Simplifying disasters: developing a model for complex non-linear events

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Presented at the Disaster Management:
Crisis and opportunity: Hazard Management
and Disaster Preparedness in Australasia and
the Pacific Region Conference,
November 1–4, 1998, Cairns, Queensland.

Introduction

All disasters are complex events. If this complexity can be reduced, a disaster becomes less severe and thus less traumatic, disruptive and damaging. A first step toward reducing complexity is to better understand how the different facets of a disaster relate.

This understanding can be developed through the use of a model of the process of a disaster event. The focus here is not on models to predict specific types of events. It is on a generic, process-oriented model which applies to the unfolding of all types of disasters, and which may be used in monitoring and guiding disaster management efforts.

Why a model?

There are a number of reasons why a disaster process model can be useful. First, a model can simplify complex events by helping to distinguish between critical elements and noise. This is particularly useful in a high-pressure disaster response environment, when little time is available to think about events or to identify critical issues. Second, contrasting actual conditions with a theoretical model can lead to a better understanding of the current situation, and how a disaster may evolve. This facilitates planning and helps make plans more complete.

Third, having available a model of the disaster process is an essential element in quantifying disaster events, itself key to reducing the complexity of disasters. Without models, efforts at quantificaiton have no base from which to organise the data collected.

Fourth, a written disaster process model helps establish a common base of understanding for all involved. Whether consciously or not, everyone uses some kind of model as a guide for decisions and actions. These models are developed from, and colored by, experience, formal learning and prejudices. Some of the complexity and confusion of a disaster can be attributed to the different cultures, languages and avocations, and thus the different mental models, of those involved in a disaster event.

A written model serves as a common ground and makes possible better integration of indigenous relief and recovery efforts with outside assistance. An accurate and clear model helps victims and assistance providers play the same game in the same ballpark.

Finally, and in a similar manner, a disaster process model can be useful to disaster managers in explaining the course and possible future outcomes of a disaster to non-specialists. If the model is clear (a major condition), then its presentation to select or general audiences can facilitate securing support for disaster management efforts.

Disaster process models

An overview

To date, the development of a disaster process model has been based on identifying the stages, events, actions and time frame which make up the course of a disaster (see Neal, Haas *et al.* and Frerks *et al.* for different perspectives on the disaster process). Of the three elements, the time element is easiest to define. It can be quantified down to seconds, but more often it is measured in hours, days and then years (e.g. a log scale).

Disaster stages identify periods in the unfolding of a disaster. Each stage serves to classify the nature of impacts that occur or actions which take place to address impacts of a disaster. Events are interlinked, as are actions, and events and actions. These linkages can be tight or loose. They are often the most difficult part of a disaster to identify, define, and understand.

Finally, the idea of defining stages in a disaster suggests some intrinsic order over time. The reality is that the disorder within and between the events and actions defines the existence of disastrous conditions (see Kiel). To be useful to disaster managers, a disaster process model must go beyond a simple definition of disaster stages and shed light on (and provide a conceptual organisation for) the basic events and actions which constitute a disaster.

The simplest disaster model is probably the sequence *Pre-event, Disaster, Post Event.*

More detailed variants of the linear model are provided below. The first is the standard process model of a disaster composed of stages involving *Preparedness, Response, Recovery, Mitigation* (Neal, 1997).

Currently, this model is presented as a continuum from disaster to development, '…a linear progression from a state of crisis through rehabilitation to development' (Macrea, 1997).

The second variant of the linear disaster process model comes from Harrald and Stoddart (1998) and ' … characterises the phases of a disaster by the evolution of internal functions and tasks of the organisational structure': *Initiation/Mobilisation (storming, forming), Integration (norming), Production (performing), Demobilisation (transition).*

Although using different terminology, both models cover the same pre-event, event, post-event sequence noted above.

This linear sequencing of disaster stages has been subject to criticism. Neal (1997) highlights three points, among others. First, different stages occur at the same time for different segments of a population. Second, some events are relevant to more than one stage. Third, stage '… divisions are arbitrary, and are only useful in distinguishing the major functional activities of a period' (Haas et al, 1977). Other criticism has been that a view of the disaster process, moving from pre-disaster to disaster and out-of-disaster conditions, incorrectly supposes a separation between disasters and non-disaster (i.e. development) periods (see DHA, 1995).

To address the complex relation between disasters and development a circular model was proposed (see *Figure 1*).

The realisation that disaster phases and development were often linked and could exist at the same time led to the proposition that disasters and development exist on a 'Mobius strip' (see *Figure 2*, Anderson, 1985). The Mobius strip was proposed by Cuny and Beaumont before the 1993 model in *Figure 1*. Here it is presented as the stage after the simple circular model, which was also put forward in an earlier form by Cuny and others in 1985 (see Anderson, 1985 and Cuny, 1985).

Although the Mobius model clearly presents the link and concurrent nature of disaster and development, the model's circular form a basic question: Is disaster history doomed to continually repeat itself, running like a dizzy rat around the tread wheel of a Mobius strip?

A more optimistic approach is to see disaster and development as linked in an upward spiral or, pessimistically, in a downward spiral (Kelly, 1998). While a spiral has the advantage of being able to show positive or negative change, it lacks the ability to portray the concurrent nature of disaster and development, so physically demonstrated in the Mobius model.

Although the models presented above all attempt to set out an organisational struc-0ture for the disaster process, they are broad statements. These models may help in understanding the general nature of the disaster process, but provide little insight into actual unfolding of a disaster. What is needed is a disaster process model which starts with the basic events and actions of a disaster and serves as a functional tool in guiding the disaster management effort. A model specifically for this purpose is presented in the following section.

Reconsidering the form of a disaster process model

In reconsidering the form for a disaster process model several points need to be taken into account. First, rapid change is probably the single greatest contributing factor in events becoming disasters. Rapid change also adds to the demands on the disaster manager. Simplifying how change is present is critical to simplifying the disaster process model.

Second, underlying the issue of change is the nonlinear nature—the chaos—of a disaster (Keil, 1996). This chaos ' ... looks like random behavior but is really unstable behavior over time that stays within clear boundaries'. Importantly, chaos is probably a ' . . . necessary and desirable condition which accommodates adaptations, cross-communications... and other such emergent behavior essential to an efficient response' (Priesmeyer and Cole, 1996).

Finally, as Haas et al. suggest, dividing disasters into stages is only useful in a general sense (see quote above). It is the actual events of a disaster which are important and need to be the focus of disaster management efforts: it does not matter what disaster stage you are in if you don't have a handle on what is happening.

One approach to disaster process modeling which takes these points into account is to use a two-dimensional Cartesian plane. On this 'phase plane,' the 'x' and 'y'
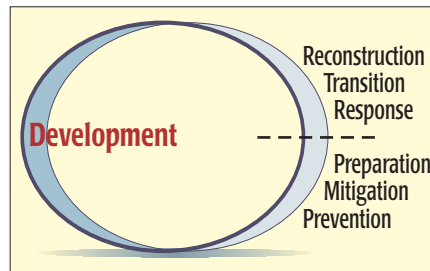

Figure 1: Circular model of disaster

Figure 2: Cuny-Beaumont Mobius strip model

lines represent two factors and each of the four quadrants a relationship between the two factors (see *Figure 3*, Priesmeyer and Cole, 1996).

The center of the phase plane represents no change. Changes in the x and y factors can be plotted over time and used to monitor the status and progress of a disaster response. (Priesmeyer and Cole discuss phase planes and their use as disaster management tools in detail.)

The phase plane concept has three advantages for disaster process modeling. First, each phase plane incorporates three factors, 'x', 'y' and time of the phase, and four areas of interaction (quadrants). Other models generally cover only one area/quadrant and normally only two components, 'y' and time (usually the 'x' axis.)

Second, phase planes can be sandwiched. Theoretically, an unlimited number of planes, representing all basic events of a disaster, can be centered along a single axis, representing no change in status (the juncture of the x and y).

Third, phase planes are only representations of reality. Thus, the position (x-y coordinate) of two factors in a phase plane

can be related to the status of other factor relationships in other phase planes without being influenced by intervening planes.

This is accomplished by making the x-y coordinates of two phase planes the x or y factor of a new phase plane. Although only two factors can be compared in each phase plane, increasingly more complex situations can be created by progressively forming phase planes for increasingly complex pairs of factors (i.e. the product of relating the results of two phase planes).

To create a generic model for disaster response, a disaster process phase plane can be organised with Response/Input along the y axis and Event/Impact along the x axis (see *Figure 4*).

The upper right quadrant represents conditions when both inputs and impacts are increasing. The lower right quadrant represents conditions when inputs are falling behind impacts. The upper left quadrant indicates conditions when inputs exceed the needs for dealing with an event, and the lower left quadrant shows conditions when both inputs and impacts are diminishing.

The normal course of a disaster moves from the lower right quadrant to the upper right, then to the upper left and finally to the lower left. An efficient response should spend little time in the lower right and upper left, and move as quickly as possible from the upper right to the lower left quadrants. A preemptive response (or mitigation activity) would be indicated by an increase in input in the upper right quadrant with little rightward movement

Figure 3: Resource needs presented on a phase plane

Figure 4: Disaster process phase plane model

along the impact axis, followed by a shift into the lower left quadrant as the threat of a event diminished. Movement to the left on the plane indicates a reduction in the level of activity related to the specific impact/input combination covered by the phase plane.

Going a step further, phase plane activities (i.e. the type of input in response to a specific type of event) can be organised according to the general stages used to describe a disaster process (see previous sub-section). The locations of the input/impact relationship on the phase planes in these groupings (left or right of the y axis) indicates whether an associated stage of a disaster is of increasing (moving right on the plane) or deceasing (moving to the left of the plane) importance. This in turn helps the disaster manager identity and define what progress is being made in dealing with the disaster.

Phase plans can be reorganised as needed to present the range of activities which are taking place at any time period in a disaster. In this way, the phase plane groupings enable a flexible definition of the stages of a disaster (Haas *et al.* 1977)

It is important to highlight that the centre point represents a static, but not necessarily a positive, situation. Just because there is no change does not mean there is no problem, only that it has not gotten worse (or better). Since disasters are characterised by constant change, this type of static situation is probably rare and only applicable to a limited number of phase planes (i.e. input/impact relationships) at any one time.

Turning the phase plane-based disaster process model into a practical tool for disaster managers is both simple and complex. The simplicity comes from the ease with which the plane-and-quadrant format presents the core challenge in dealing with a disaster: the provision of sufficient inputs to reduce impact.

The phase plane model does this without regard for questions of response stage, the nature of specific inputs or perceived severity of an event. This simplicity and versatility in handling many different aspects of a disaster has advantages in both developing consensus among professionals on the management of a disaster and in explaining the evolution of a disaster to non-professionals.

The complexity develops in trying to build the phase plane model into a stand-alone system useful to disaster managers in developing specific plans and decisions. While the phase plane approach can easily identify changes in disaster conditions, the real complexity exists in three areas:

- identifying all the relevant input/impact associations
- establishing a system for collecting, quantifying and presenting data
- defining the complex interactions of phase plane factors which exist in a disaster.

The current capacities of relational data base programs, as well as the possibility of managing phase planes through a geographic information system approach, suggest that the development of an operational disaster process model is less of a technical than a sweat-of-the-brow problem. The fundamental organisation of the model is simple. The challenge is to detail out the complexity of a disaster so it can be represented in the simple x/y parameters of the model.

Conclusion

Reducing the complexity of disasters is key to reducing their negative impacts on society. This paper provides a generic model for the disaster process which can help reduce the complexity of disaster and also handle the non-linear nature of disaster events. The model is more focused on practical disaster management needs than other disaster models. The strength of the model lies in an ability to help the disaster manager or researcher define and understanding the relationship between inputs and impacts starting from the comparison of two factors, rather than beginning with the imprecise disaster stage classification approach.

The immediate benefits of the disaster process model approach come from its simplicity and ability to indicate trends in the disaster response process. Using the model as a formal decision support tool requires developing a comprehensive data base of disaster impacts and input requirements, managed through a computer-based manipulation and analysis system. The challenge in developing this system is in defining and organising the disaster impact and input relationships. Management of the resulting data is feasible with available computer programs.

Moving from the simple phase plane approach of the basic model to a highly automated process may not be totally necessary. The basic model approach need be implemented only for those events/impacts and related resource/input requirements which are identified as being most critical to the success of the disaster management operation.

A minimalist approach to using the model can provide useful information without cumbersome, complex and time consuming procedures. This fits well with the basic intent to develop a model to make it easier to deal with the non-linear complexity at the core of a disaster.

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