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The augmented unified localizable crisis scale

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ABSTRACT

Trying to predict whether a crisis or emergency event is going to occur is a challenge, but attempting to do so without a quantifiable scale makes the task a virtual mission impossible. A crisis scale is also needed to perform effective post-crisis analysis. The extant scales, however, are inadequate. To address these issues, we developed the unified localizable crisis scale, but it only partially fulfills the prerequisites for effective emergency response and management. Among the features of the augmented unified localizable crisis scale that exploits the use of a critical emergency surface and a scheme for predicting when and how events can lead to emergency scenarios to improve forecasts about and responses to emergencies. Applicable to the measurement of any type of emergency or crisis, be it a natural or human-made event, the scale also enables users to compare dissimilar crisis events. This is of tremendous social value when, for example, the emergency responses to several regional or national emergencies need to be managed in parallel. In such situations, emergency response management teams can use the scale to evaluate the magnitudes and trajectories of the co-occurring emergencies, which will enable them to prioritize resource allocation and to take commensurate managerial actions. The efficacy and efficiency of the crisis scale is illustrated with several examples spanning local to national events.

1. Introduction

Given a situation such as volcanic ash, bank bankruptcy, prolonged critical infrastructure failure, earthquake, flood, hazardous material spillage, epidemic, landslide, tornado, wildfire, how does one objectively determine if the situation is an emergency, and if so, what is its exact dimension and at what scale? Global? National? Regional? Extant scales are generally inadequate, since providing a quantitative answer without a solid universal model and a quantifiable scale is theoretically and practically impossible. Hence we developed the unified localizable emergency scale describe herein. Applicable to the measurement of any type of emergency or crisis, be it a natural or human-made event, the scale also enables users to compare dissimilar emergency events. This has significant social value when, for example, responses to several regional or national emergencies need to be managed in parallel. In such situations, emergency response managers can use the scale to evaluate the magnitudes and trajectories of co-occurring emergencies, which will enable them to prioritize resources allocation and to take commensurate managerial actions. The efficacy and efficiency of the emergency scale is illustrated with two examples.

The model has several attributes: it defines precisely the size of an event using a three axis presentation for professionals and a linear equidistance presentation for lay users. Having defined a phenomenon numerically, the scale makes it possible to compare similar and dissimilar events. This is useful for apparatus that want to rationally allocate limited resources to simultaneous events. The scale can help indicate when a situation needs to be escalated to a higher level in the emergency management hierarchy, when it becomes clear this is imminent, even before the emergency required such assistance or intervention. Its flip side is also doable — that is — an event seems to grow beyond the ability of the jurisdiction to deal with it, but in fact it will not cross the threshold that rationally justifies external help. This attribute can be valuable when professional management needs to withstand political pressures or gigantic headlines in the media that is ever thirsty for something to publish. The application of the formal model improves rational allocation of resources and reserves before, during and after one or more emergency events. Used wisely during planning and simulations, or during debriefing, the model can provide insight heretofore unavailable.

2. Related work

Existing scales (some of which originated in the 1800s) are all predominantly subjective and qualitative, and as such, none meets the minimum requirements of an objective and quantifiable tool. They include, for example, the 1805 Beaufort Wind Scale (NOAA, 2006); the 1931 Modified Mercalli Intensity Scale — depicts shaking severity (State of California, 2003); the 1935 Richter Scales for earthquakes (USGS, 2006) doesn't measure the emergency; the 1969 Saffir–Simpson Hurricane Scale (NOAA, 2013); the 1971 Fujita Tornado Scale (NOAA, 2005); the 1999 Air-Quality Index (STAPPA and ALAPCO, 2006); and,

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the 2001 US Security Terror Alert Scale (DHS, 2001) later replaced by the National Terrorism Advisory System (DHS, 2011).

A handful of attempts to create a crisis scale involving minimal subjective and qualitative methods have been made in the last three decades. A medical severity index of disasters was proposed by De Boer et al. (1989). The usefulness of this qualitative scale, however, is limited to emergency medicine. It defines as disasters extreme events that involve physical injuries, and its parameters include number of victims, severity of injuries sustained, and the capacity of the medical services. Further, the scale discounts mentally incapacitated people because, based on scale definition, only physical injuries are considered. Therefore, its current version is clearly lacking as a universal disaster measurement tool, contrary to the claim "that [this] classification and scoring system could serve as a tool for evaluating the majority of disasters" (De Boer, 1997). Furthermore, even if it did account for mental injuries, it would still be unsuitable to situations such as a financial market meltdown, for instance. The limited applicability of the medical scale is also evident when considering, for example, a crisis in which hundreds of airplanes have to land immediately at the airports closest to them, as was the case on September 11, 2001. Thus the medical scale is only suitable for crisis events in which people are heavily affected but not directly injured.

Various perspectives on the definition of a disaster are offered by contributors from six disciplines in Quarantelli's (1998) book. No contributor offers a quantitative universal scale by which a disaster can be quantified objectively and accounts for the milieu where events occur. The sociologist Fischer suggested a disaster scale whose building blocks are scale (severity of the event), scope (how widespread), the duration, and the time it takes society to recover. The Fischer scale is an ordinal semantic list that provides ten descriptive categories of disasters. What makes this scale unique, compared to others mentioned here, is the recognition that the size of the milieu is important in determining the severity of the event. The severity of the event is dependent on the size of the city or region where the event occurs. However, the Fischer scale does not account for more sophisticated aspects of an event and the milieu, such as social resilience and economic strength.

Gad-el-Hak asks "what is a large-scale disaster" in the introduction to a book he edited and replies: "there is no absolute answer" (Gad-el-Hak, 2008). While indeed there may be no absolute answer to the question of what defines a disaster, we believe that our augmented unified localizable crisis scale proposed here provides a method to quantifiably address the question posed by Gad-el-Hak. Although he devised a disaster scale (Table 1), it is essentially qualitative, and it neglects the environment in which an event occurs. For example, a level 5 hurricane spread over an area greater than 1000 km^2 in the middle of nowhere would be a "Gargantuan disaster" according to the Gad-el-Hak scale. The rest of the book discusses some of the various aspects pertaining to natural disasters.

FEMA lists events rather than defining what constitutes an emergency (FEMA 2011), as follows (Table 2):

Conspicuously absent from that list, however, are other types of disasters, each of which wreaks its own type of damage, such as national cyber attack, massive theft, and financial markets meltdown. Generally, such lists are by their nature incomplete.

Consequently, emergency agencies are likely to give up on finding in the literature a crisis scale that is useful, and will seek answers elsewhere. Perhaps there is a useful solution in the free market. Unfortunately, there is no commercial product or company that offers a model to quantify the crisis situation using a unified scale. There are numerous companies that offer risk assessment models and accompanying software and services (Table 3).

Many government agencies are preoccupied with risk assessments, but they too do not have proprietary models and software for national level emergencies of all kinds. Even state of the art emergency management systems, listed by Dorasamy et al. (2013), do not offer a unified computable emergency scale.

The need for a unified crisis scale is vital not only for optimizing resource allocation tasks (Gomez et al., 2007; van de Walle et al., 2010; Canós et al., 2013). It is an essential tool for facilitating clear communication and mutual understanding of the nature of emergencies among the public (Lu and Yang, 2011), government agencies, and responding organizations. It has been stated that "50% of the problems with communication are due to individuals using the same words with different meanings. The remaining 50% are due to individuals using different words with the same meanings" (Kaplan, 1997). The above studies also describe how legislation still has not provided definitions of "disaster" or "emergency", nor of the difference in impact and immediacy of response.

For instance, local Emergency Operations Centers (EOCs) in the United States exist in all shapes and sizes, and the operational protocols they follow during an emergency are likewise varied. Indeed, an established, standardized procedure for managing EOC operations is lacking. In addition, individual EOCs often comprise diversely skilled people working on complex tasks, frequently across functional, group, or organizational boundaries and within limited timeframes. The absence of standard EOC operating procedures, in turn, breeds an environment of incoherence, especially when various EOCs need to exchange information about the magnitude of crisis events in their jurisdictions.

An objectively calculable crisis scale should therefore quantify and clearly communicate the notion of "emergency", or "size of disturbance". Such a model, if implemented correctly (Andrienko and Andrienko 2007), can address multiple organizational and managerial pain points (Table 4). It should represent the information in a manner suitable to the needs of various clientele, specifically, emergency management information systems users.

Table 1
Disaster scale (Gad-el-Hak, 2008 p. 2).

Scope I	Small disaster	<10 persons	or	<1 km^2
Scope II	Medium disaster	10–100 persons	or	1–10 · 1 km^2
Scope III	Large disaster	100–1000 persons	or	10–100 · 1 km^2
Scope IV	Enormous disaster	1000–10^4 persons	or	100–1000 · 1 km^2
Scope V	Gargantuan disaster	$>10^4$ persons	or	>1000 km^2

Table 2
FEMA's list of events.

Chemical emergencies	Heat	Tornado
Dam failure	Hurricane	Tsunami
Earthquake	Landslide	Volcano
Fire or wildfire	Nuclear plant emergency	Wildfire
Flood	Terrorism	Winter storm
Hazardous material	Thunderstorm	

Table 3
Risk analysis service providers (partial list).

Complementing company	Revenue and market cap
Insurance Services Office, Inc. Provider of information relating to property and casualty insurance risk	Market Cap > $2 billion 2013 Estimated revenue $844.1 M
AIR Worldwide Corporation Provider of risk modeling software and consulting services	2013 Revenue estimated $38 M
Aon Corporation Provider of risk management services, insurance and reinsurance brokerage, human capital &management consulting	2013 Market cap $25.07 billion 2013 Revenue $11.69 billion
MacDonald, Dettwiler and Associates Ltd. Providers of technologies that can leverage the emergency scale	2013 Market cap: $2.93 billion 2013 Revenue $1.71 billion
The Verisk Analytics Family of Companies Provides data, analytics, and decision-support services for professionals in property/casualty insurance, finance, risk management, real estate, healthcare, government, and human resources fields.	2013 Market cap $11.18 billion 2013 Revenue $1.68 billion