A Workshop on a New Cross-Directorate Program on Disaster Resilience, Vulnerability, and Risk Reduction

With almost every new major natural disaster event, the United States set yet another new record for disaster losses. This pattern of ever-rising losses mimics a much more dramatic trend seen worldwide. Unlike global trends however, the United States has been able to take solace in an equally important trend toward declining loss of life associated with natural disasters. Unfortunately, the events associated with Hurricane Katrina that resulted in a staggering loss of life have, if not brought that trend into question, certainly made us recognize that how tenuous that trend might be, particularly when considering the global trend that is escalating.

There are of course many and complex reasons for these escalating trends in losses in the United States and globally. A primary factor shaping these trends, whether considering disasters stemming from climatological events such as flooding and hurricanes or geological events such as earthquakes and the tsunamis they can spawn, is the ever increasing concentrations of human population and the infrastructure upon which they depend in highly vulnerable areas. Not only have we seen higher concentrations of populations in hazards areas, that expansion is often coupled with the destruction of important environmental resources like wetlands eliminating the ecosystem services they may have provided in mitigating losses. Furthermore, we still are far too depended upon and quick to choose short-term technological fixes such as levees, seawalls, and beach renourishment programs, that themselves can have environmentally detrimental consequences to protect our increasingly vulnerable communities. When a disaster occurs, we are faced with losses far exceeding the capacity of local communities or regions, hence massive infusions of public and private resources from outside the area are required to ensure recovery. And all too often, the recovery is highly uneven and likely to exacerbate many preexisting vulnerabilities. In short, the picture emerging within our own nation and across the globe is one of communities becoming ever more *vulnerable* to natural hazards, at greater risk of disasters and less disaster resilient.

Interestingly these patterns of greater vulnerability and risk coupled with lower levels of disaster resilience are occurring against a back drop of many significant scientific advances in engineering and in the broader physical and social sciences addressing natural as well as technological disasters. All too often these scientific advances occur within disciplinary silos despite increasing scientific awareness that disasters must be understood as a product of the complex interaction among biophysical systems, human social systems, and their built environments. This is not to say that disciplinary advances are not important or that disciplinary advances are not needed for scientific future advancements. Rather it is simply recognition that there is a need to address the complex and inherently multi-disciplinary issues associated with natural disasters if we as a nation are going to systematically address the issues of reducing disaster vulnerability and risk and enhancing resiliency. This is precisely what is being considered by three directorates – Engineering, Geosciences and Social, Behavioral and Economic Sciences [SBE] – within the National Science Foundation with the proposal to consider a new multi-disciplinary program focusing on Disaster Resilience, Vulnerability, and Risk Reduction. More specifically these directorates are proposing a new innovative program to advance our knowledge of the processes of and interdependences between natural and social systems and the built environment as they relate to specific natural and technological hazards.

I. Toward a Disaster Resilience, Vulnerability and Risk Reduction Program.

The call for this new program focusing on disaster resilience, vulnerability, and disaster reduction is consistent with a host of recent events and publications calling for a more comprehensive approach to

disaster and hazards related research. Some of these include: 1) the *Second Assessment*[1] which undertook an assessment of hazard and disaster research and research needs for addressing vulnerability and resiliency (Mileti 1999); 2) the *Grand Challenges for Disaster Reduction* produced by the Subcommittee on Disaster Reduction which sought to assess priority science needs for stimulating community resilience and reducing vulnerability; 3) The National Research Council's assessment of research efforts funded by the NSF as part of NEHRP (NRC 2006), which not only assessed the nature of the research funded, but outlined future research needs; 4) the National Science Board's efforts to identify hurricane science research needs and culminated in the a proposed National Hurricane Research Initiative (NSB 2007); 5) the *Rising to the Challenge* report that focused on the critical failures to integrate social science research into the existing national environmental observatories (Vjajjhala, Krupnick, McCormick, Grove, McDowell, Redman, Shabman, Small 2007); 6) NOAA's efforts to develop a social science research agenda supporting hurricane forecast and warning (Gladwin, Lazo, Morrow, Peacock and Willoughby 2007 and 2009); 6) USGS's efforts to identify our nation's needs for natural hazard risk reduction and management (Shapiro, Bernknopf, and Wachter 2007)[2] and 7) the report by a NSF and USGS workshop to create a National Resiliency and Vulnerability Observatory Network (RAVON) to address resiliency and vulnerability science needs (Peacock, Kunreuther, Hook, Cutter, Chang, and Berke 2008).

Together these reports and the associated events that spawned them called for new approaches for addressing disasters that viewed them not as acute, short-term episodic events, but rather as evolving and emerging from long-term chronic issues demanding a comprehensive approach focusing on *natural hazard vulnerability, risk reduction and disaster resiliency*. Many of these efforts not only recognized the need for interdisciplinary research but a number suggested that it is only through promoting truly innovative, integrative, and transformative interdisciplinary science that we as a nation can hope to shift actions and inactions of human and social systems that are playing primary roles in shaping vulnerability and resiliency. Furthermore a number of these efforts stressed the need to transform the nature of vulnerability and resiliency research by promoting long-term data collection efforts that will allow for the monitoring and modeling the dynamics and processes shaping the evolution of resilience and vulnerability to hazards and disasters.

The following sections address the parameters that will shape the program and hence target areas to be addressed by the workshop. The final section outlines the workshop and a timeline for its activities.

2.0. Establishing a Framework for a Disaster Resilience, Vulnerability, and Risk Reduction Program.

The critical focus of this workshop will be to outline a broad framework with which to shape this new program and define its research agenda. Before discussing the specific issues and topics to be addressed by this workshop in establishing this framework it is important to outline several parameters that will guide the development of this framework and issues that should be addressed by the workshop with respect to these parameters.

[1] See: *Disasters by Design* (Mileti 1999), which summarized the central findings and perspectives emerging from the *Second Assessment* of hazard research in the United States, along with the accompanying volumes: *Paying the Price* (Kunreuther and Roth Sr. 1998), which focused on insurance and its potential role in mitigation, *Cooperating with Nature* (Burby 1998), which focused on land-use planning, *Facing the Unexpected* (Tierney, Lindell, and Perry 2001), which focused on disaster preparedness and response research, and *American Hazardscapes* (Cutter 2003), which focused on vulnerability science and spatial analysis of natural hazards.

[2] See also two other useful USGS publications: USGS 2007 and McMahon, Benjamin, Clarke, Findley, Fisher, Graft, Gundersen, Jones, Loveland, Roth, Usery, and Wood. 2005.

2.1 First, the focus on this program will be on natural and technological hazards but not deliberate or willful acts of terrorism. In the aftermath of 911 and the establishment of the Department of Homeland Security, the Federal government has undertaken an extensive investment in its university-based centers of excellence to conduct research focusing on deliberate or willful acts of terrorism. As a consequence, this program will not address these issues. The focus of this program will be the intersections between the realms of geosciences, engineering and SBE sciences. These intersections are much more easily center on natural and technological hazards and disasters. Furthermore, natural hazards and disasters in and of themselves constitute a major threat to U.S. population and our nation's communities and economy; hence, there is a demand for concerted research efforts to address and reduce vulnerabilities and enhance resiliency.

The workshop will further discuss the actual range and scope of natural and technological hazards that should be the focus areas of this program.

2.2 The second parameter shaping the establishment of this program should be enhancing interdisciplinary research. A focus on hazard vulnerability and disaster resiliency and risk reduction demands research involving the interaction and interdependencies between human social systems, their built environments and physical systems, hence the need for interdisciplinary research is self-evident. The call for interdisciplinary research is not new as noted above, many recent efforts have addressed the needs particularly when addressing hazards, resilience, vulnerability and complex environmental systems. Indeed, the National Science Foundation has through a variety of initiatives such as its Coupled-Natural and Human (CNH) systems and Human and Social Dynamics (HSD) programs, sought to directly fund interdisciplinary research. In a recent assessment of the needs to integrate social sciences into existing NSF environmental observatories there is a direct call for focusing on not simply funding social science research but the need to stimulate interdisciplinary environmental research undertaken by (Vjajjhala et al 2007).

It is also important to acknowledge the findings the National Research Council assessment related to interdisciplinary research funded by NSF through the NEHRP program (NRC 2006). This assessment devoted considerable space to interdisciplinary hazard and disaster research noting that the in their later years, the earthquake engineering research centers (EERCs) did indeed facilitate, foster and supporting interdisciplinary research (NRC 2006: 200-12). In light of this success the report noted that with the graduation of the EERCs "NSF should institute mechanisms to sustain the momentum that has been achieved in interdisciplinary hazards and disaster research" (NRC 2006:212). However it also noted that one of the difficulties in establishing interdisciplinary research for the EERCs was that they initially were more focused on engineering research and only with extensive prodding began to incorporate social sciences in their agendas. Similarly, as note above, the environmental observatories have been slow to integrate of social sciences in their on going research initiatives, despite the NRC's *Grand Challenges in Environmental Science* report which identified eight themes in which all demand, to varying degrees, the need to incorporate social sciences (NRC 2001). It is important for the workshop and subsequently the new program to address and promote truly integrative interdisciplinary research as a fundamental dimension of its research agenda from its inception.

A central question to be addressed by this workshop will be the nature of this interdisciplinary research agenda and how it will involve engineering, geosciences, and the social behavioral and economic sciences. In addition, the workshop should address disciplinary specific research areas and how these areas of research might inform multi-disciplinary research approaches. Examples of these research topics[3] might include:

[3] These research topics were drawn from the workshop pre-meeting document drawn up by the program officers promoting this effort.

- Multi-scale, time-dependent models for forecasting and predicting hazardous events, and linking this technology to improve risk communication
- Both structural and non-structural mitigation measures, including such topics as disaster-resilient designs and materials, "smart" buildings and lifeline systems and their interdependencies, cost-effective retrofitting technologies for existing buildings and infrastructure, land-use policies and controls.
- Interdisciplinary models linking and coupling risk assessment between systems. For instance, tropical cyclone predictions, ocean wave models, and surge models coupled with damage assessment and population evacuation and dislocation models. Such interdisciplinary approaches would aim to capture the effects of cascading hazards moving from one system to another and assess vulnerability and risk accordingly.
- Development of infrastructure systems that respond to probabilistic risk assessments as they evolve. For instance, perhaps hydrologic systems may begin to empty a full reservoir system weeks prior to growing probability of tropical cyclone risk. These systems would have to weigh risk against losses by a taking what could be an unnecessary preemptive measure.
- Linking infrastructure and structural damage models with business interruption models, coupled with population displacement and dislocation estimation models.
- Social, organizational, political, and economic dimensions of disaster mitigation, preparedness, response, and recovery.
- Individual, household, community, and regional adoption of mitigation measures as well as recovery lessons.

2.3 The third parameter that should shape this framework is also borrowed from the NRC's (2006:6) summary recommendation that "Comparative research should be conducted to refine and measure core components…" related to vulnerability, resilience, and risk. In the context of the NRC assessment, a critical reason for this recommendation was that much of research funded under NEHRP through NSF was necessarily focused primarily, but not exclusively, on earthquakes. Thus, the call was for promoting comparative multi-hazard research on such core concepts as mitigation, preparedness, response and recovery. However, in the context of a cross-directorate program on vulnerability and disaster resilience and risk reduction the notion of comparative research might be expanded across a variety of dimensions including socio-political. For example, comparative research across states might be important for understanding the role insurance – which is regulated by states – might play in prompting risk reduction and mitigation. Similarly political entities such as counties and municipalities can vary considerably in the ability to address land use and building standards and codes regulations and policies. Hence for many social science and engineering studies comparative research will be critical for scientific advancement.

The workshop will address the nature of comparative research, addressing for example the various dimensions of comparison that are critical for resilience, vulnerability and risk reduction. While stimulating comparative research relates to vulnerability and disaster risk and resiliency should be a guiding element of this program, the program must remain sensitive to the observation that some areas of research will and must remain more focused on specific hazards.

2.4 The final parameter shaping the nature of this program is the need for long-term data collection activities.[4] This need stems directly from that dynamic and changing nature of vulnerability, resilience, and risk. Vulnerability is generally conceptualized as being a function of hazard exposure, often assessed in terms of the likelihood a hazard events of given magnitude and scope will strike particular area, and, most critically, the physical properties or characteristics of a the built environment that shape its

[4] It should be noted that the discussion of this parameter draws heavily from and paraphrases Peacock et al., 2008, pages 4-6.

susceptibility to damage due to the hazard impact (NRC 2006:72-3). Risk takes vulnerability a step further in quantifying the probabilities of various level of damage, although an important element of risk is perception, which can vary widely between the scientific community and the public. During the last two decades; however, our notions of vulnerability have expanded beyond physical properties to include a social dimension as well. Social vulnerability is defined as capacity of social systems to anticipate, cope, resist and recover from the impacts of a hazard agent (Blakie et al. 1994; Heinz Center 2000). This social dimension is a function of social structures and processes that determine access to scarce resources such as income, wealth, social capital, power, cultural factors, and driving forces such as urbanization and demographic change.

Disaster resilience has and is still emerging as a central concept in hazard disaster research community, although its origins are generally attributed to work in ecology. For example, Holling (1973), within the ecological literature, defined resilience as the ability of a system to absorb, change, and still persist.[5] A highly influence group in the ecological community, the *Resiliency Alliance*[6], has expanded upon this original definition suggesting it is the ability of a system to resist or absorb an impact, organize itself to overcome or recover, and adapt or learn from the experience (Carpenter et al. 2001; Folke et al. 2002; Resilience Alliance 2007). This definition is based not on a simple notion of an eco-system, but rather focuses on complex socio-ecological systems. The RAVON workshop's participants proposed the following working definition for resilience: the ability of social systems, be they the constituent element of a community or society, along with the bio-physical systems upon which they depend,[7] to resist or absorb the impacts (deaths, damage, losses, etc.) of natural hazards, to rapidly recover from those impacts and to reduce future vulnerabilities through adaptive strategies[8] (Peacock et al., 2008:5). This definition explicitly expands our vision to include social systems to the critical importance of the built environments (buildings, lifeline systems, etc.) created by social systems (see for example Bruneau et al., 2003 or Tiernery and Bruneau 2007) as well as the physical environment including the ecological systems or upon which they depend or operate within (Berke and Campanella 2006).

The workshop will address how best to carry out necessary data collection activities to facilitate and meet the research needs and thereby advance our knowledge of vulnerability, resilience and risk. For example, a possible solution might be the establishment of a network of research sites could engage in long–term, systematic data collection activities in multiple locations monitoring vulnerability and resiliency and the development of the longitudinal systematically collected data bases to allow for the analysis and modeling of resiliency and vulnerability through time. Furthermore strategically locating network nodes in regions subject to disasters can have the effect of pre-positioned the network to undertake a variety of post-event studies on a longitudinal basis which is critical for a fuller understanding of resiliency. To facilitate longitudinal and comparative work however, a network of research sites will also demand the development of common measurement protocols, instruments and data collection strategies to promote comparative research across locations. These issues and the more general topic of short, mid, and long-term data collection strategies for addressing resilience, vulnerability and risk reduction will be discussed.

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[5] See Walker, Gunderson, Kinzig, Folke, Carpenter, and Schultz 2006; Walker, Holling, Carpenter and Kinzig 2004, and Walker, Anderies, Kinzig, and Ryan 2006 for more recent applications to coupled socio-ecological systems.

[6] http://www.resalliance.org/1.php

[7] Bates (1997) refers to social systems and the systems composing their bio-physical (built and natural systems) environment as an ecological field (see also Bates and Pelanda 1994).

[8] For examples that are generally consistent with this definition see: Mileti 1999; Berke and Campanella 2006; Buckle, Marsh, and Smale 2001; Bruneau, Chang, Eguchi, Lee, O'Rourke, Reinhorn, Schinozuka, Tierney, Wallace, and von Winterfeldt 2003; Godshalk 2003; Walter 2004; UN/ISDR 2005. It should be noted that some definitions, particularly those addressing hazards, focus more narrowly on social systems. Yet these systems are embedded and interactive with natural systems and are dependent on their physical environment. Hence, natural systems should not be ignored by hazard/disaster researchers.

3. Workshop activities: Steering Committee, Activities, Workshop Structure and Timetable.

Steering Committee: Workshop will be conducted and governed by a steering committee guided by three PIs. The following provides the names and affiliations of the steering committee:

The workshop steering committee will be chaired by the PIs:

- **Walter Gillis Peacock**, Professor Department of Landscape Architecture and Urban Planning and the Director of the Hazard Reduction and Recovery Center at Texas A&M University,
- **Gregory Tripoli,** Professor of Atmospheric and Oceanic Sciences, Department of Atmospheric and Oceanic Sciences, and Multi-Scale Atmospheric Simulation Laboratory, University of Wisconsin-Madison, and
- **Sharon L Wood**, the Robert L. Parker, Sr. Centennial Professor in Engineering and Department Chair, Department of Civil, Architectural and Environmental Engineering, University of Texas, Austin.

The other members of the steering committee will include (in alphabetical order):

- **Phillip R. Berke**, Professor, Department of City and Regional Planning and Deputy Director, Institute for the Environment, University of North Carolina – Chapel Hill.
- **Susan L. Cutter**, Carolina Distinguished Professor and Director, Hazards and Vulnerability Research Institute, University of South Carolina
- **Bruce F. Houghton,** the Gordon A. Macdonald Professor of Volcanology, School of Ocean and Earth Science and Technology, University of Hawaii at Manoa.
- **Thomas H. Jordan,** University Professor and W.M. Keck Foundation Chair in Geological Sciences Director, Southern California Earthquake Center.
- **Ahsan Kareem,** The Robert M. Moran Professor of Engineering, Department of Civil Engineering and Geological Sciences, University of Notre Dame;
- **Anne S. Kiremidjian**, Professor, Civil and Environmental Engineering, Stanford University.

Workshop Structure. The workshop will be held over two days: June 1-2, 2011 and the steering committee will have a brief wrap-up session on the morning of June 3rd. The following outlines the basic structure of the workshop.

Workshop Structure and Activities:

1) ***Day one, early morning:*** The early morning activities will consist of the typical welcome and self-introductions. However the welcome should include brief statements by program officers from each of the directorates regarding the importance of this workshop and their charge to workshop participants. This will be followed by an overview of the workshop – its goals and agenda – from the PIs.
2) ***Day one, mid-morning and afternoon:*** Issues and questions. The remainder of day one will be devoted to identifying key issues and questions associate with resiliency, vulnerability, and risk reduction. The day will be divided into three sessions, each focusing on one of these topical areas. Each section will consist of: 1) a "white paper" presentation, 2) break out session, and 3) presentation of break-out findings followed by a general discussion by all workshop participants.
    a. The *"white-paper" presentation* will consist of a 15-minute presentation undertaken by an interdisciplinary team of three workshop participants focusing on resiliency, vulnerability, and risk-reduction. The goal of these presentations will be to provide a concise picture of the state of the science in each area and discuss opportunities and constraints for undertaking disciplinary and interdisciplinary research within this area. Ideally there should be a short white paper (3-5 pages) produced to accompany the presentation. Potential teams should be recognized scholars and researchers in the field the names for potential members might include some of the following (note, the names in alphabetical order):

i. ***Vulnerability:*** State of the science, opportunities, and constraints. The presentation team might potentially include:
    1. SBE: TBA
    2. Eng: TBA
    3. GeoSci: TBA
ii. ***Resiliency:*** State of the science, opportunities, and constraints. The presentation team might potentially include:
    1. SBE: TBA
    2. Eng: TBA
    3. GeoSci: TBA
iii. ***Risk Reduction:*** State of the science, opportunities, and constraints. The presentation team might potentially include:
    1. SBE: TBA
    2. Eng: TBA
    3. GeoSci: TBA

b. *Break-out sessions* will follow each presentation (60 min). There will be three *interdisciplinary* break-out groups. Each group will be tasked to address four questions: 1) what are some of key interdisciplinary opportunities that should be targeted in these areas); 2) what are the key disciplinary research questions that should be addressed in these area to facilitate interdisciplinary research; 3) what are the key factors constraining the science in these area; and 4) What are some of the key measurement and data collection issues in these areas. Each break-out group will have a leader/facilitator and recorders tasked with facilitating and documenting the findings for each group.

c. *Break-out findings and discussion* (45 min.). Following the break-out sessions there will be a presentation of each groups findings with respect to each question followed by a full discussion by the workshop. The goal of the discussion will be to reach some consensus on the insights gained and will focus on identifying and collapsing common issues and detailed questions. The goal will be to develop approximately 4-8 grand issues and a catalog of more detailed research questions and address the key opportunities and constraints to the science that might be addressed by the new program.

3) ***Day one, Evening:*** Steering committee will have a working dinner at hotel to synthesize day-one results and refine strategy for day two.
4) ***Day two, early morning.*** 1) The first part of the morning session will be devoted to a review and reassessment of the findings from the previous day's discussions with the goal of moving toward a consensus with respect to grand issues and research questions in the framework.
5) ***Day two, mid morning through a working lunch***: The second part of the morning session will focus on how best to structure the research and data collection activities within this new program. The goal of this discussion is not necessarily to develop some overarching consensus on what, where, when, and how, but rather to bring forward the issues that should be addressed by this new program. Attempts will be made to develop consensus where possible. There will be two short talks presented to stimulate discussion. Given the nature of the themes and questions that emerged from the first day the basic questions to be addressed are:
    a. Short-, mid-, and long-term data collection activities: how can we best carry out the science?
        i. Test-beds or place based targeted focus areas versus opportunistic-based strategies?
        ii. Multi-hazard versus single hazard foci.
    b. Primary versus secondary data collection and complication activities.
        i. Should there be ongoing primary data collection activities (periodic surveys, panel studies; and/or on going qualitative/ethno-graphic data collection)?
        ii. Should emphasis be placed on the gathering and processing of secondary data from a variety of sources (parcel data sets, census community study data, land use data,

documentary data collection of land-use and building code policies and changes in those policies, local mitigation and recovery plans, data, etc.)?

iii. How might we facilitate the coordination with and capitalizing on existing data collection activities. USGS, Census data research centers, etc.

6) ***Day two, early afternoon session: Finalizing recommendation for the program***. The afternoon session is somewhat flexible. It may be devoted to issues that emerged from the above, should key consensus issues emerge or provide the opportunity to summarize the

7) ***Day three, Morning:*** This will be devoted to the steering committee drafting a plan of action for the final report

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