High-Performance Inter-Organizational Interaction for Disaster Response: An evolutionary game

Fred Phillips[1], Daniel Chang[1], Shameem Heetun[2], Brian Kim[1], Ho-Joong Lee[1],and Sehee Park[1]
[1]Department of Technology & Society, College of Engineering and Applied Science,
Stony Brook University, Stony Brook, New York - USA
[2]Alliant International University, San Diego, California - USA

Abstract--**Disaster response requires cooperation among many aid agencies, some of which may never have worked together in the past. What enables such agencies to rapidly establish the trust and cooperative behavior necessary for effectively aiding victims of a disaster? Literature presents two main candidates for the enabling mechanism: Probability assessment, and indirect reciprocity. This paper describes a spreadsheet-based game that may be used to determine which of these is the dominant mechanism. The game also tests whether an agency's response strategy is evolutionary, i.e., whether the agency finds it best to shift resources between technical training (e.g., firefighting) and training in inter-agency coordination.**

I. INTRODUCTION

The many relief and law enforcement agencies that respond to a disaster must establish quick trust, coordination, and cooperation. What are the mechanisms by which this can be accomplished? Prior research on the evolution of cooperation presents several mechanisms that operate in "normal" (non-disaster) circumstances. In this paper we investigate which of these mechanisms, if any, is dominant in urgent, post-disaster situations. We present a spreadsheet-based game, currently at the pre-testing stage of its development. The game is intended as an experiment, a data-gathering instrument, and a tool for advancing theory. Ultimately it will serve also as a training tool for disaster aid agencies.

The next sections provide definition and background on the types of disasters we address, a summary of relevant prior work, and a description of the game.

II. DISASTERS AND THE INTER-AGENCY PROBLEM

A. Public Disasters

9/11, The Exxon Valdez spill, Hurricanes Katrina and Sandy, the Fukushima nuclear disaster, and the BP well blowout in the Gulf of Mexico are examples of the kinds of disasters we treat here. These "public disasters" are caused by nature, by individuals, or by public or private institutions – or a combination. Multiple organizations, often from different sectors, are to blame for the event, and/or involved in or accountable for remediation. Public disasters are high-impact events. They are low-probability events individually, but collectively the occurrence of at least one public disaster in any given period of time is quite probable.

The impact of such disasters is enormous and seemingly growing:

> The Centre for Research on the Epidemiology of Disasters reported 221 disasters in 1992 affecting 78 million people and causing economic damage estimated at $70 billion. Almost 20 years later, in 2011, these figures soared to 336 natural disasters worldwide, 209 million victims and a bill for nearly $366 billion.[7]

B. The Disaster Cycle

The frequently re-published picture in Figure 1 portrays the "disaster cycle." Each stage of the cycle is important. However, the Response and Recovery stages are the ones carrying the most urgency following any given disaster. These are the stages we address in the present paper.

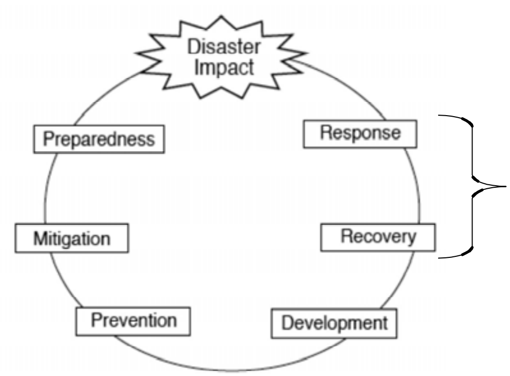

Fig.1 : The Disaster Cycle. Source: [8;12]

C. The Inter-agency Problem

Many failures of disaster response/remediation involve failures of inter-institutional relationships. The Haiti earthquake was typical in this regard: Infrastructure restoration did not support the distribution of food aid, and law enforcement interfered with public health efforts.

Aid agencies are dedicated to their relief mission. However, when interacting with like agencies, even the most dedicated and altruistic organizations may engage in jurisdictional disputes, quests for glory and budget, spats over precedence, liability-avoidance behavior, and refusal of accountability.

For-profit enterprises experience the so-called agency problem, in which non-owner employees indulge personal agendas that diverge from or even work against the firm's strategy. Most relief agencies are non-profit organizations (NGOs), and a relief agency's mission is to succor disaster victims. As NGOs do not have owners, and generally offer employees salaries lower than the for-profit sector, one may infer that they suffer even more severe agency problems than the for-profits.

Moreover, NGOs compete for donor funds. They attract these funds by showing mission successes.

Thus, after a disaster each aid organization wants to…

- Display its expertise
- Be "in charge" of overall relief operations
- Avoid legal liability
- Avoid embarrassment
- Get good press

It may try to shift accountability to, or even sabotage the efforts of, other agencies, in order to get these things.

Any effort to optimize inter-agency cooperation in post-disaster situations must acknowledge and balance these conflicting forces.

Table 1 illustrates the range of remediation agencies and stakeholders involved in three recent disasters.

TABLE 1. THE PLAYERS IN THREE CRISES. SOURCE: [17 AND 11]

Exxon Valdez	**Deutsch Bank NY**	**Mortgage crisis**
3Exxon Valdez captain, crew 3Exxon Corp. 3State of Alaska 3US Dept of Interior 3US Environmental Protection Agency 3Alyeska Corporation	3Deutsche Bank Executives 3Insurors 3New Yorkers 3Governments 3EPA 3New York courts 3Planners 3Construction companies 3Legislators 3Community Groups	3Home buyers 3Mortgage originators 3Mortgage buyers 3Mortgage insurors 3Financial intermediaries 3Investors 3US Federal Reserve Bank

III. PRIOR WORK

Phillips [17] provided philosophical context, using a multiple-perspectives systems schema. He showed how the ideas of moral hazard, externalities, adverse selection, responsibility, integrity, breach of trust, accountability, moral authority, and transparency apply to high-performance inter-agency interaction ("HPII") in the post-disaster environment.

Delton et al [4], in Proceedings of the National Academy of Sciences, showed the incidence of altruistic (cooperative) behavior depends on the actor's assessment of the chances of ever meeting the other party again, and the actor's assessment of the probable frequency of meeting the other party again.

Nowak [15] studied the evolution of cooperative behavior in prisoners-dilemma type games. Many 'generations' of plays showed the emergence of cooperative behavior. Nowak distinguished five basic cooperative strategies: Direct reciprocity, spatial selection, indirect reciprocity, kin selection, and tribal selection.

Among Nowak's remarkable findings was the "evolution of forgiveness," that is, the survival value of going beyond "tit for tat," to cooperate even when the other player has shown betrayal behavior. Nowak's spatial selection may be compared to the probability assessment idea of Delton et al., as one may assume that contact with spatially close players is more frequent than with distant players.

"Indirect reciprocity" means the decision to cooperate is based on the other player's reputation for helpfulness. Nowak notes: "Humans, more than any other creature, offer assistance based on indirect reciprocity, or reputation." This is because we have language (and Facebook, and credit-scoring agencies!) to make a person's reputation widely known.

Leadership is also a factor in establishing swift trust. "In spite of the 9/11 Commission Report and a revised incident command system, effective interagency collaboration at emergency incidents within New York City has not been fully achieved" [3]. Currao's thesis explores

> how... collaborative efforts [depend on] inter-organizational trust, and
> whether emergency management agencies [can] assume a leadership role in fostering and implementing trust-building programs [for] collaborative agency partnerships. [I interviewed] senior management of seven public safety agencies...

Currao's conclusions:

- "Trust enhanc[es] effective interagency partnerships [and] increased problem solving capacities."
- "The 'leadership in building trust' concept is complex, ... [requiring] a synthesis of agency skills to meet homeland security challenges."

IV. THE RESEARCH GAP

There are vast literatures on the performance of individual organizations. As Table 2 shows, these include the HPO literature (e.g., [19]), and indeed much of what has been written in the fields of organizational development and general management. A well-developed crisis management literature also exists for single organizations. Examples include [1] and [6].

TABLE 2: TAXONOMY OF ORGANIZATIONAL SITUATIONS AND LITERATURE

	Within the organization	**Inter-organizational**
Normal times	• High-Performance Organization (HPO) theory • Organizational development • Organizational behavior	• Alliance management • Accounting rules • Negotiation • Game theory • Some HPO theory
Crisis times	• Crisis management	• Zolin (undated) • Tatham and Kovács [18]

Literature on the interaction of two or more organizations overwhelmingly focuses on non-crisis situations. In particular, publications on alliances ([2], [9], and [20] are recent examples) have blossomed in the last twenty years.

There is also much in print concerning the stages of the disaster cycle that are not addressed in the present paper. See especially [10] and [13].

Inter-organizational cooperation for post-disaster response and recovery is an under-covered area, currently represented in the literature only by Zolin, Currao and others at the US Naval Postgraduate School, and by Tatham and Kovács' "The application of 'swift trust' to humanitarian logistics." (Most of this research has been conducted by military-affiliated scholars.) Despite their substantial contributions, the area may fairly be called a research gap, and the present paper therefore focuses on it.

V. THE RESEARCH MODEL

Of the five general strategies for cooperation, we focus on "probability assessment" and "indirect reciprocity." Though kin selection and tribal selection are conceivably operative in a given situation, the global nature of many aid efforts – and the fact of personnel and management turnover in the aid agencies – means kin and tribal selection are unlikely to be useful levers for managing disaster response. In any case, the mathematics of kin and group selection are still controversial. Likewise, direct reciprocity seems more likely to be exercised between individuals, rather than between organizations, and individuals frequently leave their employing organizations. Rather than address this complication in this initial model, we follow Nowak's view that indirect reciprocity is more worthy of our first attention. Our research questions are:

1. How can the evolutionary game idea be adapted to post-disaster cooperation among agencies?
2. Is Delton's "probability assessment" (extended Nowak spatial selection) idea most relevant to disaster situation, or Nowak's indirect reciprocity?

Figure 2 represents the fundamental decision of an aid agency head to allocate limited agency resources to core operational skills (e.g., firefighting or medicine distribution) and to the skills of inter-agency communication and cooperation.

If the agency devotes zero budget to cooperation training, it will be "in the way" rather then an effective contributor in a disaster situation. If it devotes excessive resources to cooperation training, the resulting lack of technical/operational skill will render the agency ineffective in disaster response. Obviously an optimal point exists between these extremes. This is suggested in the conceptual curve of Figure 2.

The catch is that if the agency's budget decision prepares it only to offer a "mid" level of cooperation to other agencies, it will never be able to offer "high" or "very high" cooperation if a particular emergency situations demands it.

This budget decision is an act of leadership, as the morale of employees – and to some extent the agency's external image – depend on the visible expertise in firefighting or medicine distribution, and not on the invisible and less glamorous cooperation skills. Nonetheless the leader knows the latter must be developed if the agency is to achieve its mission. Our game, to be described below, offers the agency manager an opportunity to exercise this leadership by changing the budget after an initial run of plays, that is, to display "double-loop learning." This opportunity comprises the "evolutionary" aspect of the game.

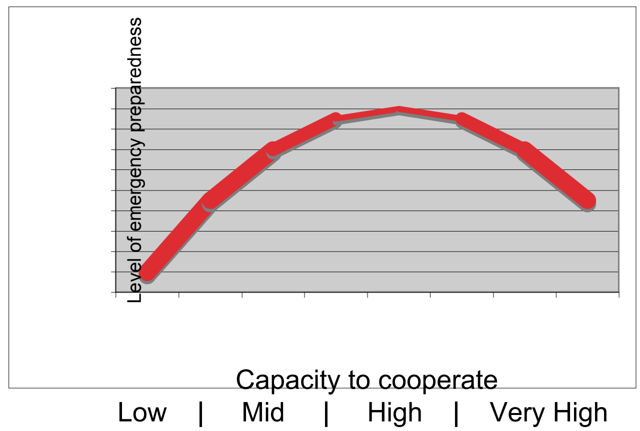

Fig. 2 : A disaster aid agency's planning (hypothetical)

We have been speaking of the leader of the agency we will arbitrarily call Agency #1, in Table 3. Table 3 shows the payoff *to the disaster victims* of two agencies' decisions regarding how far to cooperate with each other in the response/recovery situation. Their budget decisions may impose a constraint on the ability of either or both agencies to extend high levels of cooperation.

TABLE 3: MATRIX OF PAYOFFS TO DISASTER VICTIMS

		Agency #1			
		lo	mid	hi	very hi
	lo	10	10	60	10
Agency #2	mid	10	10	100	60
	hi	60	100	100	60
	very hi	10	60	60	10

Table 3's portrayal of payoffs to a third party (here, the victims) rather than to the players is highly unusual in game theory. Yet it is a natural portrayal of the altruistic missions of aid agencies. The Table shows three levels of benefit to victims. Benefit is lowest when the two agencies' cooperation is too low; when it is wildly mismatched; or when it is so high as to preclude the application of needed technical/operational skills.

VI. THE GAME

A game is presented in which an agency head must make the budget decision, and then participate in twelve hypothetical disasters. In each play (i.e., each disaster), the Agency #1 head will interact with a different "Agency #2." The head of Agency #1 will know Agency #1's probability of interacting with Agency #2 in the future, and will know the "reputation" of Agency #2 for cooperation. S/he will then choose (subject to the budget constraint) a level of cooperation to extend to the other Agency. The game responds by showing the level of cooperation the other Agency offers. The payoff to victims will be visible, as is the cumulative mean and standard deviation of payoffs in all completed plays.

After twelve plays, the Agency #1 director is offered an opportunity either to stop, or to modify the budget decision and proceed to another twelve plays.

The interaction probabilities, and the reputation of each "Agency #2" are random numbers, drawn from Excel's random number generator. A test is done to ensure that there is no accidentally high correlation between these two small-sample series. The "Level of cooperation the other agency extends to you" (see Figure 3; this is the cooperation level offered by Agency #2) has a random component plus a second component which causes the probability of tit-for-tat (i.e., matching Agency #1's offer) to rise with the interaction probability.

The dominance of "probability assessment" vs. "indirect reciprocity" as a driver of rapid post-disaster inter-agency cooperation can then be tested statistically. The categorical dependent variable is the cooperation offered by Agency #1 (low, medium, high, very high). The uncorrelated independent variables are "probability of interaction" and "reputation of Agency #2."

Insight on leadership and evolutionary behavior is drawn from players' tendency to adjust their budgets mid-game, and by the extent of the adjustment.

A. The Game – Mechanism

At the current stage of the project, the game serves as a data collection questionnaire. A respondent is asked to set the % of his/her agency's budget that will be devoted to technical training. The balance (calculated automatically) is presumed to be available for training in cooperation and alliance maintenance. Also automatically calculated are the agency's morale level (assumed to increase monotonically with technical training level) and the maximum level of cooperation this agency can extend to others. (For the latter, the ratio-scale budget percentage is converted to an ordinal lo-mid-hi-very hi scale.) The cooperation training budget, the morale level, and the maximum possible level of cooperation are displayed to remind the player/respondent that the budget decision implies trade-offs.

Likewise, the payoff matrix for the disaster victims is shown in the spreadsheet as a reminder for the respondent. It is also used as a look-up table to calculate the payoffs as the respondent reacts to the game's disaster scenarios.

After entering the budget percentage, the respondent is given twelve disaster scenarios. Each of the scenarios requires that the respondent's agency cooperate with another agency, the "cooperating agency." For each scenario, the respondent enters only two items in the spreadsheet:

1. A click in a checkbox to reveal the cooperating agency's reputation and the probability of interacting with the cooperating agency again in the future. (The latter two quantities are hidden prior to the play of each disaster scenario.)
2. From a drop-down menu, the level of cooperation the respondent's agency will extend to the cooperating agency. If the respondent enters a cooperation level that exceeds his/her allowable maximum, an error message appears and the respondent is asked to specify a lower cooperation level.

The level of cooperation with which the cooperating agency reciprocates (hidden heretofore) now appears. The benefit to the disaster victims appears in the rightmost column, and a running calculation of mean benefit and standard deviation is shown.

If, after experiencing twelve scenarios, the respondent believes the cumulative benefit to victims is insufficient, s/he may opt to try another twelve scenarios. This option is implemented in the spreadsheet but not shown in Figure 3. The option to continue, when taken, indicates evolutionary or double-loop learning.

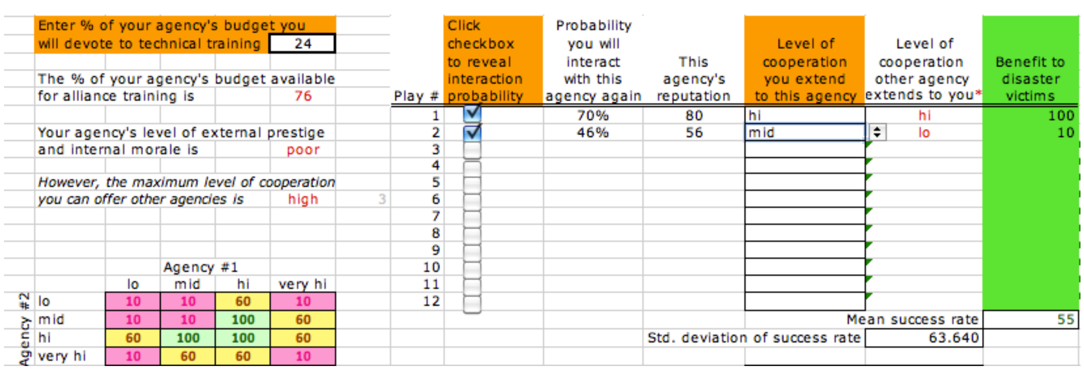

Fig. 3 : Screen shot of game, first phase

"Under the hood" of the spreadsheet, we have the following:

- The "probability you will interact with this agency again" is a random number, uniformly distributed between zero and 100%, calculated by Excel's RAND function.
- The same is true for the cooperating agency's reputation, which ranges from zero to 100. Reputation and interaction probability are thus uncorrelated (we will check for excessive 'accidental' correlation of the random vectors) and can serve as independent variables in the anticipated multinomial logit choice model, where 'cooperation extended by the player' is the dependent variable.
- The calculation of the "level of cooperation other agency extends to you" is more complicated. It has a random component, and a second component that makes matching the respondent's cooperation offer more likely if the two agencies have interacted frequently in the past. (Note that the 'probability you will interact with this agency again' can also be read as the ' probability you have interacted in the past.')

What "evolves," in this evolutionary game? First – if the player elects to take the second set of scenarios – the agencies' strategies for extending cooperation to other agencies. Second, the agencies' views of their own missions. As an example of the latter, a recent news item reported that Scottish fire departments now emphasize fire prevention skills over dousing skills. We can admire the courage and leadership needed to sublimate firefighters' desire for the heroic (putting out dangerous fires) into a commitment to the mundane (preventing such fires).

The intended uses of the game are:

- As experiment, to find out what could happen under evolutionary scenario.
- As an online game, played by disaster agency managers, so the researchers can gather data on empirical behavior of agencies.
- As thesis topic, for a student with programming skills.
- Later, as a training tool for agencies.

B. The Game – User Instructions

The players will be told:

When your agency responds to a disaster, it will usually be called upon to extend some cooperation to other aid agencies. Quick benefit to the disaster victims depends on aid agencies' ability to deliver in their areas of technical expertise (e.g., firefighting, food aid, medical relief) but also their ability to cooperate with other aid providers. This research looks into aid agencies' willingness and capacity to cooperate.

Thank you for agreeing to participate in the research. As the manager of a disaster aid agency, you are asked to help the researcher by playing a computer game. Following the game, we will ask you for general comments on the game's assumptions and level of realism.

The first task in this game is to make a budget decision for your agency. You will decide the balance of resources to be spent on your employees' technical training versus training in cooperation with other aid agencies. Your decision will have consequences for your agency's morale and public image (the game board will suggest these consequences to you), and for the maximum amount of cooperation your agency can extend to other involved agencies in any given disaster scenario.

Next, you will be presented with several disaster scenarios. In each scenario, you must deal with another agency ("Agency X") that is also involved in the crisis response and recovery. This may be a different agency in each scenario. The cooperation tendency of each Agency X will be presented, and then you can choose the level of cooperation you wish to extend to this agency. A table in the game shows the resulting benefit to the disaster victims.

It is important to save all your played scenarios and return the completed game file to the researcher.

Follow the simple steps given below.

1. Set the percentage of your agency's budget for technical training. According to your budget, the game board will determine the cooperative capacity of your agency, on a scale from low to very high.
2. Play a set of twelve scenarios and review the overall payoff to victims. In each scenario, you will click a check box to reveal the past and future cooperation tendency (the reputation) of Agency X, and your chances of working with Agency X again in the future. You will then select your level of cooperation toward Agency X.
3. After finishing a set of twelve scenarios, you will see the overall benefit (to the disaster victims) of your cooperation decisions. You can stop playing if you are satisfied with the overall payoff result.
4. If not satisfied, you may change your budget decision and play an additional set of twelve scenarios.
5. Do not forget to SAVE the spreadsheet file. If you are playing on your own computer or a shared one, return the file with the completed game to the researcher on the provided USB key, or by email to fred.phillips@stonybrook.edu.

VII. STATUS AND FURTHER PLANS

Beta-testers – disaster experts attending the 2013 International Society for System Sciences conference in Haiphong – provided encouraging feedback on the realism of the game. The next stages of this research project are to further beta-test the game (including feedback on the plausibility of payoff matrix amounts), gather empirical data from qualified agency managers, and test the research questions. A follow-up paper will report results.

Finally, we will develop the game as a diagnostic and training tool for disaster response agencies. It will help the agencies self-assess their readiness for cooperation in emergency situations. Further, it will clarify for the agencies the assumptions underlying their training strategies, and the consequences of those strategies. Use of the game as a training tool is expected to lead to re-examination of the strategies themselves, and to frank discussions concerning the motivations of agency employees to advance the interests of themselves, of their agency, and of disaster victims.

VIII. LIMITATIONS OF THE RESEARCH

In order to mount a manageable first project, this version of the game does not deal with all factors and agencies. First, the game addresses only pair-wise cooperation; however, in real disasters, multiple agencies work together simultaneously. By focusing on two agencies, we simplified the treatment of trust. Though we believe not too much generality is lost by this simplification, we recognize that agency #1's treatment of agency #2 could be moderated by the presence of agency #3.

Second, other known mechanisms like direct reciprocity and kin and tribal selection, which were discussed earlier in the paper, were not tested in this game. This game only presented two mechanisms, probability assessment and indirect reciprocity.

Third, agency #1 shows its hand and decides on the level of cooperation it will extend, before knowing how cooperative Agency #2 will be. In reality, the respective levels of cooperation may be decided simultaneously and blindly.

Fourth, it is desired to experiment with correlations between the interaction probabilities and agency reputation levels in future versions of the game.

In the research model, we made no distinction between cooperation with agency *per se* and cooperation with individuals within the agencies. In the real world, personal relationships reaching across agency boundaries can be a deciding factor in cooperation decisions. Moreover (*[5]*), players are more "generous" in games when pumped with oxytocin. Thus, cooperation may be greater when aid workers experience uplifting events during disaster response, and this consideration also is lacking in our model.

Finally, the model treats the disaster victims as passive "third players" in the game. In reality, victims can be active participants in disaster response and recovery.

IX. SUMMARY: IMPACT OF THE RESEARCH

In this paper we have particularized "evolution of cooperation" research to the disaster situation. We have proposed a practical test of Delton's "probability assessment" versus Nowak's indirect reciprocity in the disaster context. The test involves a distinctive wrinkle in 2-person game theory, namely the construction of a matrix of payoffs to a passive 3rd player (the disaster victims). The game evinces evolutionary and double-loop learning.

Improved cooperation after a disaster makes a positive difference to victims. The April, 2013 earthquake in Sichuan, China, shows that improvement is possible:

> The tent village that sprang up in two days... in Lushan [houses] China's full range of disaster response... Trucks with X-ray equipment, phone-charging stations, bank tellers,... a tent for insurance claims.... The government has continued to hone its disaster reaction – long considered a crucial leadership test in China – since a much more devastating earthquake in 2008... [21]

Speaking on the topic of disaster preparedness, Kristalina Georgieva, the EU's humanitarian aid commissioner, said, "By 2016, we are proposing that all member states have risk management plans in place."[1] We believe the research presented in this paper will form an important part of disaster risk management measures.

REFERENCES

[1] J. Bernstein, "*Manager's Guide to Crisis Management",* McGraw-Hill, 2011.

[2] B. Chen, "Managing Inter-organizational Partnerships: Preconditions, Processes and Perceived Outcomes," *Best Papers Proceedings of the Sixty-Sixth Annual Meeting of the Academy of Management, 2008.*

[3] T.J. Currao, "*A New Role for Emergency Management: Fostering Trust to Enhance Collaboration in Complex Adaptive Emergency Response Systems,"* Master's thesis, Naval Postgraduate School, Monterey, CA, 2009.

[4] A.W. Delton, M.M. Krasnow, L. Cosmides, and J. Tooby, "Evolution of direct reciprocity under uncertainty can explain human generosity in one-shot encounters," *Proceedings of the National Academy of Science,* [online] 2011 http://www.pnas.org/content/early/2011/07/20/1102131108.abstract (Accessed 20 July 2011).

[5] *The Economist*, "Free Exchange: The debt to pleasure", *The Economist*, p.64, April 27, 2013.

[6] S. Faraj and Y. Xiao, "Coordination in Fast-Response Organizations," *Management Science,* vol. 52, (8) pp. 1155-1169, August 2006.

[7] K. Georgieva, and G. Bekele, "What silent disasters are saying", [online] 19 February 2013, https://www.devex.com/en/news/what-silent-disasters-are-saying/80342?source=DefaultHomepage_Center_Sector_Tab_World+Earth+Day (Accessed: 12 April 2013).

[8] R. Ishak, (2004), "*Special report: Disaster planning and management*, NCD Malaysia," (NCD Malaysia 2004) vol. 3, (2) pp.47-51 [online] http://web.2u.net.my/a1report/upload/DISASTER%20PLANNING%20AND%20MANAGEMENT.pdf (Accessed: 7 February 2009).

[9] P. Kale and H. Singh, "Managing Strategic Alliances: What do we know now, and where do we go from here?" *Academy of Management Perspectives*, vol. 23, (3) pp.45-62, Aug, 2009.

[10] J.G. Kemeny, "Saving American Democracy: The Lessons of Three Mile. Island," *Technology Review,* vol. 83, (7) pp.64-79, June-July, 1980.

[11] H. Linstone and I. Mitroff, "*The Challenge of the 21st Century: Managing our Technologies and Ourselves in a Shrinking World",* Albany: SUNY Press, 1994.

[12] N.M. Messer, "The role of local institutions and their interaction in disaster risk mitigation: A literature review," United Nations Food and Agriculture Organization (FAO), 2003, [online] http://www.fao.org/docrep/006/ad710e/ad710e00.HTM (Accessed 7 February 2009).

[13] D. Muhtada, "Ethics, Economics and Environmental Complexity: The Mud Flow Disaster in East Java", *Systems Research and Behavioral Science*, vol. 25, (2), pp.181-191, March 2008.

[14] M. Nowak, "Why We Help," *Scientific American,* pp.34-39, July 2012.

[1] https://www.devex.com/en/news/79387/print

[15] M. Nowak, "Five Rules for the Evolution of Cooperation." *Science* vol. 314, (December 8) pp.1560-1563, 2006.

[16] M. Nowak, *Super-cooperators: Altruism, Evolution, and Why We Need Each Other to Succeed,* Free Press, 2012.

[17] F. Phillips, "Inter-institutional Relationships and Emergency Management", *International Journal of Society Systems Science,* Vol. 3, (1/2), pp.40-57, 2011.

[18] P. Tatham and G. Kovács, "The Application of 'swift trust' to humanitarian logistics", *International Journal of Production Economics* vol. 126, (1), pp. 35-45. DOI: 10.1016/j.ijpe.2009.10.006, July, 2010.

[19] A. de Waal, *Strategic Performance Management: A Managerial and Behavioural Approach,* Palgrave Macmillan, January 9, 2007.

[20] L. White, "Connecting Organizations: Developing the Idea of Network Learning in Inter-Organizational Settings," *Systems Research and Behavioral Science*, vol. 25, (6) pp.701-716, 2008.

[21] G. Wong, "Improved Quake Response", Associated Press, in *Philadelphia Inquirer*, p.A2, April 23, 2013.

[22] R. Zolin, "Swift Trust in Hastily Formed Networks," [online] (undated), www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA484211 (Accessed 1 July, 2011).