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Balancing provision of relief and recovery with capacity building in humanitarian operations

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Abstract Several humanitarian organizations today find themselves thinly stretched in multiple protracted relief and recovery operations around the world. At the same time, the need for humanitarian relief and recovery operations is forecasted to increase dramatically in the next decades. Hence, humanitarian organizations will face increased challenges to provide assistance (e.g., assessing needs, moving the displaced, tending the wounded, restoring water and sewage systems) while trying to build and maintain capacity (e.g., hiring and training people, capturing lessons learned, structuring organizational processes). In this paper we develop a formal simulation model that quantifies the tradeoff that exists between providing assistance and building capacity in humanitarian organizations. We explore in our model the performance of two polar resource allocation strategies: one focusing on relief and recovery efforts and another focusing on capacity building. When humanitarian organizations cannot retain the knowledge gained in the field, a strategy that emphasizes relief and recovery is not enduring and leads to a better-before-worse behavior. However, if humanitarian organizations can retain a large fraction of the lessons learned in the field, they can achieve more enduring performance with a relief and recovery strategy. Nevertheless, high stress levels, caused by relief requirements significantly above those which can be made available by the organization, increase personnel turnover and limit the fraction of learning that the organization can retain, imparing a relief and recovery strategy. Our work sheds light on the tradeoff that humanitarian organizations face between providing relief and building capacity in stressful and demanding environments.

Keywords Humanitarian relief and recovery operations · Capacity building · System dynamics · Causal loop diagrams · Simulation modeling

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1 Introduction

While on average 500 large scale disasters kill about 75,000 people and affect a population of 200 million people every year (van Wassenhove 2006), these numbers pale in comparison to future expectations. Forecasts estimate that over the next 50 years natural and man-made disasters will increase five-fold both in number and impact (Thomas and Kopczak 2005). A characteristic of disasters taking place today is that they disproportionately affect populations in less developed nations (McEntire 1997, p. 226). As a consequence of the rise in the number and impact of natural or man-made disasters, the need for disaster relief and recovery will continue to increase. Nowadays, several humanitarian organizations (HOs) have resources thinly stretched among simultaneous operations in different theaters around the world. The inability of humanitarian organizations to properly scale capacity in the face of ever-increasing needs, however, has led to a generalized scarcity of resources and intense pressure to improve operational efficiency of disaster relief and recovery efforts (Thomas and Kopczak 2005). Hence, humanitarian organizations face a fundamental challenge providing assistance (e.g., assessing needs, moving the displaced, tending the wounded, repairing roads and bridges, restoring water and sewage systems) while trying to build capacity (e.g., hiring and training people, capturing lessons learned, structuring organizational

processes). Providing assistance allows organizations to make good use of existing resources in the short-term. Intensive use of resources, however, prevents organizations from building capacity, since it requires investments in personnel, infrastructure, and procedures that must be taken out of normal day-to-day operations.

Often times humanitarian organizations must provide "regular training or on-the-job instruction when disaster strikes" (McEntire 1999). Balancing the allocation of resources to humanitarian relief and recovery operations while maintaining (and building) proper capacity is a challenging problem faced by humanitarian operations (Chomilier et al. 2003; Fenton 2003; Gustavsson 2003; Kaatrud et al. 2003). Unfortunately, there is little practical guidance or academic prescription to address this problem. Both the literature on disaster management and the more recent literature on humanitarian logisitcs discuss the importance of capacity building in the effective provision of humanitarian relief. The disaster management literature addressing capacity building focuses mainly on the important role played by local people (McEntire 1999). The research in this area highlights that local communities should be made more aware of the risks associated with disasters (Allen 2006); relief workers should have previous experience (Wauty et al. 1977) or receive specific training (Maskrey 1989); and should be more prepared to mitigate the impact of disasters (Allen 2006).

Along those lines, several studies point out that local people often do not know how to respond to an emergency, such as evacuating low lying areas during floods, or identifying local shelters in advance of a hurricane (see for instance Mitchell 1979). Furthermore, local involvement and participation in disaster response efforts is often associated with an increase in that community's resilience. When communities require external assistance, many HOs aim at providing assistance with qualified personnel. For instance, Peace Corps volunteers must "undergo three months of intensive language, culture and humanitarian operations training before they are sent out into the field" (McEntire 1997). The Adventist Relief and Development Agency provides training on rural life, relief operations, and emergency protocols (McEntire 1998). Nevertheless, HOs recognize that they often lack the adequate numbers of qualified people required by their operations (Gustavsson 2003; Thomas and Kopczak 2005). Finally, much of the focus on local capacity building in disaster management refers to preparedness and development. Such emphasis highlights the dichotomy between short-term relief and long-term development (different aproaches and time horizons) with which scholars are concerned. Nevertheless, many researchers point out that disaster relief may unintendedly lead to dependency. Therefore, relief operations should be designed with long-term development goals to reduce its potential negative impacts (Cuny 1983).

The humanitarian organizations literature addressing capacity building focuses on its importance and the need for HOs to think strategically about them (Gustavsson 2003; Thomas and Kopczak 2005; Van Wassenhove 2006). A number of humanitarian practitioners recognize the need for qualified human resources to improve HOs relief operations. For instance, Donald Chaikin, head of logistics at Oxfam GB, suggests that: "[a]gencies need logisticians with management experience… there is only a small pool of management level logisticians" (Chaikin 2003). Lars Gustavsson, Director of Emergency Response and Disaster Mitigation at World Vision International, emphasizes the point: "Logisticians in the field are often not trained professionals but have developed their skills on the job. Competency-based capacity-building initiatives and mechanisms need to be developed and supported so that humanitarian logisticians' skills and know-how are raised to more professional levels…" (Gustavsson 2003). In an attempt to improve human resources management in HOs, humanitarians founded People in Aid. Shortly after, People in Aid developed the *Code of Practice* a primer on human resources management proposing standards for HR policies, practice, training, and monitoring (People in Aid 2003). Birch and Miller (2005) further discuss the need for training of relief workers to allow them to better prepare for emergencies as well as maintain those skills in a rapidly changing environment. In addition to training, researchers point out that HOs must do a better job retaining its people. Thomas (2003) estimates that HOS experience a 80% turnover of field logisticians.

Despite the extant disaster management and humanitarian logistics literature on capacity building, there is scant research addressing how HOs should allocate efforts between providing relief and building capacity. In this paper we develop a formal simulation model that quantifies the tradeoff that exists between providing relief and building capacity in humanitarian organizations. The system dynamics approach, not previously used in this context, permits an integrative perspective capturing aspects that can cut across functional boundaries (e.g., disaster response takes place in the field, but capacity building and retention takes place at headquarters) and span different time horizons (e.g., short-term impact of disaster response and the long-term impact of capacity building).

We explore in our model the performance of two polar resource allocation strategies: one focusing on relief and recovery efforts and another focusing on capacity building. When humanitarian organizations cannot retain the knowledge gained in the field, a strategy that emphasizes relief and recovery is not enduring and leads to a better-before-worse behavior. However, if humanitarian organizations can retain a large fraction of the lessons learned in the field, they can achieve more enduring performance with a relief

and recovery strategy. Nevertheless, high stress levels, caused by relief requirements significantly above those which can be made available by the organization, increase personnel turnover and limit the fraction of learning that the organization can retain, imparing a relief and recovery strategy. Our work sheds light on the tradeoff that humanitarian organizations face between providing relief and building capacity in stressful and demanding environments.

In the next section, we introduce the system dynamics approach and tools. We then develop a formal mathematical model to explore the fundamental challenge of a humanitarian organization that must allocate resources between providing relief and recovery and building capacity. We then describe and analyze the behavior of the model investigating the ability of the organization to retain lessons learned in the field and the limiting impact of stress. We close with a discussion of our findings and its limitations.

2 The system dynamics approach

During emergencies, managers in HOs may allocate all resources to relief and recovery efforts, and may shuffle resources among different programs. Managers may offer specific training to people, when faced with a specific need (e.g., MSF volunteers to recovery efforts in Haiti were sent to French courses prior to deployment). Such resource allocation decisions frequently reflect immediate needs. However, because HOs ability to provide relief and recovery depends also on its capacity, resource allocation decisions focusing on immediate needs may not be well aligned with long-term goals. Managerial decisions must consider not only pressing immediate needs, but also the long-term consequences of such decisions. Effective balance of short-term and long-term needs in complex environments requires methods and tools that allow managers to visualize such systems in terms of the structures and policies that create dynamics and regulate performance (Sterman 1994). The system dynamics approach provides managers with such set of tools and also allows them to evaluate the short and long term outcomes of their decisions. These tools include causal mapping, which enables managers to represent the dynamic complexity in a system of interest, and simulation modeling, which allows them to assess the consequences of interactions among variables, experience the long-term side effects of decisions and systematically explore new strategies (Sterman 2000).

System dynamics modeling starts with a clear and precise problem statement. The problem is represented in terms of the evolution of key variables over time (Forrester 1961; Richardson and Pugh 1981). Such key variables provide clues about important "stocks" (or levels) that describe the state of the system and "flows" (or rates) that change such stocks over time. Feedback processes (and other elements such as delays and nonlinearity) are incorporated to capture the interconnection among different parts determining the dynamics of the system (Sterman 2000). Once the main stock-and-flow structures (or levels and rates of change) and feedback processes characterizing the system are captured, it is possible to translate them into a mathematical simulation model. All variables in the model have a real counterpart and the representation of decision processes capture how managers make decisions in the real system given the actual constraints faced and information cues available. While a model is a simplification of a real system, it should respond in a way similar to what the real one would, given the specific conditions faced. Once the model captures the behaviors observed in the system for the right reasons, it is possible for managers to approach the model to assess the consequences of interactions among variables, experience the long-term side effects of decisions, and systematically explore new strategies.

2.1 Problem statement and major levels

Consider a humanitarian organization that provides aid in different regions, but also responds quickly to emergencies. A new emergency mobilizes the organization's attention and resources. Assessment teams are assembled quickly and deployed to the affected area (Chomilier et al. 2003). People deployed to the emergency gain field experience, which may eventually be institutionalized into better organizational processes. However, high personnel turnover may prevent such lessons-learned to be captured systematically by the organization. Managers often recognize the constant need to recruit new people, provide proper trainning, improve ineffective processes and overall develop long-term capacity while continuing to provide aid to recovery and relief operations.

A major level for the problem described above could capture the overall "organizational capacity" of its human resources. Levels change over time. Organizational capacity increases with investments in capacity (e.g., training, hiring, capturing lessons-learned, etc.) and decreases with capacity erosion (e.g., attrition, firing, etc.). Another major level would capture the amount of effort allocated to relief or capacity building. With limited resources, more effort allocated to relief and recovery limits the amount of effort available to build and maintain capacity. Any feedback processes must capture the interconnection among these two major levels and answer questions such as:

- How can HO's allocate resources to maximize its long-term ability to provide relief and recovery?
- How does HO's focus on allocating effort to relief and recovery impacts long-term organizational capacity?

- How does personnel turnover affect long-term ability of HO's to provide relief and recovery?

A causal loop diagram depicting the feedback processes for an HO allocating resources between providing aid and building capacity can build on the capability trap phenomenon (Repenning and Sterman 2002). The next section develops a formal mathematical model for the capability trap in the humanitarian sector, capturing "a set of dynamics that prevent … capabilities from developing" (Repenning and Sterman 2002).

2.2 Causal loop diagram

An important measure of performance for humanitarian organizations providing aid is the number of *People Receiving Relief/Recovery*. Two factors influence it: the *Effort Allocated to Relief/Recovery* and *Organizational Capacity*. By allocating more effort to relief/recovery—through additional people, trucks, and other resources—the organization can improve performance in the field. However, increased performance can only be sustained while the additional resources are available. In contrast, *Organizational Capacity* provides more enduring effects. The level of *Organizational Capacity* increases with investments in capacity; and decreases with capacity erosion. By developing the logistics capacity of its field people (and retaining them), or building standardized processes, the organization increases the productivity of its relief/recovery efforts allowing it to be more effective assessing needs in the field, understanding potential bottlenecks, and adapting to challenging conditions. According to Lars Gustavsson (2003), director of emergency response and disaster mitigation for World Vision International:

> [NGOs'] systems and approaches are often antiquated… [which] means increasing the time required to handle information and process a shipment… [leading to] reduced efficiencies, duplication of functions, increased inaccuracies in reporting and increased costs.

HOs can compare actual performance (*People Receiving Relief/Recovery*) with a desired performance level (*People Requiring Relief/Recovery*) to assess whether there is a gap between them. Figure 1 provides a causal loop representation of the mechanisms that influence people receiving relief/recovery in the field.

A performance gap leads to managerial action to close it. Managers at headquarters can correct poor performance observed in the field by allocating more resources (e.g., people, supplies, etc.) to relief and recovery efforts. Managers may accomplish this by bringing resources from other recovery operations or deploy people that were supposed to attend different training programs. Earmarked

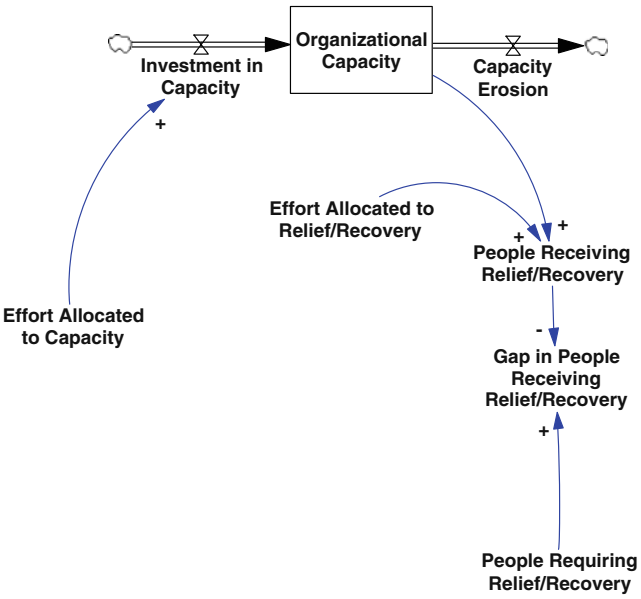


Fig. 1 The basics of humanitarian relief/recovery efforts. Note: The positive (+) signs indicate that the effect is positively related to the cause. More *Effort Allocated to Relief/Recovery* causes an increase in the number of *People Receiving Relief/Recovery*

funds may pose constraints. For instance, funds earmarked to a specific relief operation may prevent HO managers from shifting them to another operation. Frequently, earmarked funds may prevent use toward capacity building, often perceived as administrative overhead. Furthermore, since disasters cause lasting impacts in the affected regions, HOs maintain recovery efforts long after the disaster has occurred just as they devote some resources to capacity building.

Figure 2 details the managerial decision making process at headquarters. A *Gap in People Receiving Relief/Recovery* leads to increased pressure to provide relief/recovery and increased pressure to improve capacity. Once more effort to relief/recovery is made available, it closes a balancing feedback loop—the *Relief/Recovery Focus* loop (B1). Because deploying more people to the field is fairly quick, this loop operates quickly as the gap is identified. Headquarter managers can also allocate more effort to improve capacity, closing another balancing loop—the *Capacity Focus* loop (B2). The action of allocating more effort to capacity building accumulates, increasing the level of organizational capacity. Due to the inherent delays associated with building capacity, however, this loop operates with a longer time delay. Hence, the two balancing loops can operate in a virtuous way closing the performance gap and allowing the humanitarian organization to provide more relief/recovery to people in need. Because the *Relief/Recovery Focus* loop (B1) operates more quickly than the *Capacity Focus* loop (B2), it yields measurable

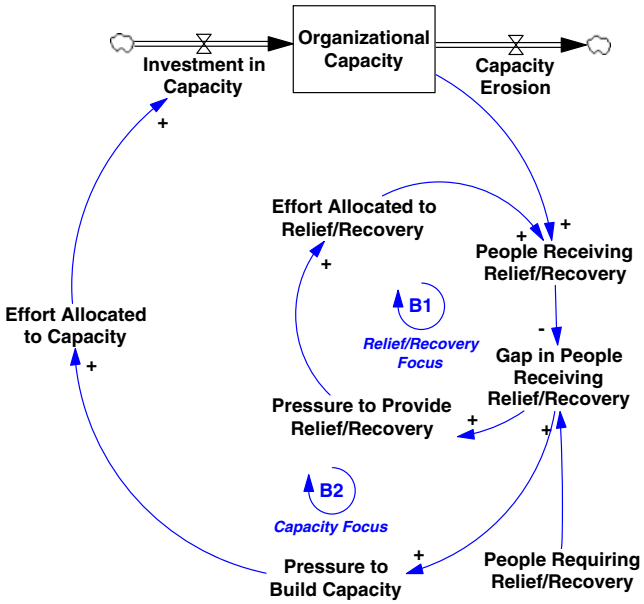


Fig. 2 Managerial action: pressure to build capacity and do more relief/recovery

results faster. Hence, several managers frequently adopt a relief/recovery focused strategy (operating loop *B1*) instead of a capacity focused one (operating loop *B2*).

Because total resources are limited, however, more resources allocated to relief/recovery results in fewer resources available to capacity building. At the individual level, personnel deployed to an emergency forego opportunities for training. At the organizational level, resources allocated toward relief/recovery take away from resources that could have been used to develop new training programs, institutionalize lessons learned or implement new processes. The relationships associated with limited resources establish new links and close additional feedback loops in the causal loop diagram of the system. In particular, the *Relief/Recovery Over Capacity* loop (*B3*) is another balancing loop that balances the effort allocated to capacity (Fig. 3). In contrast, the *Reinvestment* loop (*R1*) is a reinforcing loop that amplifies the initial trajectory of the system.

Not all effort allocated to relief/recovery result in a decrease in organizational capacity. Some of the specific knowledge that relief workers gain in an emergency while providing relief (e.g., logistics operations, cultural needs, infrastructure constraints) can be retained by HOs increasing organizational capacity and allowing them to perform better (e.g., due to better cultural awareness, established contacts, regional awareness, etc.) when a new emergency strikes in the same country or region. Field people hold the specific logistic and culturally relevant knowledge, however, such knowledge is tacit, fragmented, and dispersed among different people. To capture, make sense, and disseminate learnings from past emergencies, HOs must allocate resources to develop post-mortems, gather lessons learned, write cases, and incorporate such findings in training programs and processes. A fraction of the knowledge obtained when HOs allocate effort to relief and recovery operations can be retained. Such feedback closes a balancing loop that allows a fraction of the relief effort to build organizational capacity and decrease the gap in required relief. However, high turnover rates among field people significantly limit the fraction of relief/recovery effort that can effectively be retained by HOs. Not surprisingly, stress levels in the field influence personnel turnover. Stressful relief and recovery operations often lead to very high personnel turnover rates. To capture the dynamics of stress, we include a link from the gap in people requiring relief—a proxy for stress among relief workers—to the ability of HOs to retain knowledge obtained in the field. The stress feedback process closes a reinforcing loop that limits HOs to retain field knowledge due to personnel turnover.

The results accruing from the *Relief/Recovery* strategy are fast, lead to tangible results and are unambiguous (i.e., more resources lead to more people getting relief/recovery) and so they tend to be used more often than the *Capacity* strategy. In resource constrained environments, however, effort to relief and recovery consumes resources preventing them to be allocated to capacity building. If the HO allocates more effort toward relief and recovery, the reinvestment loop will reinforce these dynamics emphasizing relief/recovery, while capacity erodes. Because some of the relief/recovery effort is retained by the HO, it leads to some capacity building and mitigates the consumption of resources. However, if the relief and recovery requirements are high,

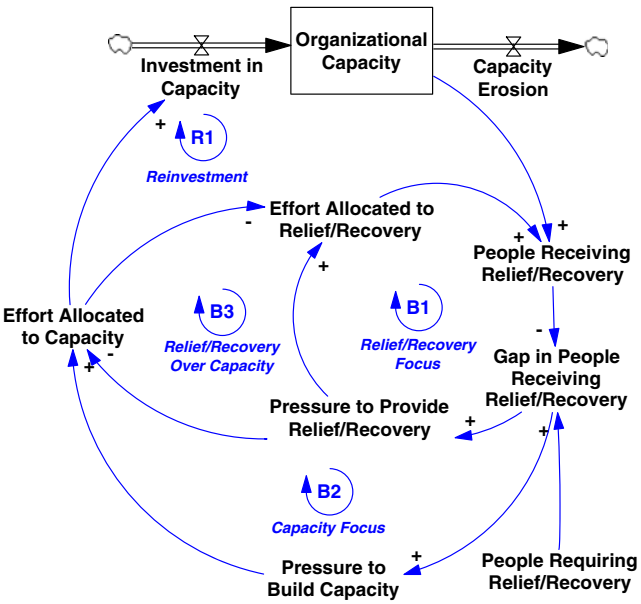


Fig. 3 Counterintuitive behavior from relief/recovery and capacity tradeoff

increased stress levels will lead to a low fraction of organization capacity captured from the relief efforts. With inadequate investment in capacity, *Organizational Capacity* will erode over time, reducing the effectiveness of its relief and recovery efforts. Gustavsson (2003) recognizes the cost of these dynamics: "Millions of dollars could be saved each year by simply being able to work more 'smartly'—more efficiently" through investment in technology and communication. Alternatively, if the organization allocates more effort to capacity, despite the pressure to allocate more resources to relief and recovery, then the reinvestment loop will reinforce those dynamics, allowing the organization to be more effective with existing resources. However, such decisions come at a cost of not being able to adequately provide relief and recovery in the short-term.

3 Model structure

HOs performance measured as the number of *People Receiving Relief/Recovery* is given by the product of the *Effort Allocated to Relief/Recovery* (E_R), measured in man-hours, and the *Productivity of Relief/Recovery Effort* (*Pdy*), measured in people/man-hours:

$$P_t = E_{Rt} \cdot Pdy_t \tag{1}$$

where the *Productivity of Relief/Recovery Effort* (*Pdy*) is determined by the product of *Normal Productivity* (*NPdy*) and a capacity factor, which squares deviations between the actual *Organizational Capacity* (*C*) and its indicated level (C^*). Capacity deviations are squared to capture the strong impact that it has on productivity. The indicated level of organizational capacity (C^*) is determined by the ratio of reference effort allocated to improvement and total effort, with organizational capacity initiated at C^*.

$$Pdy_t = NPdy_t \cdot \left(C_t/C^*\right)^2 = NPdy_t \cdot \left(C_t/(RE_{I_t}/ET)\right)^2 \tag{2}$$

The stock of *Organizational Capacity* (*C*) accumulates the difference between the inflow of *Investment in Capacity* (C_I) and the outflow of *Capacity Erosion* (C_E)

$$\dot{C}_t = C_{I_t} - C_{E_t} \tag{3}$$

where *Capacity Erosion* (C_E) is given by the ratio of *Organizational Capacity* (*C*) and the average capacity lifetime (τ_L):

$$C_{E_t} = C_t/\tau_L \tag{4}$$

and where *Investment in Capacity* (C_I) is given by a fractional adjustment of the gap between the actual *Organizational Capacity* (*C*) and the indicated one (*IC*). The fractional adjustment is given by 1/*Time to Invest in Capacity*, capturing the rate that managers can build organizational capacity:

$$C_{I_t} = (IC_t - C_t)/\tau_C \tag{5}$$

HOs can assess whether a gap in performance exists by comparing actual performance to a desired performance level. Hence, the *Gap in People Receiving Relief/Recovery* (*GP*) is given by the difference between *People Requiring Relief/Recovery* (P^*) and *People Receiving Relief/Recovery* (*P*):

$$GP_t = P_t^* - P_t \tag{6}$$

When HO managers adopt a relief/recovery strategy, they can assess the required relief and recovery efforts from *Gap in People Receiving Relief/Recovery* (*GP*). In particular, they can estimate a *Gap in Relief/Recovery Effort* (*GE*) by dividing the *Gap in People Receiving Relief/Recovery* (*GP*) by the *Productivity of Relief/Recovery Effort*.

$$GE_t = GP_t/Pdy_t \tag{7}$$

Moreover, given the current level of relief effort, HO managers can assess the required increase in relief/recovery efforts simply by summing the existing *Effort Allocated to Relief* (E_R) and the *Gap in Relief/Recovery Effort* (*GE*). Managers, however, cannot allocate more effort than that available in the organization. Hence, there is a sharp nonlinearity for the *Indicated Effort Allocation to Relief* (IE_R) at the *Total Effort* (*ET*) available. At the same time, organizations must maintain a *Minimum Effort Allocated to Relief/Recovery* (E_{RMIN}) if they want to operate in the field.

$$IE_{R_t} = MAX(E_{RMIN}, MIN(ET, E_{R_t} + GE_t)) \tag{8}$$

With the indicated amount of effort required and a preference for a fast relief/recovery strategy (loop *B1*), managers can allocate effort to relief/recovery. The *Effort Allocated to Relief/Recovery* (E_R) is a stock that increases or decreases depending on the *Change in Effort Allocation* (CE_R). The amount of change in effort per period is a fraction of the difference between the *Indicated Effort Allocation to Relief* (IE_R) and the actual *Effort Allocated to Relief/Recovery* (E_R). The fraction of 1/*Time to Change Allocation* captures the speed that managers seek to correct the effort allocation.

$$\dot{E}_{R_t} = (IE_{R_t} - E_{R_t})/\tau_E \tag{9}$$

Due to limited total resources, more resources allocated to relief/recovery results in fewer resources available to be allocated to capacity building. The *Effort Allocated to Capacity Improvement* (E_I) is given by the difference

between the *Total Effort* (*ET*) and the *Effort Allocated to Relief/Recovery* (E_R).

$$E_{I_t} = ET - E_{R_t} \tag{10}$$

Because a fraction of the knowledge gained when HOs allocate effort to relief/recovery operations can be retained, the *Relief/Recovery Effort Impacting Capacity* (E_C) is set by the product of the *Fraction of Relief/Recovery Effort Impacting Capacity* (f_{CE}) and the *Effort Allocated to Relief/Recovery* (E_R).

$$E_{C_t} = E_{R_t} \cdot f_{CE_t} \tag{11}$$

High turnover rates of field personnel can significantly limit the fraction of relief/recovery effort that is retained by HOs. Moreover, high stress levels lead to very high turnover rates. The *Gap in Relief/Recovery Effort* (*GE*) serves as a good proxy for the level of stress in the field, since it is composed of both the *Gap in People Receiving Relief/Recovery* (*GP*) and the *Productivity of Relief/Recovery Effort* (*Pdy*). The former quantity captures the gap in humanitarian aid actually reaching the affected population. The latter captures how productive the efforts by the HO personnel are. Together they provide evidence of the effectiveness of the HO effort being provided. If the gap in relief/recovery effort is small, then stress levels are also small. In contrast, a large gap in the relief effort required highlights high stress levels. Hence, the *Gap in Relief/Recovery Effort* (*GE*), normallized by *Total Effort*, affects the *Fraction of Relief/Recovery Effort Impacting Capacity* (f_{CE}). In particular, the *Fraction of Relief/Recovery Effort Impacting Capacity* (f_{CE}) is given by the product of a *Normal Fraction of Relief/Recovery Effort Impacting Capacity* (Nf_{CE}) and the *Effect of Stress* (S_E). For simplicity, we model the *Effect of Stress* (S_E) as a simple negatively proportional effect.

$$f_{CE_t} = Nf_{CE_t} \cdot S_E = Nf_{CE_t} \cdot [1 - \alpha \cdot (GE_t/ET)], \text{w}/\alpha > 0. \tag{12}$$

According to Eq. 12, when the gap in required effort is zero (GE=0), there is no effect of stress on turnover and the *Fraction of Relief/Recovery Effort Impacting Capacity* is at the normal level. However, when the gap in required effort is high (GE>0), the effect of stress decreases the fraction of Relief/Recovery effort that can impact capacity, making it lower than the normal ($f_{CE} < Nf_{CE}$).

HO managers establish the possible increase in organization capacity by considering the sum of the *Effort Allocated to Improvement* (E_I) and the *Relief/Recovery Effort Impacting Capacity* (E_C). In particular, the *Indicated Organizational Capacity* (*IC*) is given by the product of the current organizational capacity and the ratio of the available effort and a *Reference Allocation of Improvement Effort* (RE_I). The *Reference Allocation of Improvement Effort* (RE_I) is the amount required to maintain the current organizational capacity at its current level. Because organizational capacity aggregates across diverse dimensions of the organization (such as amount and skill of employees, physical resources, etc.), we conceptualize it as a variable that goes from zero to one. If organization capacity is zero, it cannot operate in the field; if it is one, it has all resources available to provide relief and recovery at maximum productivity. At the same time, organizations may maintain a *Minimum Organizational Capacity* (C_{MIN}), above zero, otherwise it cannot operate.

$$IC_t = MAX(C_{MIN}, MIN(1, C_t \cdot (E_{I_t} + E_{C_t})/RE_{I_t})) \tag{13}$$

The set of 13 equations above completely describe the mathematical model capturing the resource allocation problem described in the previous section.

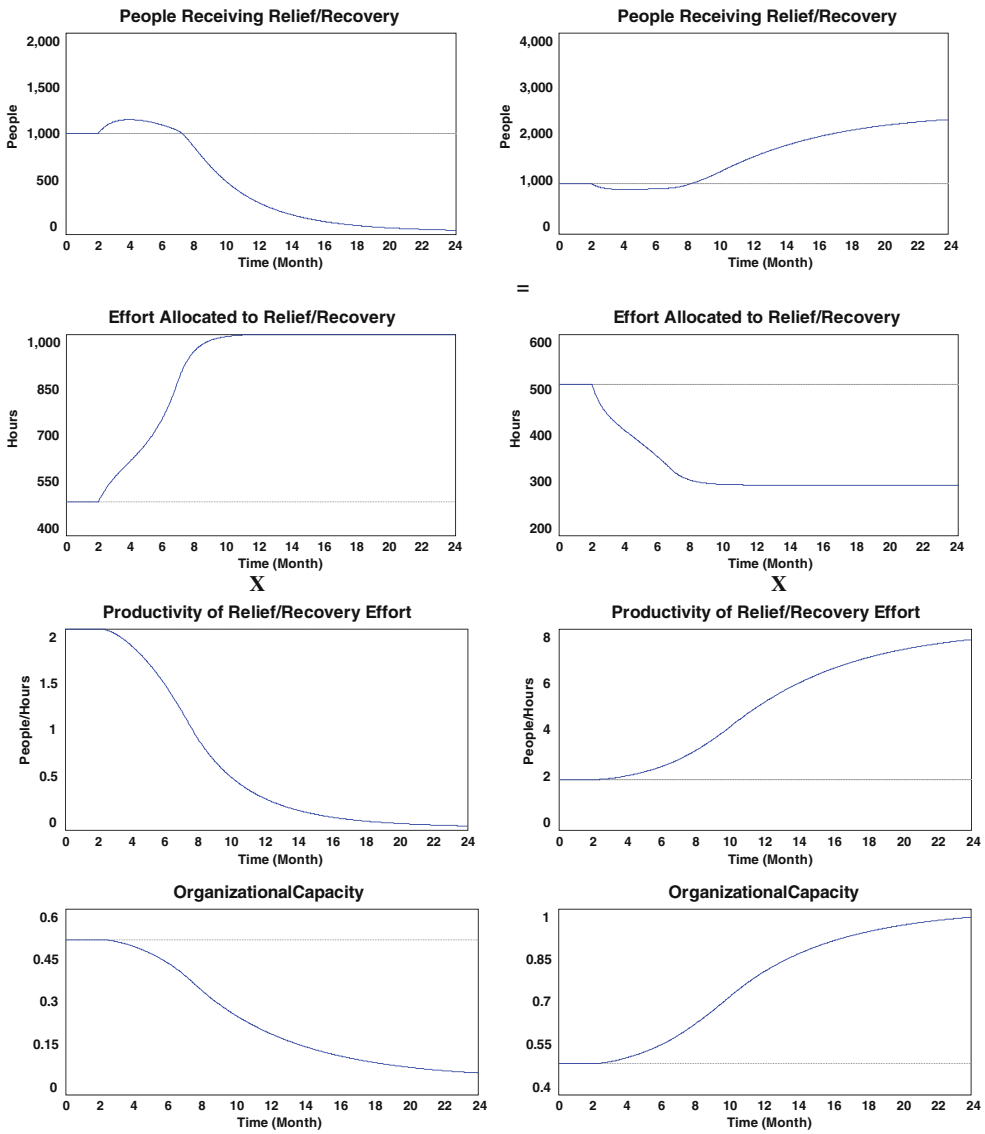
4 Model behavior

To illustrate the behavior of the model, it is implemented in Vensim, a simulation software environment that allows the creation of nonlinear systems of first-order differential equations. The model, fully described in the previous section, starts in dynamic equilibrium and is run for 24 simulated months. When no additional shocks (i.e., emergencies adding people requiring relief) take place, the HO is capable of operating in a desirable manner, maintaining performance in equilibrium. In equilibrium, the HO has a total effort of 1,000 man-hours/week available, and it allocates 500 to relief/recovery and 500 to improve organizational capacity. It maintains organizational capacity at half (0.5) of its maximum level, which allows the HO to maintain a productivity of relief/recovery effort at two people/man-hour dedicated to relief/recovery. With the allocated time (effort) to relief/recovery and average productivity, the HO can provide aid to 1,000 people/week for the specific programs it has in the region.

When an emergency takes place, it adds to the number of people needing relief. For instance, an emergency could lead to a 20% increase in the number or people requiring food, raising the number of people requiring relief/recovery to 1,200 people/week for the specific HO program. To address the increase in requirements, the HO must reallocate resources. An emergency, increasing the number of people requiring relief, is modeled as an external shock introduced in the second simulated month. To explore HOs' performance, two polar resource allocation strategies are investigated: one that emphasizes relief/recovery efforts and another that emphasizes capacity building efforts.

4.1 Dynamic behavior: polar strategies

Figure 4 shows the behavior of a number of important variables (e.g., people receiving relief/recovery, effort to relief/recovery, productivity of relief/recovery efforts, and organizational capacity) for the two polar (relief/recovery focus and organizational capacity) strategies. The first simulation (Fig. 4—left column) shows the HO performance when it emphasizes relief and recovery. As HOs allocate more effort to relief/recovery, the number of people receiving relief/recovery immediately rises. Because the amount of available resources is fixed, however, the organization allocates less effort to capacity building, decreasing the inflow of investment in capacity. In the first 2 months, the decrease in capacity investment causes only mild impact on organizational capacity. With time, however, organizational capacity erodes and as it does it decreases the productivity of future relief and recovery efforts. The product of *Effort Allocated to Relief/Recovery* and *Productivity of Relief/Recovery* determines the number of people that receive relief/recovery (as seen in Eq. 1). Immediately after the increase in relief/recovery effort, performance improves. Because organizational capacity only erodes slowly at first, the increase in relief/recovery effort allows more people to receive relief/recovery in the short-term. However, the benefit associated with the HO's emphasis on relief and recovery does not last long. As capacity erodes, it limits the effectiveness of the operation. While more people provide relief/recovery, they are not as effective as before due the limited organizational capacity. Hence, the strategy emphasizing relief and recovery shows a better-before-worse behavior.



Relief/Recovery Strategy Organizational Capacity Strategy

Fig. 4 Dynamic behavior of the relief/recovery and capacity focused strategies

In contrast, the second simulation (Fig. 4—right column) shows the behavior of the system when the HO emphasizes building organizational capacity. Here, the external shock captures a decrease in the number of people requiring relief due to the HO concluding operations in an affected region in the second simulated month. As fewer people need to receive relief/recovery less effort is allocated to relief/recovery and more effort is available to capacity building. The shift toward improved organizational capacity leads to a higher investment in capacity. And while the stock of organizational capacity grows slowly at first due to its inertia, with time organizational capacity grows further, raising the productivity of relief/recovery effort and the overall effectiveness of the operations. While less effort is allocated to relief/recovery, better trained personnel can work smarter and better structured processes allow them to work more effectively. Performance rises even as less effort is allocated to relief/recovery. Hence, the strategy emphasizing capacity building shows a worse-before-better behavior, the decrease in number of people receiving relief in the short-term is substituted by an increased capacity to provide relief in the long-term.

4.2 Dynamic behavior: fractional relief effort retained

The two previous simulations assume that resources allocated to relief have no impact on organizational capacity, that is, that the *Fraction of Relief/Recovery Effort Impacting Capacity* is zero. However, humanitarian organizations do build organizational capacity by retaining field personnel and incorporating the learnings obtained from relief and recovery efforts. The set of simulations below explores the performance of a simulated HO adopting a relief/recovery strategy subjected to an emergency when it can retain different fractions of relief effort gained in the field (Fig. 5).

While the polar strategy emphasizing relief and recovery shows a better-before-worse behavior when the HO cannot retain the experienced gained in the field, such behavior can drastically change if the HO manages to retain its people and institutionalize lessons learned. Figure 5 shows that as HOs retain a greater fraction of the leassons learned in the field it maintains a higher organizational capacity (5-d) and higher relief/recovery productivity (5-b), thereby requiring less overall effort allocated to relief (5-a) and allowing it to provide relief and recovery to more people. The result shows that HOs can avoid the "better-before-worse" behavior and achieve a "better-before-better" behavior, if they are able to retain a sufficient amount of the experienced gained in relief and recovery efforts.

The set of equations in Fig. 6 capture not only different fractions of relief/recovery retained by the HO, but also the size of the emergency, impacting the number of people requiring relief. Each point in the three dimensional graph captures the final HO performance for a whole simulation run. Each graph compiles 100 simulated runs (i.e., 10 fractions of relief/recovery retained and 10 different levels of people requiring relief). Figure 6 shows that emergencies have a nonlinear impact on organizational capacity. When HOs can retain only a small amount of relief/recovery effort, large emergencies have a greater impact on organizational capacity than smaller ones. This result takes place because large

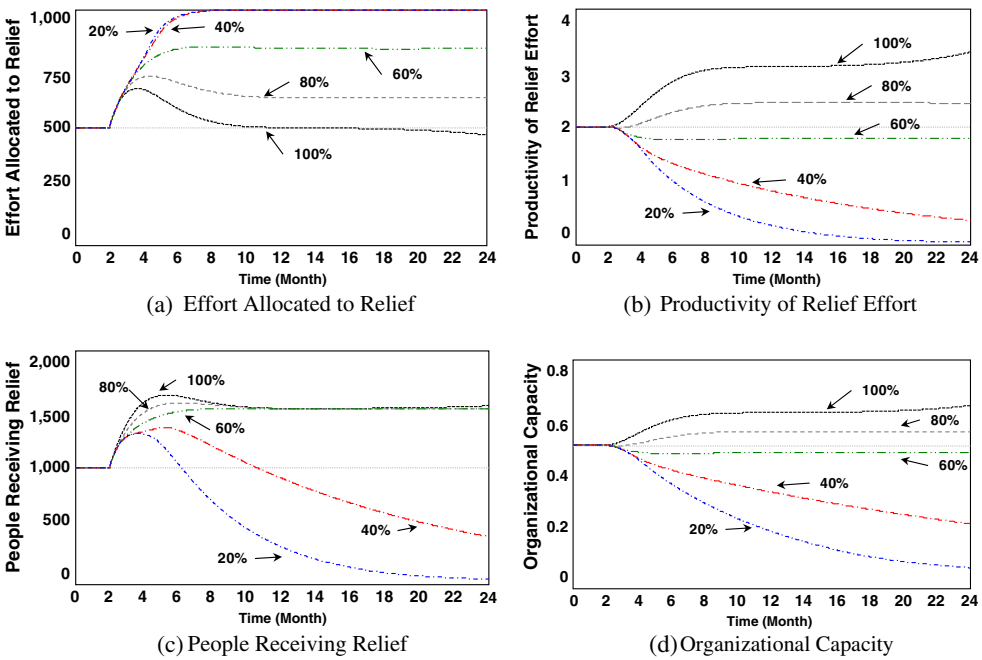
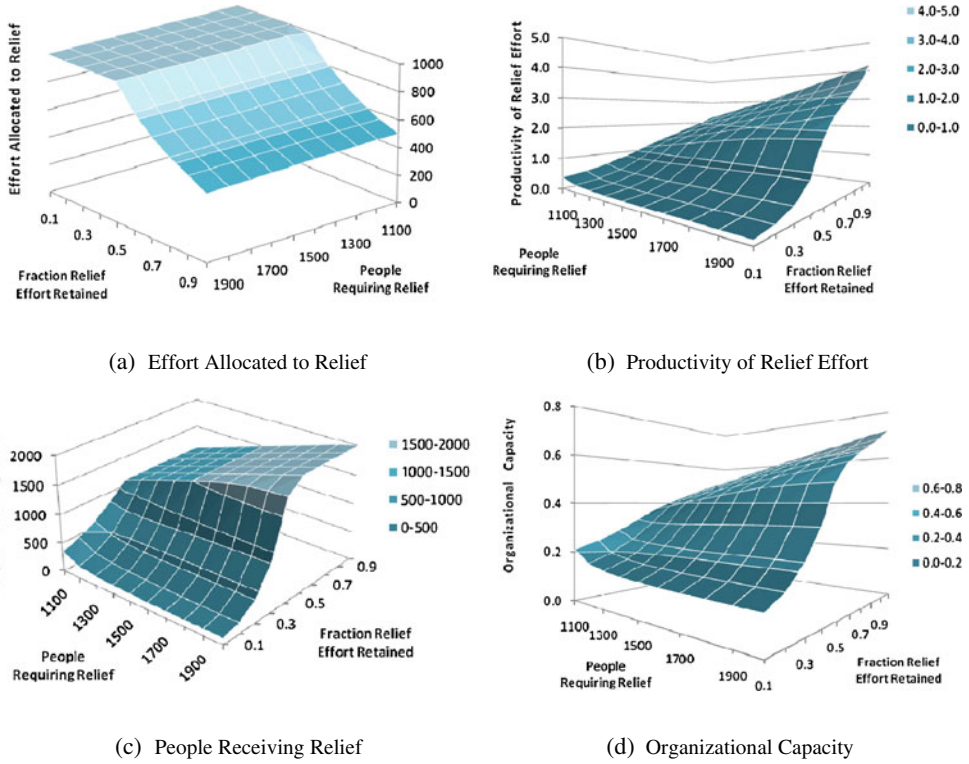


Fig. 5 Effect of different fractions of relief/recovery retained on HO performance. **a** Effort allocated to relief **b** Productivity of relief effort **c** People receiving relief **d** Organizational capacity



(a) Effort Allocated to Relief

(b) Productivity of Relief Effort

(c) People Receiving Relief

(d) Organizational Capacity

Fig. 6 Simulating the relief/recovery focus and capacity focus strategies. **a** Effort allocated to relief **b** Productivity of relief effort **c** People receiving relief **d** Organizational capacity

emergencies require significant effort to relief/recovery that do not contribute to organizational capacity. However, when HOs can retain a high amount of relief/recovery effort, providing relief/recovery effort in large emergencies contributes more to organizational capacity than small emergencies. When HOs can retain more of the effort allocated to relief to improve organizational capacity, more of the effort allocated to relief translate into greater organizational capacity.

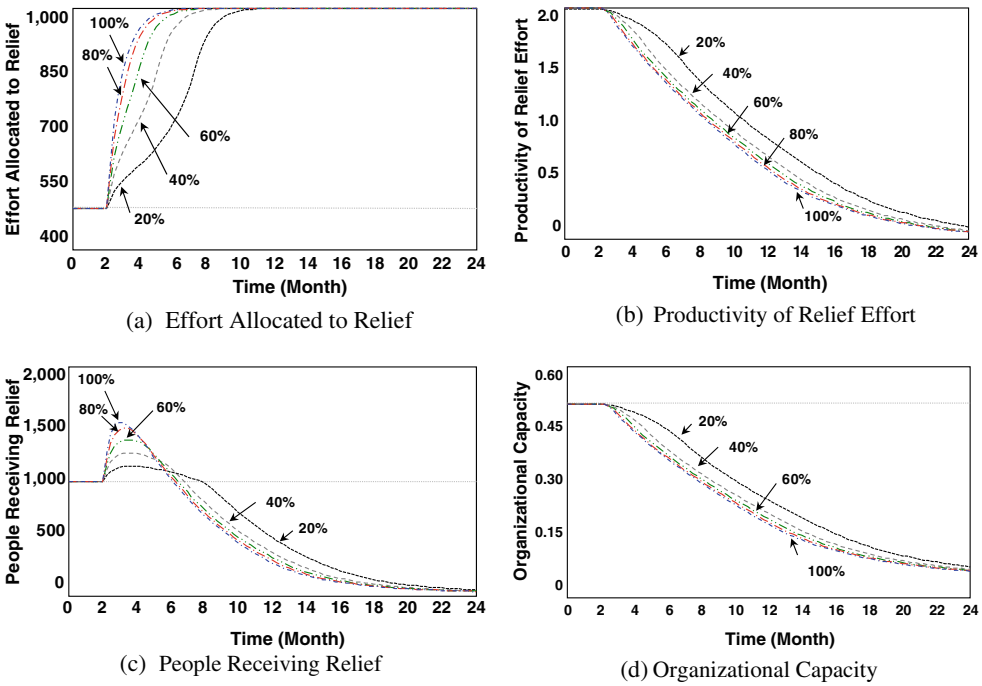
4.3 Dynamic behavior: stress induced turnover

The previous section shows that as HOs retain a sufficiently large fraction of the relief and recovery effort they can avoid the "better-before-worse" behavior. However, when HOs face emergencies affecting more people, a higher fraction of relief/recovery effort must be retained to preserve organizational capacity. Because these results do not incorporate the effect that large emergencies have on stress, which increases personnel turnover and reduces the fraction of relief effort retained, they are conservative.

The set of simulations below explores the performance of the relief/recovery strategy when the fraction of relief effort retained is influenced by stress levels measured in the gap of people requiring relief. Figure 7 shows that as emergencies grow larger, requirring from 20% to 100% more people than the current level of operations, they impact HO performance. Larger emergencies require more effort allocated to relief/recovery (a) than smaller ones, eroding organizational capacity (d) and reducing productivity of relief/recovery effort (b). Because the effort allocated to relief rises sharply with larger emergencies, Fig. 7c shows that the HO can provide relief/recovery to more people at the beginning of the response. However, the increased stress causes people to leave rapidly and reduces the ability of the HO to retain field knowledge. With limited resources allocated to organizational improvement, organizational capacity and the productivity of relief/recovery effort decreases, impairing the HO's ability to provide relief/recovery. The sharp rise in the number of people receiving relief is followed by a subsequent drop causing the HO to perform below initial standards.

5 Conclusions

Despite the important tradeoff that humanitarian organizations face between providing relief/recovery and building capacity, the extant literature on disaster management and humanitarian logistics have little to say about how HOs should allocate resources between the two. In this paper we develop and analyze a formal simulation model that quantifies the tradeoff that exists between providing relief/recovery and building capacity in humanitarian organizations. First, we study the dynamic behavior of two polar resource allocation strategies. We find that, when humanitarian organizations cannot retain the knowledge gained in the field, a strategy that emphasizes relief and recovery efforts is not enduring and leads to a better-



(a) Effort Allocated to Relief

(b) Productivity of Relief Effort

(c) People Receiving Relief

(d) Organizational Capacity

Fig. 7 Effect of different emergency sizes (stress levels) on HO performance. **a** Effort allocated to relief **b** Productivity of relief effort **c** People receiving relief **d** Organizational capacity

before-worse behavior. When HOs can retain a large fraction of the lessons learned in the field, they can achieve more enduring performance with a relief and recovery strategy. Nevertheless, high stress levels during demanding emergencies increase staff turnover and limit HOs' ability to retain knowledge gained in the field.

The paper contributes to the Operations Management literature by explicitly capturing: (1) the tradeoff that exists between providing relief/recovery and building capacity in humanitarian organizations, (2) the fraction of disaster response effort that contributes to organizational capacity (e.g., through relief workers that remain in the organization), and (3) the impact that stress in the field has on the ability of HOs to retain such contribution to organizational capacity (e.g., more stressful responses lead to lower staff retention). All together the feedback processes captured in our model allow HOs to understand how field response conditions influence their ability to provide relief/recovery, retain field staff and when it might make sense to respond less aggressively. In particular, our work highlights the importance of limiting staff turnover as a complementary strategy to the traditional relief and recovery efforts.

HOs traditionally deploy significant amount of resources to provide relief after a disaster strikes. Relief efforts can severely cannibalize HOs' parallel efforts to build capacity. The strategy emphasizing efforts to relief and recovery shows clear benefits in the short-term, making a compelling case for its adoption. However, it also has the potential to significantly erode long-term organizational capacity. While the costs of a relief focused strategy are well recognized in the humanitarian sector (as seen in the previous quotes by Gustavsson 2003), its adoption is not easily avoided. In addition, donor specific requirements and earmaked donations often impose constraints on the ability of organizations to decide how to allocate available resources. By retaining a higher fraction of the lessons learned and institutionalizing them, HOs can offset the impact of limited investment in organizational capacity. Moreover, HOs must try to avoid the pressure to adopt only a short-term strategy toward humanitarian operations.

Alternatively, a strategy focusing on capacity building is more lasting and leads to a worse-before-better behavior. However, having to deal with worse-before-better levels of performance may impose a hurdle that is too high for many, perhaps most, HOs. For such HOs a worse-before-better behavior may prevent them from ever considering investments in organizational capacity. However, in practice, organizations adopt strategies that lie in a continuum between the two polar extremes, with the majority favoring relief/recovery. At a basic level, provided with the question of how many people to help, most HOs often attempt to help as many as possible. But by trying to do too much—either by providing too much relief/recovery or by supporting too many operations with existing resources—organizations may be affecting their long-term effectiveness. The impossibility to address all relief/recovery requirements create frustrating environments to humanitarian practitioners, resulting in high turnover levels which impair the ability of HOs to maintain and build long-term capacity. Hence, organizations must consider carefully the amount of relief that they can effectively provide.

There are a number of limitations in the stylized model presented here. First, organizational capacity is aggregated. It

includes both human resources, material resources and processes. Disaggregating specific resources would allow us to directly capture the impact of stress on employee turnover, or on procedural shortcuts, or on overuse of material resources. A more specific model would allow HO managers to identify critical areas requiring attention. Second, our model assumes that HOs will attempt to provide more relief when called upon it. While this may be the case, there are several organizations that focus on specific tasks and limit the scope and scale of their activities. In addition, we assume that resources are fixed. This limitation is only imposed to simplify the analysis. More realistically, this assumption could be relaxed to allow resources to change over time. HOs have a challenging time scaling up its operations to required levels. Delays in hiring and training are representative of capacitated organizations in the short-term. While these limiting assumptions can easily be relaxed, the stylized model explicitly captures the tradeoff between providing relief and building capacity in humanitarian organizations and serves as a first attempt to address this challenging problem.

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