The Importance of Social Science Research.

The 2004 and 2005 hurricane seasons awoke the United States to the potential societal impacts of landfalling Atlantic hurricanes. The toll was greater than $175 billion in damage and about 5,400 deaths throughout the Atlantic Basin. While 2006 and 2007 were quieter, climatologists believe that we are still in a period of increased hurricane activity. Given that crucial hurricane forecasts, especially those for Katrina, were accurate and timely, it is necessary to understand why many people did not or were not able to heed those warnings. In this sense, hurricane disasters are “social constructs”—as much or more manmade than “natural” disasters. Over the last decade, there has been a growing recognition that social and behavioral research is essential to understanding the causes of high societal-impact weather-related disasters. As stated in Pielke and Kimpel’s Societal Impacts of Weather report, “It is generally accepted that weather problems are both social and physical phenomena. Research findings from the social sciences have been crucially important in understanding and improving human responses to economic, social, and environmental weather-related risks. Despite the centrality of this research area, it has in the past received too little attention and resources.” Pressing meteorological, technological, and social issues that drive the need for social science research on forecasts and warnings include: changes and improvements in forecast products; changes in ways to create, manipulate, and disseminate information; increased recognition of hurricane impacts as social phenomena; increasing and increasingly diverse population and assets in harm’s way; availability of new social science tools, methods, and paradigms; and institutional requirements to evaluate, justify, and develop guidance for programs and future practices.

Based on a 2005 workshop in Pomona, California; 2004 and 2005 Natural Hazards workshop sessions held in Boulder, Colorado; a series of white papers; and additional input from the broader social science research community, the August 2007 special issue of Natural Hazards Review (NHR) contains a series of papers on societal aspects of the hurricane forecast and warning system, written to identify gaps in understanding and needs for social science research. As Gladwin et al. stated in NHR, “Expected results from this effort are (1) a focused applied research agenda designed to generate short-term immediate benefits; (2) a broader, more basic research agenda addressing fundamental theoretical and exploratory research designed to generate long-term improvements; (3) methods to enable the social science research community to gather and further develop research priorities and future agendas; and (4) a concept for a long-term, multidisciplinary, institutional approach to undertaking identified research priorities.”

Science Issues. At least three cross-cutting issues necessitate innovative social science investigations. First, as was never more apparent than in the case of Hurricane Katrina, vulnerable populations require particular consideration. Many people lack economic and/or human resources to respond appropriately. Circumstances and response options of vulnerable populations must be recognized and understood to develop appropriate warning products and policies to prevent...
THE EMPEROR HAS NO RAIN

Based on the findings of a recent article in *Science*, Chinese leaders during some of the nation’s longest dynasties may have wished they could have been able to try cloud seeding. The study found that three of the five ruling dynasties that lasted for multiple centuries came to an end after an extended period of insubstantial summer monsoons, and subsequently, drier conditions in the country. The researchers looked at a stalagmite preserved in a cave in northwest China that gave a 1,800-year-old history of Asian monsoon seasons. Analysis of the stalagmite’s oxygen composition gave a rainfall record that showed several decades of relatively weak monsoon seasons preceded the fall of the Tang (618–907), Yuan (1271–1368), and Ming (1368–1644) dynasties. The dry conditions were especially prevalent in the northern and western parts of the country. According to the paper, “whereas other factors would certainly have affected these chapters of Chinese cultural history, our correlations suggest that climate played a key role” by causing unproductive rice harvests and inciting discontent among the masses.

another Katrina. Second, the historical “ideal” model of a linear warning system—whereby meteorological information flowed into the National Hurricane Center (NHC), forecasters posted watches and warnings, emergency managers heeded warnings and ordered evacuations, and citizens dutifully evacuated—is no longer valid. New models must evolve that recognize the nonlinear nature of communication as citizens, enterprises, and local governments rely increasingly on sources outside institutional channels—especially broadcast media, the Internet, and peer-to-peer communications. Third, faced with the nature and complexity of challenges involved in societal responses to hurricanes, interdisciplinary work that, for example, integrates appropriate meteorological and social science research will be critical. With these cross-cutting issues in mind, we discuss four areas for social science research: 1) warning process, 2) decision making, 3) behavioral response, and 4) social impacts and valuation. For each topic we provide some context on social science issues and examples of specific research needs that social science can help to address.

WARNING PROCESS. Transforming hurricane forecasts into suitable public advisories to guide decisions and actions no longer follows the classical linear communication model, but appears closer to what has been called (by Lindell and Perry in their 2004 book) the “Communication Network Model.” Although NHC remains the authoritative source, private companies have moved into the forecasting business, often tailoring their messages to specific client needs. Media outlets integrate forecasts, models, radar/satellite imagery, and mapping to broadcast comprehensive weather information. Consumers receive weather information from multiple sources via the Internet, cell phones, personal data assistants, and network, satellite, and cable television. Warning systems in general—as well as the structure, format, and timing of hurricane warnings in particular—need to be better understood. Research shows that repetition increases belief—but the host of sources raise the possibility of conflicting messages. Risk communication research indicates that believability depends on trust and confidence in the source, raising questions about ways in which citizens evaluate information sources. If risk communication is to be effective, the experiences, values, and beliefs of intended audiences must be understood since social and cultural differences can influence access, perception, credibility, and actions. It is also essential to acknowledge the existence of a “digital divide” where less affluent or older citizens are likely to have limited access.

To communicate forecast information better during the warning process under these circumstances, further behavioral research is needed on the content of forecast information and channels for its dissemination. With respect to forecast content, studies are needed to better understand which graphics and visualization techniques promote appropriate public response. Research shows people do use the Saffir-Simpson Hurricane Scale, but they often misunderstand it, thinking it covers all hurricane hazards. Forecast probabilities are also quite difficult to communicate, and new research would explore issues on communicating uncertainty and guide current efforts by forecasters to devise better communication approaches. Furthermore, given the multiplicity of media channels for forecasts, research is needed to determine how broadcast meteorologists and private-service providers can be assisted to present consistent and effective forecasts and warning messages, as well as how to enhance the contribution of local weather forecast offices in the process.
**DECISION MAKING.** Activation and evacuation decisions that emergency management organizations and others make when a hurricane threatens involve evaluating meteorological information, community-related information, and a wide range of situational factors. The decision networks responding to such pronouncements, however, consist of individuals, households, families, organizations ranging from small local businesses to national or international corporations, and all levels of government. Yet research typically focuses on individuals as if they were operating in isolation. Furthermore, decision making spans not just the organizational scale but also temporal and spatial scales, and yet there is little understanding of the temporal aspects and of how diverse information influences decisions.

A major constraint on response can be how institutions respond to forecasts and warnings; if businesses fail to release their employees or to suspend operations, employees will delay household preparations and decisions. The roles of informal networks based on proximity (neighbors and coworkers), familial relationships, and other social ties are not well understood. Little is known about how forecasts and warnings influence risk perception critical for appropriate evacuation decisions. Study is needed to see how well forecasts match decision makers’ needs to plan for locations and populations that differ in risk and vulnerability at the relevant organizational, temporal, and spatial scales.

Research is also needed to clarify how decision makers in different institutions respond to forecast information—including how these decisions change under varying circumstances of the hurricane hazard. This is particularly true of probabilistic forecasts, since decision time scales, costs, and benefits differ widely among institutions involved in hurricane response.

**EVACUATION RESPONSE BEHAVIOR.** Although hurricane forecasts call for many behavioral responses, evacuation has the broadest consequences. Many people wait until the last minute, putting themselves and others at risk. Others may evacuate when they would be safer at home. And large numbers of those who should evacuate from storm surge and low-lying areas do not. Facing this complexity, forecasters and emergency managers need to know how and when people will respond to hurricane warnings. Evacuation behavior modeling must better integrate the specificity of qualitative research with the quantitative modeling required to predict aggregate evacuation rates and timing. Getting large numbers of people out of densely populated, threatened areas requires knowing how long evacuation will take. Longer clearance times require earlier warnings, although the lower accuracy of longer-lead-time forecasts means more evacuations and more false alarms. Transportation engineers can model clearance times if they have good data on the number of people who will evacuate from each location, as well as where and when they will go. Traffic issues also feed back into the decision process as people learn from past experience and media coverage. Other activities, such as preparation, mitigation, and education, also depend on forecasts in crucial ways and have implications for evacuation itself. Ideally, an evacuation model should include variables that predict the effects of all conditions specific to each location.

Further research on evacuation behavior needs to focus on methodologies to integrate different geographic scales (i.e., street level to state or regional level) and time scales (i.e., minute-by-minute to multiple days) into models that incorporate subjective and objective elements. Research with this scope can address such concerns as the effect on evacuation timing of commuting, school schedules, the feedback effects of news about traffic delays on evacuation route selection, and the refusal to evacuate versus shadow evacuation (i.e., people evacuating from outside the evacuation zoneنمو}).

**ECHOES**

> More interesting will be to see how people adapt to it.”

—William Mitsch, environmental and natural resources professor at Ohio State University, on the Three Gorges Dam project on the Yangtze River in China. The largest hydroelectric project in the world, it is intended to combine the generation of clean power with downstream flood control. During the winter, the level of water in the dam reservoir will be at 575 ft above sea level, covering approximately 400 mi$^2$ of abandoned cities and fields. In the summer, the level will drop to 100 ft, and the cycle will repeat each year. “Nature is going to see something it’s never seen before,” notes Mitsch. “There is no ecosystem that has such an exaggerated change in flooding levels.” Mitsch hopes that the new ecosystem will bring opportunities such as new agricultural practices during low water levels and establishing food production businesses revolving around the changing water levels. (Source: Ohio State University)
official evacuation zone). Above all, evacuation behavior research has to be multidisciplinary given the complexity of communication and decision making issues, economic and societal impacts, organizational and infrastructure constraints, and the dynamic nature of evacuation responses.

**SOCIETAL IMPACTS AND VALUATION.** Limiting societal impacts estimates to obvious economics costs fails to account for the full range of human and social costs. Yet identifying and representing “hidden costs” is inherently complicated and involves studying largely invisible and powerless groups. From a societal perspective, appropriate treatment of equity and fairness issues is often missing in economic analysis. Much human suffering and social disruption could be reduced with a better understanding of hurricanes in the context of people’s lives. This knowledge could lead to better tailoring forecast and emergency management communication to human circumstances and needs. Phillips and Morrow state in the NHR special issue, “When organizations fail to reach those marginalized by economic, political, social, or cultural circumstances, lives are lost”—a lesson emphatically illustrated by Hurricane Katrina. Within conventional economic frameworks, reliable data on the value of forecasts and warnings can give policy makers information on the net economic benefits to society of investments in forecast efforts. Economic valuation studies are needed to encompass different attributes of forecasts at different temporal and spatial scales and across the range of stakeholders. In studying behavior and decision making relevant to the forecast process, economics has not been adequately integrated with other social sciences. Thus, little information exists on the economic value of improvements in the communication and understanding of forecasts or on values for different response options. Integrating economic theory and methods with sociology, psychology, hazards research, communication, and other disciplines in a multidisciplinary approach offers new avenues of understanding to meet societal objectives.

Broadening benefit–cost approaches to incorporate hidden and long-term costs is a significant challenge. It will require integration of qualitative work like field studies, ethnographies, and case studies with quantitative surveys and experiments. Policy makers will also need the research community to develop meaningful metrics for the economic performance of hurricane forecasts and warnings. The social scientists engaged in this research will also need to work with forecasters to educate policy makers on its importance.

**ADVANCING THE SOCIAL SCIENCE RESEARCH AGENDA.** Significant ongoing discussion within the social science community is needed to identify research needs, broaden participation, and facilitate interdisciplinary discussions. Several activities are recommended to achieve these objectives:

**Social Science Workshops.** The social science research community would benefit significantly from workshops focused on specific aspects of the forecast and warning process. In addition to a multidisciplinary workshop exploring broad research needs, small-scale workshops should appraise the state of the art, review current and new research methods, discuss research needs and opportunities, and foster discussion across the disciplines.

**Common Protocols and Data Depository.** To permit comparability and integration of knowledge across events and projects, common protocols for gathering, analyzing, maintaining, and reporting data by researchers from different fields are needed. For instance, independently developed survey questions addressing the same issue are often phrased somewhat differently and, thus, responses may not be reliably compared between the different survey efforts. Therefore, researchers across the disciplines need to share questionnaires and other data collection protocols. An important component of collaboration would be a data depository where all researchers would be encouraged—or, in the case of federally funded research, required—to make their data accessible for replication and further analysis by other researchers, especially graduate students.

**National Hurricane Social Science Research Program.** Developing interdisciplinary research requires both long-term commitment and fundamental cultural change. The development and long-term funding of a National Hurricane Social Science Research Program (NHSSRP) is crucial to this effort. This could efficiently be implemented as a “virtual” program involving cooperation across a broad range of institutions, researchers, and disciplines as opposed to one physically located at a single institution. A virtual program could leverage existing expertise and
CONCLUSION. Meteorology has evolved considerably, both as a science and in terms of the tools and modalities used to communicate messages to an increasingly diverse array of users. Nowhere is this more obvious than in the case of hurricane forecasts and warnings where interested parties—jurisdictions, enterprises, households, and individuals—receive more information than ever before. These changes raise many issues and questions requiring social science research. Each social science discipline brings unique vocabularies, theories, and methodologies to bear on the forecast and warning process. The relevant topics and questions require a coordinated interdisciplinary approach that incorporates qualitative and quantitative methods. The next Katrina can be avoided only through the integration of strong social science research efforts with meteorological efforts to improve hurricane forecasts and warnings that translate into real-world actions to reduce societal vulnerability.

FOR FURTHER READING