves as a basis for

initiatives aiming at disaster risk reduction (UNDRR, 2015). Efforts to reduce the damage of and progress to a disaster strive to build **resilient** societies with sufficient **coping** capacity (M. L. Birnbaum, Daily, O'Rourke, & Loretti, 2016; Sundnes & Birnbaum, 2003). Coping involves risk-awareness, sufficient resources and a functioning management, in normal times as well as during disasters. Thus, response capacity and resilience is linked to absorption capacity and recovery from the effects of a hazardous event (UNDRR, 2017).

Vulnerability is related to individual characteristics or geophysical or societal circumstances (Sundnes & Birnbaum, 2003; UNISDR, 2009; UNDRR, 2017). What constitutes vulnerability varies depending on the type of hazard and the damage it may cause. Socio-economic vulnerability is a key factor that determines whether a hazardous event develops into a disaster or not (Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011; Hallisey, 2018; Peduzzi et al., 2009). The risk that hazards lead to disasters are, thus, higher in low-income countries compared to high-income countries (Kahn, 2005).

In reality, the progress from damage to disaster is dynamic and dependent on several interacting factors, where coping and resilience can mitigate while vulnerability will aggravate the situation (M. L. Birnbaum et al., 2015; Gerdin, Chataigner, Tax, Kubai, & von Schreeb, 2014).

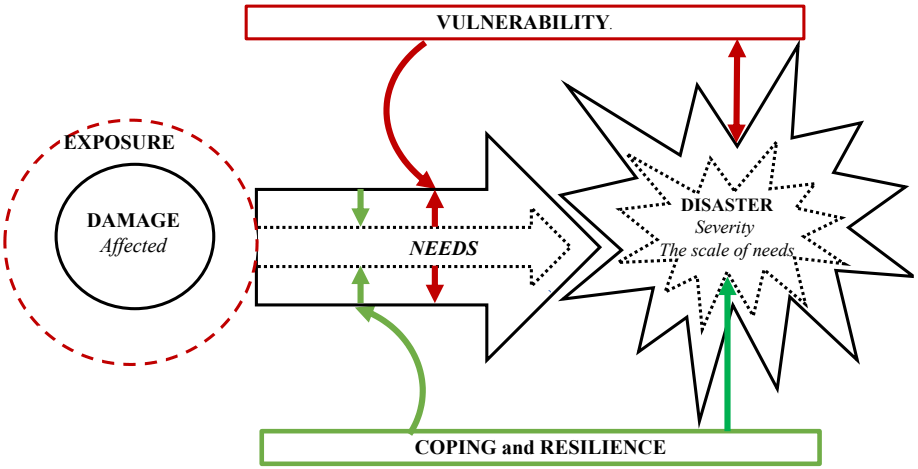


Figure 3. Detail from the disaster framework presented in Figure 2 (Birnbaum et al., 2014; Birnbaum et al., 2015; Sundnes & Birnbaum, 2003).

A disaster is defined by **severity and needs**. Disaster severity is, thus, a manifestation of the damage of a hazardous event in combination with the vulnerability, coping capacity and resilience of the affected society (Sundnes & Birnbaum, 2003). Severity refers to the conditions and status of the affected people and the urgency of life-threatening needs. Severity is also influenced by the complexity of the situation and other factors that affect mitigation (Acaps, 2019). In the thesis, the scale of needs combines severity with the number of people affected or in need of assistance. It is, thus, a quantifiable measurement that allows comparison between disasters in terms of the proportion of needs.

Complex emergencies: I focused on factors that negatively influence the severity and the scale of needs in disasters, i.e. vulnerability and exposure. In exposure, I concentrated on damage (affected). I used severity and the scale of needs as disaster outcomes.

Earthquakes: I set out to identify predictors for the scale of needs after earthquakes. I assumed a situation where the prediction of the scale of needs would be based on the magnitude of the hazardous event, vulnerability and exposure. In this paper, I used the broader term of exposure: the people living in the area exposed to the earthquake. Further, I assumed that the damage could indicate the scale of needs. I used the number and proportion of people who died in the earthquake or who were directly affected by the earthquake as indicators of damage.

Outcome indicators

Excess mortality rate is an established public health indicator that describes the increased death rate in a population due to the exposure to a hazardous event. Excess mortality rates equivalent to the doubling of baseline crude mortality has since the 1990s been a recognised threshold for disaster (CRED, 2018a; Chan & Burkle, 2013; Checchi et al., 2007; Checchi & Roberts, 2008; Checchi et al., 2017; Salama et al., 2004). This indicates a worsening situation with unmet needs for life-saving assistance (Checchi et al., 2007; PAHO, 2002; Salama et al., 2004; Spiegel, 2005; The Geneva Declaration Secretariat, 2008). I used excess mortality as an outcome indicator in complex emergencies. For earthquakes, I used available information on the number of people who died in the earthquakes, as well as the number and proportion of people affected.

Study designs, analyses and statistical methods

Complex emergencies: A literature and Internet search of indicators rendered more than 100 indicators that characterize vulnerability and exposure in complex emergencies. In the two-step search, the indicators were compiled according to a) relevance and relation to best practices or evidence, b) timeliness and c) availability. Each indicator was then ranked per criterion using a scale of 1–3. The ranked indicators received a score ranging from 3–9, with a

higher number representing higher relevance, timeliness and availability. A core set of six indicators was selected based on the same criteria.

A model that builds on the selected factors in the research framework was developed and populated with the selected indicators. A three-tiered scoring system was set for the value of each individual indicator to allow comparison and to distinguish severity between complex emergencies (Low-Moderate, High, and Critical). The scoring of the vulnerability indicators builds on values from approximately 50 countries with low development index, <0.5 (UNDP), while exposure values use data from the 15 UN Consolidated appeals for 2012. The model was then applied on 25 countries affected by complex emergencies between 2013 and 2015. Based on the results, heat maps were developed and tested for indicator availability, variations over time, and variations between countries.

In a second step, severity and the scale of needs was calculated building on the research framework logic (Figure 2). Each indicator was given a numeric value based on its score (Low-Moderate, High, and Critical). I tested the validity of the model by applying it to a number of complex emergencies with a "known" outcome.

Earthquakes: I assessed the predictive performance of the vulnerability and outcome indicators of commonly used disaster risk and severity indexes, first individually and then in different combinations using linear regression. The number of people who reportedly died or were affected was used as an outcome variable for the scale of needs.

The disaster indexes used were the following:

- the Global Humanitarian Needs Assessment (GNA) produced between 2004 and 2015 (ECHO, 2014).
- the Index for Risk Management (INFORM), which replaced the GNA (Inter Agency Standing Committee et al 2016).
- the UN's Global Disaster Alert and Coordination System (GDAC) earthquake alerts (United Nations and European Commission).

In addition, the model developed complex emergencies was assessed.

The indicators from the selected indexes were tested on 53 countries that experienced 226 earthquakes between 2007 and 2016. The results were then compared to the outcome.

The predictive performance of the indicators was estimated for each indicator individually and in different combinations. The root mean square error (RMSE) was used as the measure of predictive performance. Linear regression models were built first for individual indicators and in a second step for different combinations of indicators.

Results

Indicators that approximate severity and needs

A total of 19 single indicators were identified as valid in capturing vulnerability or exposure in complex emergencies. A total of 17 out of 19 indicators were found in the available vulnerability and development indexes. I found 14 indicators and one index (HDI) that were used for at least 9 countries in the 2010 and 2012 UN Consolidated Appeals.

Table 2. Single indicators identified to approximate mortality, vulnerability and exposure in disasters. Adapted from paper I.

Economic	**Gross National Income (GNI) per capita at PPP**	**7**
Education	**Literacy rate (>14yrs) F/M**	**6**
Environmental	Arable land	5
Political	Voice and accountability	3
	Rural population growth rate	5
Population	Urban population growth rate	5
	Population density	5
	Uprooted people (Internally Displaced – IDP + refugees)	**8**
	Life expectancy at birth	5
	Improved water source, Access to improved Water	6
	Access to improved sanitation	6
	Child mortality rate, U-5	**7**
	Crude mortality per 10 000/day	5
Public Health	Excess mortality	5
	Vaccination coverage (measles)	7
	Maternal mortality per 100 000	5
	Prevalence of HIV/AIDS, TB, malaria	6
	Malnutrition weight for age	**7**
	Calorie intake per capita	5
Added from CAPs search, indicators used $\leq$ 9 CAPS	**Number of affected people**	**7**
	Health work force per 10 000	6
	Global Acute Malnutrition, Severe Acute Malnutrition	6, 5

The indicators in bold were selected for the model (Table 2). They were selected based on the ranking and with the intention of including proximations from the public health area and other areas of vulnerability that were suggested to be relevant in the preceding review.

The developed model

Of the top ranked indicators, six were selected for the severity- and needs-scoring model:

To define and quantify vulnerability:

- GNI per capita, PPP
- Under-five mortality rate, per 1 000 live births
- Adult literacy rate, % of people aged 15 and older
- Underweight, % of population under 5 years

To define and quantify exposure, the following two indicators were selected:

- Affected in total number and as a proportion of the total population
- Uprooted people in number and as a proportion of the total population

To obtain the severity scores, I summed up the ranking of the vulnerability indicators and multiplied them with the sum of the indicators for exposure (Equation 1). In the 7-eed model, the severity score can vary from 4 to 36. The needs score is elaborated through a multiplication of the severity score and the amount of people in need of humanitarian assistance (Equation 2).

Equation 1

$$Severity = Vulnerability \times \text{Exposure}$$

Equation 2

$$The\ scale\ of\ needs\ = Severity\ x\ Million\ people\ in\ need$$

The usefulness of the 7-eed model

To illustrate how the developed model estimates severity and needs, I named it: **the 7-eed model** (seve(rity)need).

Indicator availability and variation

The vulnerability indicator data was to a large extent available and the availability also increased over time. In 2015, only one country (Somalia) had missing data for one single indicator. A drawback was that the values for two of the indicators (adult literacy and underweight) were not updated yearly. Undernutrition is no longer one of the WHO core health indicators. It is therefore not collected broadly (WHO, 2018). The indicator was replaced with the "prevalence of stunting".

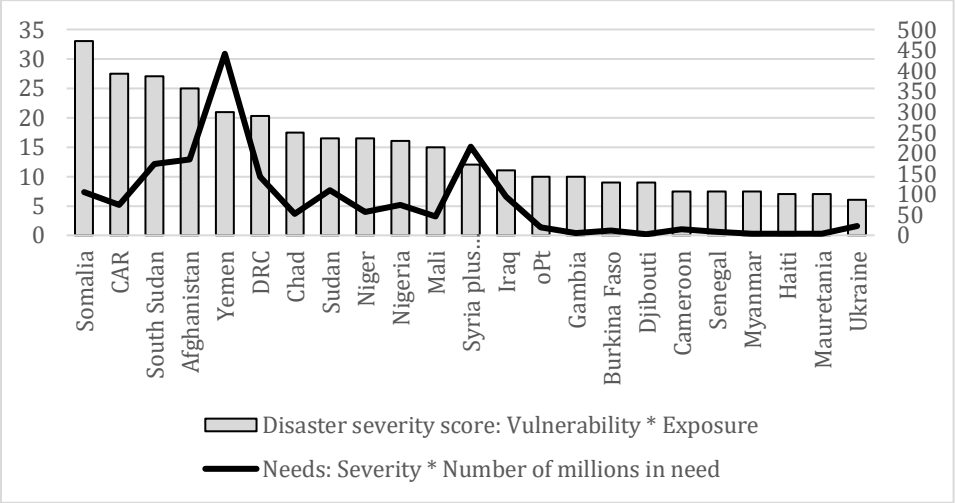
Information on the number of people affected was not consistently presented; it was presented as per the intervention sector, such as health or food security, and in other cases as an overall number. The number of people in need was available for all assessed countries in the 2015 UN appeals. It was therefore included in the 7-eed model instead of the number and proportion of affected people.

Variations between countries and over time

The vulnerability, exposure and severity score varied significantly between countries. The needs score showed an even larger variation, as the number of people in need varied between 300 000 and 21 million people (Figure 4).

The severity score for the countries assessed in 2015 is presented as bars, while the needs score is presented as a curve (Figure 4). For a country with a high severity score, the needs score can still be low. A high severity score in a context with few people in need will yield a lower needs score and vice versa; see, for instance, CAR. The 7-eed model takes both the severity and the scale of needs into account.

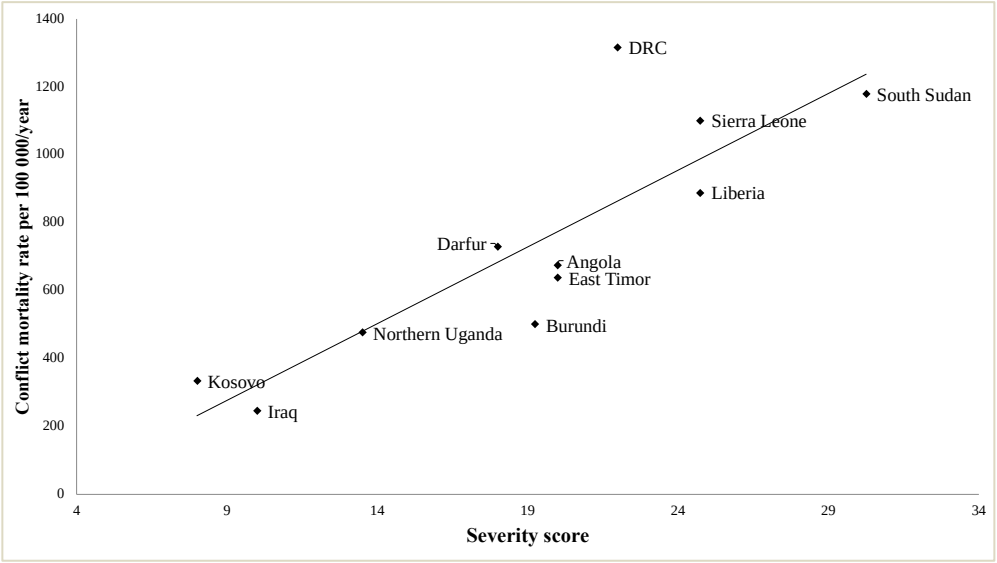
Figure 4. Severity and needs score for assessed countries in 2015, based on data from paper II.



Is the 7-eed model valid?

When the 7-eed model was applied to the eleven previous complex emergencies, the severity score follows the estimated excess mortality in ten of the eleven countries. The exception is DRC, where the estimated excess mortality suggests a more severe situation than what we found when we applied the severity scoring model to the same context (Figure 5). Conflict mortality rate refers to the deaths directly attributed to a conflict (killing, warfare) and the indirect deaths attributed to the conflict, when compared to the expected crude mortality baseline in the specific setting. Conflict mortality is, thus, equal to excess mortality.

Figure 5. Calculated severity score plotted against average excess mortality, Source: Paper II, modified to include the names of the countries in the chart.



Predictors for the scale of needs after earthquakes

No obvious correlation between the standardised index scores and the number of deaths, the number of affected, the proportion of deaths and the proportion of affected among exposed individuals were visually observed in the initial analysis. I could, in addition, not identify a correlation between any of the individual indicators tested through cross-validated RMSE across predictors for each outcome. In the last step of the study, the created multivariable models did not result in any substantially improved performance. I was not able to identify any predictors for the scale of disaster needs after earthquakes.

Table 3 shows models for the number of deaths and the number of affected, using the 7-eed vulnerability indicators. In addition, the magnitude and depth of the earthquake was added, as well as the number of people exposed.

The RMSE (95% CI) of the prespecified 7-eed for the number of deaths was 712 (392–1091). The RMSE (95% CI) of the prespecified 7-eed model for the number affected was 595 932 (252 828–840 877). This makes the models incapable of predicting the number of deaths as well as the number of affected with any precision and, in turn, of even broadly predicting the scale of needs.

Table 3. The models with the 7-eed indicators in addition to magniture and depth

	Prespecified 7-eed model of number of deaths			Pre-specified 7-eed model of number of affected		
Predictor	*Coefficient*	*95% CI*	*95% CI*	*coefficient*	*95% CI*	*95% CI*
(Intercept)	-3 572	-5 968	-1 175	-1 217 964	-3 010 729	574 801
GNI	0.01	-0.01	0.03	-9	-24	5
Under-five mortality	14	-0.02	29	51 36	-5 698	15 970
Adult literacy rate	9	-11	29	4 642	-10 306	19 590
Stunting	-16	-34	2	-9 839	-23 096	3 418
Magnitude-earthquake	436	236	635	174 322	24 996	3 23 648
Depth	-7	-16	1	-2 072	-8 335	4 191
Exposed-earthquake	0.000	0.000	0.000	0.03	0.000	0.07

Discussion

In the thesis summarized in this brief, I identified and used indicators that are recognised to approximate the vulnerability of countries and people. I further identified additional indicators, recognised to estimate the exposure to hazardous events and the human damage resulting from hazardous events, as well as indicators that point to the magnitude of earthquakes. These indicators are established as factors that contribute to the severity of, and the scale of needs in, disasters, according to recognised theoretical frameworks for disaster

research (Birnbaum et al., 2014; Sundnes & Birnbaum, 2003). The factors are also recognized as central in the field of disaster risk reduction and are included in numerous disaster risk indexes (Beccari, 2016; UNDRR, 2015).

In the development of the 7-eed model, I strived to put theory into practice by associating existing theories with numbers and measurements. The model could be a tool to make sense of, and allow comparison of data between, disasters, which is greatly needed but has been overlooked (Donini, 2018; Spiegel, 2017; ACAPS, 2020). The model enables a systematic and transparent comparison of the scale of needs in countries affected by complex emergencies. The plotting of severity scores against excess mortality showed an almost perfect correlation for the 11 assessed complex emergencies (Figure 5). This points to the internal validity of the 7-eed model in estimating severity in these specific complex emergencies.

However, I was not able to identify predictors that capture the scale of needs after earthquakes. In addition, I applied the same assessment to another type of hazard by assessing the outcome in over 200 floods (unpublished data). None of the results gave any indication that prediction of the scale of needs in floods could be made with the help of the assessed indicators. My hypothesis that approximations of vulnerability, the magnitude of a hazardous event and the size of the population exposed can give an early prediction of the scale of needs after earthquakes (and floods) was rejected since no correlation could be established. As the assessed indicators are used in many risk indexes, this is an important caveat (Bakkensen, Fox-Lent, Read, & Linkov, 2017; Beccari, 2016). To better understand these results, further research and analysis is needed. It should also be noted that additional indicators found in the field of geophysical science and engineering were deemed beyond the scope of this paper and, thus, not explored.

An overall challenge was to systematically apply robust scientific methods on secondary data that often have missing values or are fragmented, in addition to the uncertainty of their reliability with regards to timeliness of data capture. Disaster data is often patchy and incomplete (Guha-Sapir & Checchi, 2018). To ensure that my work could be of practical use, the starting point for the thesis was to make use of readily available and accessible data, published by credible sources. There may be other indicators than those selected here that better capture severity and needs. However, since they, are not broadly available, they are likely to be of limited practical use.

Quantitative measurements should of course be interpreted in the specific disaster context. Additional qualitative information, such as violations of human rights and other factors that our model does not capture as well as important regional or local characteristics, must hence be part of the narrative analysis,. In addition, other relevant aspects that are beyond the scope of this study include the role of resilience, coping, prevention and modification as factors influencing disaster severity and the scale of needs.

The choice of indicators and their sources: reflections on reliability and validity

The use of databases that present aggregated country data on a regular basis was a deliberate choice as they are easily accessible and regularly updated. However, to use vulnerability indicators on the country level, rather than the local level, has limitations since variations in vulnerability between different groups or regions within a country are not necessarily identified. A high vulnerability in one area of a country can be hidden by a low vulnerability in another area.

Time is another aspect that influences the reliability of the vulnerability indicators. Typically, some time passes between data collection and publication in the databases. Data from countries in a disaster situation, such as a

protracted complex emergency, may be even more outdated. Moreover, how to interpret the absence of data remains an unsolved problem. Conversely, precise point estimate data from a country with a complex emergency may bring into question data reliability (Hilbert, 2016).

For complex emergencies, I selected indicators that approximate the human damage, the number and proportion of affected people and uprooted people. While the absolute numbers reflect the extent of damage, the proportion of the total population provides an indication on the remaining capacity to cope in a country. In this sense, they are valid indicators for the severity and the scale of needs (Brooks, Neil Adger, & Mick Kelly, 2005; Cutter, 1996; Darcy & Hoffman, 2003; Garfield, 2007).

The number and proportion of uprooted people was selected as displacement is known to increase needs (Heudtlass, Hosten, & Kayouli, 2014; MSF, 1997; Miliband & Tessema, 2018). However, among groups of uprooted individuals, it is generally recognised that internally displaced individuals are among the most exposed to complex emergencies, while refugee populations have been shown to be better off , as the ability to reach a country of refuge may correlate with the availability of resources as well as the access to safety and assistance (Heudtlass et al., 2014). The selected indicator, uprooted, does not consider these variations, nor does it differ between recent or long-term displacement. This may affect the validity of uprooted as an exposure indicator in a disaster.

In addition, exposure data was primarily extracted from UN reports and collected by the UN and partner organisations in the field, which should indicate high reliability. However, access problems, willingness to inflate data due to fundraising concerns as well as varying or unclear methodologies for data collection could affect data reliability (Colombo & Pavignani, 2017). A concern noted during the research process was the change from year to year in the type of data and measurements.

The excess mortality rate can be difficult to monitor in a timely manner and can in addition be a late sign of a deteriorating situation (Checchi & Roberts, 2008). Moreover, measures of excess mortality is difficult to obtain in complex emergencies. The validity of excess mortality as a measurement of severity is however emphasised i numerous studies (Checchi et al., 2007; Checchi & Roberts, 2008; Garfield, 2007; Salama et al., 2004; Sphere Association, 2011).

In sudden-onset disasters, one must interpret the immediate deaths with caution. Hazardous events such as tsunamis that momentarily kill many and leave fewer injured. In these situations, excess mortality does not indicate the scale of needs for assistance of those remaining (PAHO, 2002). In contrast, in earthquakes the number of people who lost their lives could be more appropriate as a measurement of severity, as it leaves significantly more people in need of life-saving assistance (Keim, 2006; PAHO, 2002). Moreover, reported excess mortality and reports on immediate deaths must be interpreted with caution as it is a politically sensitive indicator that can be both under- or over-reported (Guha-Sapir & Checchi, 2018; Stephens et al., 2007; von Schreeb, Rosling, & Garfield, 2007; Wefer & Von Schreeb, 2012). For instance, the number of people who died in the 2010 earthquake in Haiti is believed to be highly overestimated (Daniell, Khazai, & Wenzel, 2013). A more recent example is the Hurricane Maria in the Caribbean, where the mortality is suggested to be higher than reported (Rivera & Rolke, 2018). In addition, the number of deaths only captures the direct and immediate effects. The data in the EM-DAT does not capture the excess mortality that may be present over longer periods of time (Green et al., 2019). The validity in relation to the scale of needs could therefore be questioned. A typology of time to mortality after earthquakes could allow for more accurate, comparable measurements. Moreover, the term ´"affected" is ill-defined and has several meanings, as described in the introduction. The number of people reported to be affected in the same disaster can therefore vary, depending on the definition.

Policy implications

My research is one peace in the puzzle to define needs and the scale of needs. The results do however provide a tool that highlight some discrepancies between present the appeals-funding and the estimated needs. The 2019 UN appeals were briefly presented in the introduction. These suggest that the needs per person substantially vary between contexts. In the Middle East and North Africa, the UN appeals foresee, on average, a need of close to 500 USD per person, compared to just over 200 USD per person in the remaining 28 UN appeals (UNOCHA, 2019a). According to the 7-eed model, most of these remaining UN appeals concern countries that present a substantially higher vulnerability and severity, compared to the Middle East (Figure 4). Thus, according to the logic of the 7-eed model, the amount per person should have been the reverse. The only reasonable explanation for this is that other considerations than the scale of needs are directing the amounts requested in the appeals. If the correlation between the 7-eed severity score and excess mortality were to be valid in current complex emergencies, this raises a serious concern as there are situations where less funding is requested and allocated despite greater needs and likely greater excess mortality.

Ethical implications

One must be aware of the ethical challenge involved in attributing estimates to human suffering and scoring the severity of distress in poor and conflict-affected countries. The literature suggests, and my thesis highlights, that the attention and resources directed to disasters are unevenly distributed. The inflow of various international actors and massive attention in a given context leads to a situation where more needs are identified and addressed, compared to situations with less international involvement and attention.. This, in turn, may create scenarios where the people affected by disasters and in need of life-saving humanitarian assistance fail to receive it in proportion to the scale of their needs.

The deontological principle, the human urge to assist the people that we "have in front of us", overrides the global principle of impartiality. While recognising that my studies constitute but one peace in a complex puzzle, the ethical implications could be a more even distribution of assistance in accordance with the scale of needs.

Future developments

Needs-based funding and assistance remains high on the agendas of donor agencies, the UN and other humanitarian actors (IFRC, 2018; Sveriges Regering, 2017–2020; UNSG, 2016). To my knowledge, there is no common understanding of how the scale of needs should be estimated or how estimates should guide needs-based funding decisions. My studies may provide some insight to address this.

During my research, I was part of a network of UN staff, researchers, representatives from governmental funding agencies and others who have developed a crisis severity index that, based on approximately 30 indicators, rates the severity of different crisis situations in the world. During the development of the index, I have been able to contribute with my research findings. In the network, we have also tried to address how to capture variations within countries and between populations, which I raised earlier in the discussion (Acaps, 2019). This index is a promising tool.

My research, however, builds on the assumption that donors also need to conduct independent analyses and put appeal-information, such as indicator values, into a perspective where they can be objectively compared. In my own research, I aimed for a model that would be practical to use and easy to understand, while building on a recognized theoretical framework and tested variables. While it is important to be cautious regarding errors and false conclusions stemming from the measurable, my thesis builds a foundation that could serve as a base for further analysis. My research raises a number of

methodological, practical and ethical questions: Is it possible to validate a severity index against reality and, if so, what do the results actually tell us? How can the non-measurable aspects be taken into account? Can the model actually help to ensure needs-based funding or are there too many additional factors that need to be considered? From an ethical perspective, one also has to ask if impartiality really can be measured in monetary allocations, or if the living standards and receptivity should be taken into account.

These question require further research and – even more urgently – policy discussions. For a donor agency, the 7-eed model could right now provide a starting point for an independent analysis of the scale of needs and its results serve as a quantitative basis for discussions on how to estimate needs in disasters.

Conclusions

In the introduction, I set out to increase the understanding of what factors contribute to disaster severity and how they can be measured in order to estimate the scale of needs. Based on the findings, I can conclude that:

- There are easy to find, accessible indicators that correlate with severity and the scale of needs in complex emergencies.
- The application of the 7-eed model is sensitive to changes over time and shows variations in severity between complex emergencies.
- Out of the selection of indicators from commonly used disaster indexes, none are able to predict the scale of needs after earthquakes.

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Humanitarian assistance should be needs-based, but is underfunded and unevenly distributed. This DDB develops a model to estimate the scale of needs in disasters.

Humanitärt bistånd ska baseras på behov, men är underfinansierat och ojämnt fördelat. Denna DDB utvecklar en modell som uppskattar behoven vid katastrofer.

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