Safety Science xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/ssci

Dynamic decision support for managing regional resources: Mapping risk in Allegheny County, Pennsylvania

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ARTICLE INFO

Article history:
Received 21 July 2015
Received in revised form 8 September 2015
Accepted 11 September 2015
Available online xxxx

Keywords:
Decision support
Risk mapping
Community resilience
Incident coordination
Emergency preparedness
Emergency management

ABSTRACT

To build resilience, communities must redesign standard practices in emergency management training and operations such that stakeholders share a common view of community risks and resources. A shared image of community risks and resources can facilitate engagement of organizations across sectors and jurisdictions in collective action to reduce shared regional risks. Moreover, creating a reliable, trusted knowledge commons or shared knowledge base for information search, exchange, and updating can support cognition and communication among participating actors, a critical task in achieving effective collective action, especially in urgent, complex, and evolving emergency systems and situations. In this article, we present the initial stage of a prototype decision support system for emergency operations in Allegheny County, Pennsylvania. This prototype represents the first step in building a shared knowledge based to support community resilience in multi-jurisdictional regional system. Vetted and endorsed by experienced practicing emergency managers in the county, the prototype system uses geospatial modeling to map resource allocation scenarios in relation to various types of risk in the region. By providing a trusted knowledge base of regional risks and resources, the prototype system can support emergency managers in developing an integrated perspective on shared regional risks and in collectively exploring, assessing, and improving the efficaciousness of coordinated inter-organizational and inter-jurisdictional resource allocation strategies in virtual emergency response and readiness scenarios. Dynamic functions are proposed for future development.

1. Building community resilience to hazards

Building community resilience requires balancing demand, time, and cost in making decisions regarding hazard exposure and risk management under dynamic conditions. This dilemma represents a long-standing problem for emergency managers. As the number, frequency, and severity of hazardous events increase, losses escalate and the ensuing increase in time and cost of recovery compels a re-examination of disaster management decision processes. Defining the development of disaster resilience as a "national imperative," the National Research Council (2012, p. 11) documented fourteen disasters that each incurred costs of over $1 billion in 2011 within the United States alone. Since that report was released, other disasters have escalated the cost and disruption of major disasters within the U.S. For example, losses from Superstorm Sandy in 2012 were estimated at $72 billion (Benfield, 2013), and estimated losses from the 2013 Moore, Oklahoma tornado ranged from $2 billion to $3.5 billion (Buhayar, 2013).

Yet, given increasing risks that threaten communities exposed to multiple hazards, the capacity of local communities to manage threats has been decreasing, due to budget cuts and changing demographics of local emergency management personnel that have been heavily reliant on volunteers in suburban and rural areas (Skertich et al., 2013). Under these conditions, the need to engage a wider set of organizations with different missions and skills becomes an essential component of emergency management, diversifying the experience and range of resources that require skillful coordination for timely, effective management of risk. Consequently, the task of balancing increased demand under urgent time pressure and mounting costs becomes a primary responsibility for emergency managers at multiple levels of jurisdiction.

As hazards increase in number, scale, and consequences, anticipating risk to facilitate coordination among multiple organizations and jurisdictions while maintaining efficiency in using available resources requires innovative models and interdisciplinary expertise to support decision making in uncertain conditions. In practice, planning for disasters is shifting from response *after* extreme events occur to building resilience to known risks *before* the hazards strike (Kaufman, 2012). The Federal Emergency Management

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http://dx.doi.org/10.1016/j.ssci.2015.09.013
0925-7535/

Agency (FEMA) has led this effort by initiating a national dialogue in the development of the 'whole community approach' to disaster management (FEMA, 2011), which seeks to engage private companies, nonprofit organizations, local and state public organizations, and the general public in a comprehensive effort to assess risk at multiple levels of operation and to "foster collective learning from communities' experiences across the country" (FEMA, 2011, p. 2). This effort undergirds the larger, federal effort to redefine the national framework for emergency preparedness, response, and recovery under Presidential Policy Directive 8 (Obama, 2011) in coping with the increased complexity and cost of managing disasters at the national level. FEMA also recognized the particular vulnerability of local communities exposed to recurring hazards, where the degree of preparedness and efficacy of initial decisions shape the subsequent trajectory of actions taken to bring a hazardous event under control.

Seeking to create incentives for local communities to rethink the relationships among risk, resources, and community resilience, FEMA sponsored the 2012 Community Resilience Innovation Challenge (FEMA, 2012) funded by the Rockefeller Foundation. The intent was to foster modest experiments at the local level that would enable communities to achieve a more effective balance in the continuing effort to recalibrate demand, time, and cost in managing emergencies. In the process, the goal was to facilitate change in the mental models with which the broad set of community actors viewed risk and their responsibility for managing hazards more effectively. In this light, building community resilience to hazards becomes a classic collective action problem, with the added urgency of commitment to the long-standing goals of emergency management: protection of lives, reduction of property losses, and continuity of operations for the community under threat. The question is whether current models of collective action can be updated to incorporate modern information technology, broader public engagement, and effective leadership in fostering responsible commitment to meet the public service goals of emergency management.

2. A conceptual framework for community resilience

The concept of community resilience builds on a long tradition of research on collective action, a persistent problem in social and organizational change. Many distinguished scholars have addressed this problem, which hinges on the voluntary nature of engaging members of a specific community to take informed action for the mutual benefit of all members of the community. Early scholars (Olson, 1965; Hardin, 1968) were largely pessimistic, assuming that short-term, individual interest would trump the goal of achieving collective benefit over the long-term. Elinor Ostrom and her colleagues returned to this problem a decade later and cast it as a process of building a basis of shared knowledge with rules for action and collective enforcement by using progressive sanctions for violation of community norms and rules (Ostrom, 1990, 2005; Hess and Ostrom, 2006; Poteete, Jansen, and Ostrom, 2010). This formulation shifted the concept of collective action to a learning process, one that could be structured and shaped through feedback from members of the whole community to redirect errant members who stray from agreed-upon rules, enforced through progressive penalties sanctioned by the larger community. Ostrom and her colleagues sought empirical evidence for their Institutional Analysis and Development (IAD) framework, and conducted observational studies of collective action problems in many countries and cultures (Hess and Ostrom, 2006). These studies largely focused on individuals making choices in developing economies – an instructive, but substantially different problem than that confronting FEMA in designing a 'whole nation' approach to collective action in a context of increasing risk, declining resources allocated to public action, and markedly diverse populations.

For FEMA, the issue was not only engaging individuals in collective action, but also engaging established organizations in working toward the shared goal of disaster resilience. Bardach (1998) reframed the issue of collective action in terms of organizational choice in his classic book, *Getting Agencies to Work Together*. Bardach shifted the focus to public agencies competing for resources and power while charged with protection of the public interest. In an insightful analysis, Bardach illustrates the importance of fostering communication among agency personnel as a means of building a shared understanding of common purpose among the participants, a process essential to overcome barriers to collaboration established by rules intended to strictly control resources and personnel in separate agencies. Further, these agencies also served diverse clientele with differing degrees of commitment to serving the public interest, thus increasing the complexity of the communication process. Innes and Booher (2010) acknowledged the complexity of planning processes at the community level, and recognized that diversity and interdependence among the participants could be addressed through authentic dialogue, a process that built sufficient credibility and trust among participants that they were willing to create innovative solutions to shared policy problems. The approach of Innes and Booher (2010), while tested and found effective in some communities, relied on regular face-to-face interactions which proved difficult in larger, more diverse communities with less recognition of shared problems and less immediate costs of nonparticipation. Acknowledging both diversity and complexity in collective action problems that cross jurisdictional boundaries, Feiock (2013) reviews the range of mechanisms that have been developed to resolve institutional collective action problems and offers a framework for assessing, monitoring, and measuring the effectiveness of different combinations of authority, resources, and functions in understanding the context of institutional collective action. With echoes of Ostrom's (2005) IAD framework, Feiock offers a more comprehensive approach to understanding the task of building a national approach to collective action by recognizing the role of institutions as aggregating mechanisms to frame collective choice, a function that is implicit in FEMA's 'whole nation' concept of building resilience to disaster.

3. Control vs. resilience in managing risk

The theoretical frameworks discussed above, each based on empirical studies, provide a rich background in which to explore the major shift in policy and practice that FEMA has outlined in seeking to build a 'whole nation' approach to resilience. Yet, an unintended hindrance to this inclusive approach is the long-established and widely accepted effort to establish hierarchical control over the rapidly changing, dynamic context of disaster events through the organizational framework of the Incident Command System (ICS; Boersma et al., 2014). Although FEMA has now officially changed the terminology to the National Incident Management System (NIMS; United States Department of Homeland Security, 2008) and integrated the NIMS framework into its overall design for emergency preparedness, response, and recovery, elements of the old ICS paradigm continue to influence perceptions and training in public organizations with emergency responsibilities, with mixed results in practice. The ICS approach represents a systematic effort to ensure coordinated action among multiple organizations engaged in response operations in disaster environments. The ICS framework originated in the context of urban wildland fires in southern California in the late 1970s, as hundreds of fire departments with different types of equipment, different levels

Please cite this article in press as: Chalfant, B.A., Comfort, L.K. Dynamic decision support for managing regional resources: Mapping risk in Allegheny County, Pennsylvania. Safety Sci. (2015), http://dx.doi.org/10.1016/j.ssci.2015.09.013