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COMMUNICATING RISK AND WARNINGS: AN
INTEGRATED AND INTERDISCIPLINARY
RESEARCH APPROACH

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**Communicating Risk and Warnings:
An Integrated and Interdisciplinary Research Approach**

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Abstract

Forecasting weather has become a very important scientific, economic, and political endeavor. With the development of new and enhanced technology, weather forecasting skills have improved significantly in the United States and internationally (NRC, 1999 and 2003). However, weather forecasting is a probabilistic science and many uncertainties still remain (see NSF, 2002). Indeed, despite significant improvements in our ability to predict the weather in the short- and long-term, recent experiences with natural hazards show that we continue to confront important challenges regarding lead times, false alarm rates, the accuracy and reliability of the information that is being communicated, and our ability to elicit the appropriate response from the public.

As lead time in issuing severe weather warnings to threatened populations increases with improvements in weather monitoring, detection, and mass communication technology, the social and organizational features of integrated warning systems become paramount as key factors in saving lives and reducing damages to property. There is a need to continue to expand our knowledge regarding how people and organizations perceive and react to weather forecasts and warnings. This knowledge must be integrated with other technical information on weather forecasts already available so as to make weather information more useful to society.

This paper explores the role of technology, the media, and interdisciplinary research in the communication of warnings, risk, and disaster information. We also focus on how researchers can communicate the importance, value, and contribution of hazard and disaster research to the end-user community, including emergency management organizations and the general public. We argue that significant changes need to occur in the existing scientific paradigms in order to incorporate the needs and problems that the end-user communities confront. Further, we provide a critical analysis on the importance and potential contributions of interdisciplinary research in the disaster field. We emphasize the need to develop an integrated research model to communicate risk and warnings, which takes into account the new and emerging technology, the role of the media, and the changing socio-economic and demographic characteristics of the general population.

Keywords: Disasters, Warnings, Risk, Vulnerability, Interdisciplinary Research, Technology, Media

Introduction

Forecasting weather has become a very important scientific, economic, and political endeavor. With the development of new and enhanced technology, weather forecasting skills have improved significantly in the United States and internationally (NRC, 1999 and 2003). However, weather forecasting is a probabilistic science and many uncertainties still remain (see NSF, 2002). Indeed, despite significant improvements in our ability to predict the weather in the short- and long-term, recent experiences with natural hazards show that we continue to confront important challenges regarding lead times, false alarm rates, the accuracy and reliability of the information that is being communicated, and our ability to elicit the appropriate response from the public.

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This paper explores the role of science, technology, the media, and interdisciplinary research in the communication of warnings, risk, and disaster information. We also focus on how researchers can communicate the importance, value, and contributions of hazard and disaster research to the end-user community, including emergency management organizations and the general public. Further, we provide a critical analysis on the importance and potential contributions of interdisciplinary research in the disaster field. We emphasize the need to

develop an integrated research model to communicate risk and warnings, which takes into account the new and emerging technology, the role of the media, and the changing socio-economic and demographic characteristics of the general population.

The NRC's Panel on the Human Dimensions of Seasonal-to-Interannual Climate Variability concluded that the eventual value of improved weather forecasts "will depend on how people and organizations deal with the new kind of information. Are they likely to pay attention to it? Will they understand what the climate models mean for them? Will they trust the messengers?" (1999:16). Even if the public understands weather forecasts, their trust in the reliability and accuracy of weather forecasts and in the sources that provide such information may significantly impact their behavior and response (Lindell and Perry, 2004; NRC, 2003; Mileti, 1999, Perry and Greene, 1982). For example, public confidence and trust in the sources that provide such information (e.g., weather forecasts and warnings) has an impact on their perception of risk (Slovic, 1993; Slovic, et. al., 1991). Slovic (2000:410) points out that "the limited effectiveness of risk-communication efforts can be attributed to the lack of trust...if trust is lacking, no form or process of communication will be satisfactory." However, trust in institutions is a variable entity, often a function of minority status and power (Perry and Greene, 1982) that at times is undermined by mass media accounts that convey inaccurate and biased information (Wenger, et. al., 1980; Nigg, 1987; Quarantelli, 1987; Fischer, 1994; Pérez-Lugo, 2001).

In order for weather forecasts and warnings to be useful to individuals and communities, they must be understood, must meet their needs, and must provide accurate and reliable information as well as sufficient lead time to allow them to take appropriate action. Previous research has shown that one of the most significant problems with weather forecasts is how the information is presented and communicated to end-user communities (e.g., government agencies,

emergency management organizations, industry, and to the general population; see NRC, 1999 and 2003; Mileti, 1999; Fischer, 1994). It is noteworthy, however, that even forecasts of severe weather events that attempt to solve these problems may fail to elicit appropriate protective action given that an individual's response to forecasts and warnings is often influenced by factors that have little to do with the technical features of weather forecasts, such as the individual's social class, education, gender, race, ethnicity, cultural background, and previous experiences with weather events.

Access to weather forecasts and warnings, the type of technologies used to access weather information, and perceptions (e.g., trust, confidence, and usefulness) regarding weather forecasts and warnings also vary according to race/ethnicity, levels of education, and income (Slovic, 2000; NRC, 1999; Weber and Hsee, 1998; Perry, 1987; Perry and Greene, 1982). Weather forecast information delivery systems are primarily oriented "to the educated, the affluent, the cultural majority, and the people in power...and they are...least effective in reaching the elderly, cultural minority groups, people with low incomes, and those without power" (NRC, 1999:86). Further, although the perception of personal risk is a function of individuals' past experiences with a given weather hazard, their views about the certainty of its impact, how close they are to it, and how severe they think the impact likely to be (see Blanchard-Boehm, 1998), there also appears to be a relationship between perceived risk and ethnicity, although this evidence is contradictory. On the one hand, Perry and Greene (1982) suggest that minorities, when compared to majority individuals, have, on average, lower levels of perceived personal risk. On the other hand, more recent research (Slovic, 2000) shows that people of color (and women) are more likely to report a higher degree of perceived health risks to a number of hazards and activities relative to their white counterparts. Slovic points out that "perhaps women and non-

white men see the world as more dangerous because in many ways they are more vulnerable, because they benefit less from many of its technologies and institutions, and because they have less power and control over what happens in their communities and their lives” (2000:402).

Although a hazard event can be devastating for a particular society or for a particular group of individuals, its effects are mediated by cultural, social, economic, and political factors. Some of these factors, such as demographic and socioeconomic characteristics, can ameliorate or exacerbate the effects of a hazard. Furthermore, political and public policy choices, such as whether or not to strengthen and enforce land-use and building codes, will work either to mitigate or exacerbate the hazards’ effects, depending on the actual set of choices made. However, strategies that individuals, groups, and communities develop to deal with stressful events may result in increased resilience and, therefore, will work in the direction of reducing the hazard’s negative consequences.

The primacy of these social factors led Quarantelli (2003) to argue that hazard events (e.g., earthquakes, tornadoes, floods, tsunamis, terrorist attacks, etc.) may result in disasters, not because of the event itself but because of the activities and actions taken (or not taken) at the governmental, community, and individual level. Quarantelli points out:

“allowing high-density population concentrations in flood plains, having poor or unenforced earthquake building codes for structures, permitting housing on volcanic slopes, providing inadequate information or warnings about tsunamis, for example, are more important than the disaster agent itself in creating the casualties, property and economic losses, psychological stresses, and disruptions of everyday routines that are the essence of disasters” (2003:12).

Communicating the Value and Contributions of Disaster Research

In order to generate a better understanding of hazards and disasters among the end-user community and, therefore, contribute to improve their preparedness and response initiatives, there is a need to effectively use the necessary mechanisms to convey to them, in a reliable and

understandable framework, the need, importance, and contributions of disaster research. How do we prepare a population for a hazard which may not be perceived as a possible threat? How do we communicate information on risk and vulnerability to emergency management personnel and to the general population itself? We know that the general perception of the population and emergency management organizations regarding their hazard risk may impact their mitigation, preparedness, and response behavior. If individuals perceive that they are at a high risk of being impacted by an event (e.g., hurricanes, floods, earthquakes, tsunamis, terrorism, etc.) then we would expect them to develop initiatives that will result in a reduction in the loss of life, injuries, and damage to property (see Blanchard-Boehm, 1998). However, if people do not perceive that their lives or those of their loved ones or their property are imperiled by such events then they will not take the corresponding action.

In order to be made useful, scientific research must be generated and integrated with the needs of individuals and organizations seeking to address the problems, challenges, or opportunities that they confront (Pielke and Pielke, Jr., 1997). In this context, we should ask ourselves how we can develop mechanisms by which emergency managers and the population at large may have access to hazard or disaster research and information in order for them to develop a better understanding of the risk and vulnerability that they are exposed to as a consequence of natural and other types of hazards. How can we use disaster research to better inform our population of the risks they confront and elicit appropriate preparedness and response strategies? In order to accomplish this, the knowledge gained through hazard and disaster research must meet the following criteria:

- it must reach the intended end-users or the population at risk in a comprehensible and useful form;

- it must be perceived by them as relevant to their situation (i.e., individuals need to be made aware and recognize their hazard risk and potential outcomes such as the loss of life and damage to property);
- and, the end-users must have the capacity and the necessary resources to use this information in ways that will allow them to better prepare, respond to, and recover from a hazard or disaster situation.

To gain a better understanding regarding the impact of hazard and disaster research on society in general, we must address the following questions: how do scientists disseminate their research findings? How do intervening actors (such as the mass media, among others) re-interpret and transmit this knowledge to the general public and, eventually, to the individuals who supposedly are to benefit from it? Does the general public understand the information that is being transmitted? How relevant is this information to the needs and responsibilities of the end-users? Are end-users aware of the risk that they confront? How do different end-users define or estimate their risk? To what degree do they have the knowledge and the necessary resources to act upon the information they receive? These questions imply the need to develop interdisciplinary research efforts aimed at understanding and disseminating scientific knowledge that will impact society in a useful manner¹.

Disaster losses result from the interaction between physical environments (i.e., hazardous events), the built environment (e.g., infrastructure such as roads, bridges and buildings), and the social environment (i.e., the social, cultural, demographic, economic, and political characteristics of communities) (see Mileti, 1999). Therefore, in order to understand the full consequences of hazards and disasters, (ranging from risk perception; mitigation and preparedness; behavior and response during an actual event; recovery efforts; and short- and long-term reconstruction strategies), and their societal impact (social, economic, psychological, etc.), we have to examine these from an interdisciplinary perspective². This effort must integrate engineers and physical

and social scientists if we are to leverage improved knowledge in the study of hazards in order to enhance mitigation and preparedness and to reduce societal vulnerability. The following section focuses on the role of interdisciplinary research in allowing us to develop a better understanding of societal vulnerability to disasters.

Understanding Vulnerability: An Interdisciplinary Approach

Extreme weather events (such as tornadoes, hurricanes, and flooding) have exacerbated the social and economic conditions of society's most vulnerable groups, including racial and ethnic minorities, children, women, and the elderly. Moreover, given the changing demographic patterns (e.g, increasing population size and population density); an increase in the population with special needs (e.g., the elderly, the physically disabled, and the poor); urbanization and urban sprawl; industrial development without adequate planning; and the construction of housing, buildings, and community developments in high risk areas (e.g., flood-prone areas, steep slopes, and areas which may be subject to liquefaction), societal vulnerability to hazards has increased. Therefore, extreme weather events have the potential of becoming much more damaging in the future and may very well result in an increase in the number of deaths and injured, extensive damage to infrastructure, severe economic losses, and extreme economic and emotional hardship for the most vulnerable population groups.

According to Pielke and Pielke, Jr. (1997), vulnerability consists of two core components: event incidence and societal exposure (see Figure 1). Event incidence refers to the type of event (e.g., a tornado), its frequency (i.e., the number of tornado touchdowns), the strength of the event (intensity of tornadoes on the Fujita Scale), and the location of the event. On the other hand, societal exposure refers to the population at risk (including its demographic, cultural, socioeconomic, and psychological characteristics); the property at risk (homes, condominiums,

hotels, and the industrial infrastructure, among others); disaster mitigation, preparedness, and recovery initiatives; and resilience (for an extensive discussion of these concepts see Tierney, Lindell, and Perry, 2001; Anderson, 1991; Tierney, 1989; Gillipsie, et al., 1987; Britton, 1987; and Quarantelli, 1985 and 1987).

******* Figure 1: A Vulnerability Model *******

An individual, a group or a community is vulnerable to a hazard to the degree that they are susceptible to suffer damages and have difficulty in recovering from these losses. As indicated by the Heinz Center, human vulnerability is the “result of circumstances that place people at risk, reduce their means of response, or deny them protection” (2002:1). Vulnerability has also been defined as person or group characteristics that influence their capacity to anticipate, deal with, resist, and recuperate from the impact of a natural hazard (Blaikie, et. al., 1994). We should also note that factors such as population growth, deforestation, poverty, inequality, and lack of mitigation initiatives, among others, have increased our vulnerability to natural hazards, supporting Quarantelli’s thesis that “human beings are responsible for [their] vulnerability³” (2003:12). Nonetheless, communities also develop coping mechanisms that enable them to deal with the negative impacts and recover from the outcomes of a given hazard (i.e., resilience⁴).

Cutter, Boruff, and Shirley (2003), using Census data at the county level to develop a Social Vulnerability Index for the United States, found that factors such as personal wealth, age (particularly a high concentration of children and/or elderly population), density of the built environment, single-sector economic dependence, housing stock and tenancy, and race and ethnicity, among others, were important correlates of social vulnerability (also see Lindell and Perry, 2004 and Mileti, 1999). They show that some of the counties with the highest levels of

social vulnerability in the United States are in the southern regions, which tend to be “regions with greater ethnic and racial inequalities as well as rapid population growth” (2003:255).

“Event incidence,” as shown in Figure 1, is a component of vulnerability that needs to be explored by physical scientists and engineers. However, “societal exposure” needs to be explored from a social science perspective. Nevertheless, in order to generate science and technology that will have significant societal impact, it is necessary to bring together the knowledge generated by these disciplines. King (2004 - referring to research carried out by Golden and Adams, 2000), refers to the need to promote interaction between the physical and the social sciences in order to improve the disaster warning process. Also, White (1974 – cited in Cannon, 1994) focuses on the need to incorporate the knowledge gained through engineering, land management, and the social sciences in order to have societies effectively cope with hazards. The study of natural hazards and disasters, and their consequences, using an interdisciplinary framework, will result in scientific knowledge with “better value and use” (Pielke and Pielke, Jr., 1997) which will contribute to enhancing disaster preparedness and reducing societal vulnerability.

Communicating Risk and Warnings

An extraordinary amount of federal and state funding has been aimed at the development of science and technology in order to improve weather forecasts, prediction of hazard related events, and at increasing lead times. The assumption is that if we can reduce the levels of error or uncertainty in determining if, when, and where an extreme event, such as a tornado, will strike then we will experience a reduction in the number of deaths or injuries and property damage as a consequence of improved sensing and prediction. However, this is not necessarily the case.

Although significant improvements in tornado warning systems have been alluded to as one of the important variables in the reduction of tornado-related deaths (see Mileti, 1999 and Balluz,

et. al., 2000), the research literature also suggests that inadequate warnings/warning systems is one of the primary factors contributing to the number of deaths and injuries caused by hazard events such as tornadoes (see Balluz, et. al. 2000). Therefore, improving weather forecasts and increasing lead times is only part of the equation in determining the population's preparedness and response to natural hazards. Moreover, effective and reliable warning systems are only one component that may impact how individuals or communities prepare and respond to such warnings.

Human behavior is dynamic, diverse, and depends on a multitude of demographic, social, cultural, economic, cultural, and psychological factors. We know that people respond to these types of warnings if they perceive that there is a serious threat to themselves, their families and their property. There are, nevertheless, a number of other factors that will impact if, how, and when individuals respond to these warnings such as how credible are the sources that are providing the information, the perceived accuracy and reliability of the warning message, the role that the government and government agencies are playing in this process, and the types of messages and the frequency with which the population receives the same, among others (see Lindell and Perry, 2004; Blanchard-Boen, 1998; Nigg, 1995; Mileti and Sorenson, 1990, to name but a few).

The disaster research literature shows that there are a number of variables that will determine if the population at large will seriously consider a warning message and will take appropriate action. For example, the clarity of the message, its consistency and frequency, the presence and "respectability" of officials that are providing the warning, the accuracy of past warnings, and the frequency of the hazard will have a significant impact on the credibility of the message and on individual response to the same (Fischer, 1994 and Mileti, 1999). Furthermore,

how individuals or communities respond to warnings may be impacted by factors such as income, race/ethnicity, gender, and cultural background, among others. For example, whether or not people adopt the officially recommended action embedded in weather forecasts, assuming that they have access or have received the warning, to protect themselves depends on their subjective interpretation of whether the threat is real or not, which in turn depends on their ability to confirm the warning, the credibility of the authorities and the source of information, and on their own assessment of personal risk.

According to Perry and Greene (1982), adoption of the recommended line of action in severe weather forecasts is said to be a function of whether, in the view of potential victims, protection is in fact possible and can be undertaken, which in turn is a function of how much time is available, whether family members are accounted for, and the presence of prior emergency plans. It is also a function of the presence of a belief among those threatened that protective action can significantly reduce the negative consequences of the severe weather event and that the officially recommended action in fact will be superior to alternative lines of action taken by kin, neighbors, or advanced by conventional wisdom.

The adoption of a recommended action also appears to be correlated with ethnicity and race, with the resulting implication that minorities will be less likely to adopt the recommended actions in cases of severe weather events relative to their majority counterparts. This issue is further complicated given that, despite the fact that minorities are more likely to report higher levels of perceived risk (Slovic, 2000), they are less likely to receive the warnings that would allow them to take protective action. For example, preliminary research on response to tornado warnings has shown that African Americans were less likely to report having received warnings when compared to their White counterparts (Paul, et. al., 2003; also see Lindell and Perry, 2004).

Moreover, research results show that minority groups are more likely to be impacted by hazards and disasters, to sustain a greater amount of damage, and to have greater difficulty in recovering from these events relative to their Anglo counterparts (Steinberg, 2000; Peacock and Girard, 1997; Dash, Peacock, and Morrow, 1997). Therefore, having a minority status may be a “risk factor” which contributes to this group’s vulnerability to natural hazards and other events (see Cutter, et. al. 2003).

Communication is an extremely important component in contributing to or in averting a disaster situation. As Lindell and Perry point out, “one important function of risk communication is, explicitly or implicitly, to promote appropriate protective behavior by those to whom the information is directed” (2004:3). The primary goal of communicating this type of information to the general population or to a particular community is to protect those who are at risk of being impacted by an impending hazard, with the aim of reducing the loss of life and the number of injuries. Researchers have argued that a disaster is a result of a crisis in the communication process or a result of a communication breakdown⁵ (see Gilbert, 1998).

In order to generate scientific knowledge, communicate it to the general population in an efficient manner, and, therefore, enhance its levels of preparedness and response to a particular hazard, we need to develop an integrated research approach combined with an effective communication model. Figure 2 presents a model for communicating hazard risk that accounts for the development of technology, dissemination of scientific knowledge, and education and training of end-users (e.g., emergency management agencies, mass media, politicians and government representatives, industry, and the general population), based on Nigg’s (1995) paper on the components of a warning system.

******* Figure 2: A Model for Communicating Hazard Risk *******

The aforementioned model is aimed at integrating the scientific knowledge generated by social and physical scientists and engineers regarding hazards and disasters and their impacts on society. This knowledge or scientific information needs to be disseminated to the end-user community using diverse and multiple communication sources in a way that is accessible and can be understood by this diverse community. This model is dynamic, interactive, and highly dependent on frequent communication and interactions among and between these groups (see Nigg, 1995), through both formal and informal networks.

The interaction between scientists (including engineers and social and physical scientists) and the end-users is extremely important and indispensable if we are to develop a model that is effective and efficient in communicating hazard risk. For example, the NRC's Panel on the Human Dimensions of Seasonal-to-Interannual Climate Variability (1999) points out that the usefulness and utility of climate forecasts can be enhanced by systematically bringing together science and the needs of the end-users. They argue that "key to making climate predictions more socially useful is to develop links between those making the predictions and those who can benefit from them" (1999:29). They call for a direct communication between consumers and producers of climate information. In that way, "consumers discuss and identify the information they would find useful and the producers discuss the information they could provide⁶" (NRC, 1999:36). Providing training and education to these users must be a priority if the proposed communication model is to be successful. In the following sections, we highlight the role and importance, as well as the complexities, of the media and technology in the communication of risks.

The Mass Media and the Communication of Risk and Warnings

There are a variety of mechanisms which can be utilized to provide information to emergency managers and the general public regarding hazards, extreme weather warnings or disasters. Among these, the mass media (e.g., television, newspapers, radio) plays an extremely important role in the communication of hazard and disaster related news and information (King, 2004; Paul, 2003; Pérez-Lugo, 2001; Wijkman and Timberlake, 1988; Mileti, 1999; Nigg, 1995). The media is one of the most important sources of disaster information (Fischer, 1994) and it significantly influences or shapes how the population and the government views, perceives, and responds to hazards and disasters. Dynes (1998:114), recognizing the role and the influence of the media, points out that “implicitly, one of its major functions has been to define disasters.”

The opinions or views of individuals or groups who are perceived by the general population to be “experts” (in this case the media) play a central or defining role in the construction of risk. As Widalksky (1979) states, the perception of risk is reflected by the media’s coverage of these events. In the context of the United States, Fischer points out that “if most Americans rely on the various forms of mass media to obtain their information about what occurs before, during, and after a disaster, then it stands to reason that the accuracy of their perception is dependent upon the media.” (1994:23). However, Fischer goes on to argue that “a less than accurate image is still commonly portrayed in both the print and broadcast media” (1994:24). Prior research on the mass media and disasters has often portrayed the media as conveying inaccurate, biased, and exaggerated information, focusing on human loss and physical destruction (Wenger, et. al., 1980; Nigg, 1987; Quarantelli, 1987; Pérez-Lugo, 2001; King, 2004). In relation to the negative effects that the media may have on our understanding of a disaster situation and, therefore, on how we prepare and respond to a disaster, Mileti points out:

“Disasters are framed by news organizations in ways that can be misleading and especially oversimplified. The media can convey erroneous impressions about the magnitude and even location of disaster damage...To the extent that they perpetuate myths about disaster behavior, the news media convey unrealistic impressions about disaster-related needs and problems, potentially leading both the public and decision makers to worry about the wrong things” (1999:225).

However, the role and the power of the media in disaster situations are irrefutable. Platt (1999), citing information on what the National Academy of Public Administration has called the “CNN Syndrome” states:

“One of the most dramatic contextual changes for emergency management is the greater intrusiveness and influence of news media. Disaster and emergencies provide dramatic news and the appetites of news media, particularly television, are insatiable. This means that emergency management agencies will have to perform under intense media scrutiny. It also means that few emergencies and disasters will remain local – most will now be “nationalized” and politicized as a result of media coverage...The media pressures reluctant local and state leaders to “ask for federal help,” presidents to dispatch such help, and representatives and senators to demand it on behalf of constituents (1999: 22).”

Platt (1999) goes on to argue that even disaster declarations are, to a large extent, the result of the coverage that the media provides of these events, of human suffering, and the loss of life and property. However, media coverage does not necessarily focus on the geographical areas or the communities that have been the hardest hit by natural or technological hazards or those that are more vulnerable to these types of events (Steinberg, 2000). Therefore, governmental assistance (e.g., evacuation, shelters, and recovery and reconstruction efforts) may not reach the groups in greatest need but those that receive the greatest news media coverage. It is then logical to assume that the media plays an important role in defining disaster events and may even impact or drive government and community disaster policies and response to such events.

Nevertheless, hazard and disaster information reported by the mass media captures the general population’s attention (Sood, Stockdale, and Rogers, 1987) and may significantly impact emergency response and behavior. On a more positive tone, Mileti argues that the news media

can potentially play an important and positive role in communicating reliable and accurate information to the general public:

“the news media also make a strong positive contribution in disaster situations. Effective warnings broadcast through the media are widely credited with reducing casualties from hurricanes, tornadoes, and floods. By reporting extensively on disasters and the damage they create, the media can help speed assistance to disaster-stricken areas, and post disaster reporting can provide reassurance to people who are concerned about the well-being of their loved ones” (1999:225).

Technology and the Communication of Risk and Warnings: Other Advantages and Complexities

In this discussion, we must also consider the role that the new, or the not so new, and emerging technology has played and continues to play in the dissemination of disaster or hazard-related information and its impact on individual and community behavior and response to disasters. For example, the internet has become a primary source of weather-related information for a large proportion of the United States population and for the international community as well. Although little is known about the general public’s use of weather information (NRC, 1999), The Weather Channel[®] claims that 95 million individuals worldwide watch it at some point everyday and that its Internet site averages 130 million page views per month (www.weather.com/jobs/index.html; 4/sept/02). AccuWeather[™] claims 4.4 million unique visitors and 40 million page views per month (www.accuweather.com/adcbn/affiliate/advertising, 28/sept/02). Further, Adya, Bahl and Qiu (2002) report that weather forecasts accounted for approximately 500,000 (or 15%) out of 3.25 million notifications sent by a wireless internet access provider over a six day period in August 2000. Other research confirms the primacy of weather as an Internet interest. The Pew Research Center for the People and the Press reported, in 1998, that with 41% of US adults using the

Internet, weather information was the “most popular online news attraction,” given that 64% of Internet news consumers sought out weather information.

Practically all, if not all, major news organizations, the National Hurricane Center, the National Weather Service, and FEMA, among others, provide continuous and up-to-date weather information on the internet and the evidence shows that an increasing number of individuals are accessing the internet to obtain weather related information. Technological innovations, including weather radar and satellites, geographic information systems (GIS), global positioning systems (GPS), remote sensing, the internet, internet wireless connections, e-mail, the development of cellular phones resulting in extensive communication and information networks, text messaging, PDA’s and other handheld electronic devices, and fax machines, among others, have transformed the way we communicate.

Adya, Bahl, and Qiu (2002) indicate, for example, that access to the internet through wireless hand-held devices is gaining popularity. Further, in a survey completed by 72 emergency managers in the State of Oklahoma, Rodríguez, Díaz, and Donner (2004) found that the primary sources used to access weather information by this group of respondents were: the internet (93%), television (88%), radio (64%), cell-phones (28%), and palm pilots and other hand-held technology (7%), among others (respondents were allowed to choose all the sources from which they obtained weather-related information). This technology has radically altered the way we collect, process, analyze, utilize, distribute, and disseminate information. The media and the ever expanding communication networks have transformed hazards and disasters from local to national and even international events. Mileti (1999:241) argues that “some of them [technological innovations] hold great promise for the development and implementation of

sustainable hazards mitigation because they point to better data and information...and allow for greater linkages between research and practice.”

Although the general population has greater access to weather information (including severe weather forecasts and warnings), widespread access, through multiple sources of information, can also generate problems for consumers of said information, particularly if they are receiving information from multiple sources that is inconsistent and contradictory. This tends to create confusion and impacts the credibility and the confidence of the population on the sources of weather information and the information that they provide, therefore, impacting individual behavior and response to warnings and to other types of weather-related announcements and messages. Moreover, despite all the technological innovations in the communication’s field, there are still communities that do not receive the warning messages (see King, 2004; Paul, et. al., 2003) given that they do not have access to the necessary technology or due to technological failures or malfunctions, among others. Nevertheless, given important transformations in telecommunications and information systems and the potential advantages and problems that they may generate, it is time that we re-think, re-conceptualize, and re-evaluate warning systems and their impact on organizational and individual disaster preparedness and response.

Further, there are a variety of issues that emerge with the creation and development of new technologies. What is the intended use and applicability of emerging technology? What are the major advantages and disadvantages of such systems, particularly as they relate to extreme weather forecasts, warnings, and disasters? Who has the necessary resources to access such technology? How effective, accurate, and reliable is this technology in providing or communicating weather related information and emergency warnings? What type of education and/or training has been provided to end-users to enhance their use and management of new

technology and thus minimize errors and the dissemination of inaccurate or incorrect information to the general public? How has this technology increased our resilience as well as our vulnerability to natural or human-induced hazards⁷?

We must also ask ourselves how efficient is this communication technology in responding to different types of hazards. Different hazards have somewhat different characteristics that are known to impact warning systems. Some events (e.g., hurricanes) are slow-onset hazards that can be followed for an extended period of time, allowing emergency management organizations and the population to track the same and initiate preparedness and response strategies. Tornadoes, on the other hand, are quick-onset events providing very little lead time, so that warnings may be issued only minutes before they strike. Our ability to develop technology and warning systems that take into account these climatological differences and effectively communicate information to emergency management agencies and the general population in an expedient manner is extremely important.

Increasingly, emergency management organizations are developing communication strategies aimed at automatically informing their constituents of impending emergencies. Just recently (September 2003), the Delaware Emergency Management Agency (DEMA) began testing a new emergency warning or alert system for the state. This system would be able to send out 300 calls per minute to homes and business to provide a warning of an impending emergency. DEMA will be able to activate this system for localized or statewide emergencies and will provide information to the corresponding communities. It is expected that everyone who has a listed telephone number will have immediate access and will be informed of an impending emergency. Individuals or businesses with unlisted numbers will have to register for the service.

It is noteworthy that the State of Oklahoma (among other states) has also developed or is currently developing similar warning systems, called “reverse 911.”

Despite the spread of such “warning” systems, there are, however, a variety of questions that merit our attention. For example, given the high costs of developing and implementing such technology, will all local communities, particularly minority and poor communities, have the necessary economic resources to access these emerging systems? Also, for those communities that are implementing the “reverse 911” systems, how will individuals or families that do not have telephone services be warned of an impending threat or danger? How will low-income, migrant or minority groups, which have higher levels of poverty than the general population and may lack access to telephone services, receive these warnings? Ultimately, we need to know whether the new technologies improve information flows throughout the population or do they merely magnify the informational advantages that the “haves” already enjoy over the “have-nots” (Bimber, 2003), therefore, increasing the “digital divide” and accentuating existing inequalities. These are critical issues and questions which warrant our immediate attention in order to effectively communicate risk, warnings, and disaster information to the population at large.

Given the transformation of the communication systems and other technological innovations and processes, these must be further studied in order to determine the effectiveness of the same in transmitting warning messages and disaster-related information. We also need to focus on who has access to these new and evolving technologies; how do they access the information; how do these systems disseminate information or communicate emergency warnings; and their impact on disaster preparedness and response at the individual, community, and national level.

Concluding Remarks

It is important for us to emphasize that the payoffs of increasing technological sophistication and improving lead time, for example, may be reaching a point of diminishing returns in which morbidity will not come down and in fact may increase in the absence of socially based programs to educate the public and facilitate their understanding of weather related information. In this context, the end-user community must be able to provide inputs and feedback to the technical or scientific community that generates this type of information. The science community must, therefore, be receptive and must encourage feedback from the user communities. However, these efforts require the integration of the contributions and knowledge generated by social science into the technological scientific effort.

Risk and disasters are socially constructed phenomenon, which are influenced by social and cultural norms, prejudices, and values. Therefore, warnings, hazards, and disasters must be studied and understood within the societal context in which they occur. If we continue to emphasize the study and development of technology, while ignoring the social forces that shape individual and community behavior and response to hazards generally and warnings specifically, then we may have “improved” technology without understanding the complexities of human dynamics. Therefore, the anticipated result (i.e., “improved societal/individual response” to warnings and a concomitant reduction in the loss of life and injuries) may continue to elude us. Leading researchers in the disaster field have argued that improving local management and decision-making processes will be more critical or important than the majority of future technological innovations (Mileti, 1999:7). Nevertheless, we argue that we should continue to promote the development of new technology but we also need to focus on the social forces that shape organizational, community, and individual behavior and response to hazards generally and

warnings specifically. As indicated by Slovic (2000), in his analysis of risk and risk perception, these issues go beyond science and are “deeply rooted in the social and political fabric of our society” (2000:402). Therefore, we must continue to promote interdisciplinary research in order to generate integrated, comprehensive, or holistic research models aimed at better understanding and communicating risks, disasters, and vulnerability.

More accurate and reliable weather forecasts and warning systems may lead to improved disaster mitigation, preparedness, and response initiatives. However, improving weather forecasts and increasing lead times is only part of the equation in determining the ultimate effectiveness of organizational and individual preparedness and response to hazards, for we may be reaching a point in which increasing lead time of severe weather warnings fail to protect people because the associated warning systems do not address the problems of subjectivity and the diverse socio-economic, cultural, and political factors that may impact human behavior and response to severe weather events and other types of hazards and disasters. If we are able to link the knowledge and expertise of the social sciences with the technology and other scientific developments generated by engineers and other scientists and communicate the same in an effective manner to the private and public sectors, as well as to the general public, then we will contribute to the growth and development of disaster research and the corresponding communication process.

We must emphasize, however, that we do not only require improved communication processes but that significant changes also need to occur in the existing scientific paradigms in order to incorporate the needs and problems that the end-user communities confront. Scientists, particularly those focusing on the development of new technology, must realize that the need of the end-user communities must be taken into account from the very beginning of the scientific

and technical process, including the design and development of warning systems. The role of social sciences in this process is of paramount importance.

It is also important to note that in order to develop effective risk communication models, the demographic, social, economic, and cultural characteristics of the population must be taken into account. Who is our audience? What are their characteristics? From what sources do they obtain disaster or weather-related information? Do they have access to the major or most important media outlets that provide information on hazards, disasters, and warnings? What media outlets do they access most frequently? Do they perceive that these media organizations provide accurate, reliable, and up-to-date information? These are important questions that need to be addressed in order to obtain a better understanding of disaster warnings, the mass media, and the population's perceptions and their preparedness and response to disasters. Moreover, the communication process must be adapted to the changing socio-economic and demographic characteristics of the population. For example, the US is characterized by an increasing elderly population. Consequently, the proportion of the population with chronic illnesses and disabilities (e.g., cancer, cardiovascular diseases, and diabetes) will continue to increase. Even if we incorrectly assume that this population has widespread access to the mass media and warnings, will they be able to respond to a disaster situation without the assistance of family or community members or from emergency management organizations? These factors must be taken into account in the development of organizational emergency and disaster planning and management policies.

The United States has also experienced a significant increase in the number of female headed households. These types of households have lower levels of education and economic resources and thus have higher levels of poverty relative to their male counterparts.

Consequently, important issues and problems during a disaster event will emerge for this important sub-group of the US population. Although significant research focusing on gender and disasters has been conducted (see Enarson and Meyreles, 2004; Enarson and Morrow, 1998; Peacock, Morrow, and Gladwin, 1997; Morrow and Enarson, 1996), it is still a slowly emerging sub-field that merits the attention of the disaster research community.

In a detailed historical analysis of “natural” disasters in America, Steinberg (2000) argues that racial and ethnic minorities (particularly African Americans) have been disproportionately impacted by these events (also see Peacock and Girard, 1997). He further argues, however, that the impact of disasters on these groups has been largely ignored and neglected, adding that “race has had a filtering effect on the collective memory of disaster” (2000:79). In this particular context, it is important to note that, for the most part, disaster researchers have excluded or have “failed to measure” ethnicity in their research (Lindell and Perry, 2004:163). To compound matters, in the United States, the minority population has also continued to increase and the Latino population has become the largest minority group on the mainland. The migration flows from Latin America and Asia continue to be an important component of population growth for the United States. We also know that, generally, these immigrant groups tend to be at an economic disadvantage when compared to the general US population, experiencing higher levels of unemployment and poverty.

The somewhat limited disaster research literature, which makes reference to racial and ethnic minorities, shows that these groups experience higher levels of vulnerability to natural hazards (Curson, 1989; Peacock and Girard, 1997; Dash, et. al., 1997). As Curson points out “the poor, the disadvantaged and the marginal generally suffer most, whether the disaster is an epidemic, famine, earthquake, flood or war” (1989:10). These groups are more likely to be

minorities, to reside in hazard-prone areas and, given their limited economic resources, will have greater difficulties in recovering from disasters. Also, these groups' culture, including their primary language, social values, and attitudes, among others, are distinctly different from those traditionally encountered in the US. These changing factors will impact risk communication and disaster preparedness and response for the unforeseeable future. Therefore, we must understand how to effectively communicate warnings to this population through diverse mechanisms (print or visual media, radio, community and other informal communication networks) that they have access to, in ways that are understood and are culturally relevant, and through sources that are perceived as reliable and trustworthy. This is extremely important if our goal is to generate individual and community disaster preparedness and response behavior that will minimize the loss of life and property among these diverse racial and ethnic groups.

As described above, the United States population is experiencing important demographic and socio-economic transformations. Disaster research must, therefore, explore the impact of these changes on the communication of risk and warnings, and on disaster preparedness and response. Theoretical and methodological approaches to the study of disasters need to be re-examined, re-evaluated, and further developed in order to incorporate the demographic, cultural, and technological transformations that are impacting national and international communities.

Notes

¹ Researchers such as Dynes, Drabek, Quarantelli, and Mileti have documented the use, applications, and contributions of disaster research, particularly sociological research, in informing and even significantly impacting science, public policy, and disaster management and planning practices. For a more complete discussion on the use and contributions of disaster research, see Tierney, Lindell, and Perry (2001); Mileti (1999); Dynes and Drabek (1994 and 1991); and Quarantelli (1994a and 1991), among others.

² Quarantelli, in a compelling and thought-provoking monograph, argues that interdisciplinary research “has not come into being anywhere in any viable form for more than 2000 years” (1994b:3). Although we agree that interdisciplinary research is still in its early developmental stages and that much needs to be accomplished in this area, we also think that interdisciplinary research, if correctly developed and applied, can make significant and long-lasting research contributions to the study of hazards and disasters. However, we should emphasize that, in some aspects, Quarantelli’s argument is sustained by the way we, as scientists and researchers, develop our research agenda. Interdisciplinary research is complicated by the very nature of our disciplines, the disciplinary boundaries or walls that we establish, the divisions that we create between engineering, the so-called “hard” sciences and the “soft” sciences, and by the disciplinary segregation that institutions of higher education create when establishing their “colleges” and “departments.” Furthermore, the reward structure at the university or college level (for example, in the tenure and promotion process) generally tends to discourage rather than promote interdisciplinary research. Moreover, some scholars and researchers in the name of maintaining and protecting the “purity” and “integrity” of their discipline would not even consider the possibilities of interdisciplinary research. However, all hope is not lost. Even Quarantelli acknowledges that “most practical applications of research require a multi or interdisciplinary view of the problem” (1991:22). Moreover, important and prestigious funding agencies, such as the National Science Foundation, are establishing new research initiatives which call for multi- and inter-disciplinary work, thus recognizing the importance and relevance of these types of collaborative research efforts. Just recently (2004), the National Science Foundation launched a new funding priority area focusing on “Human and Social Dynamics.” They are calling for inter- or multi-disciplinary work (including engineering, information technology, and the social sciences, among others) to “advance our understanding of human behavior and performance.” NSF’s effort and new priority area represent an important and expanding concern which recognizes the merits, need, importance, and potential contributions of interdisciplinary research. We should also note that research Centers, such as the Disaster Research Center at the University of Delaware and the Center for Applied Social Research (CISA) at the University of Puerto Rico-Mayagüez, have developed and participated in some successful interdisciplinary research projects. Nevertheless, although a somewhat extensive list can be generated focusing on interdisciplinary research in the disaster field, the overwhelming majority have a multi-disciplinary focus with the different disciplines working as individual and separate entities with little cross-fertilization. Nevertheless, it is quite clear that if we are to meet the needs and demands of the growing hazards or emergency management community and professionals in the area, an interdisciplinary perspective/approach is in order, with a strong theoretical/conceptual and methodological emphasis on technology and the physical and social sciences.

³ Hewitt (1998) argues that the “vulnerability paradigm” is inadequate because it portrays societies, communities and/or individuals as passive, pathetic, and weak. He goes on to point out that “the term itself hardly conveys the way people in nearly all circumstances, are active, creative and alert; or how organized decisions may endanger them by undermining their capabilities and resilience” (1998:83). On the other hand, King (2004) views vulnerability to hazards as “parallel states of susceptibility to hazard and resilience...[that] may occur simultaneously, side by side or in contradiction” (2004:58-59). For a more detailed discussion and analysis of vulnerability, its causes, and implications, see Blaikie, et. al., 1994; and Varley, 1994; and Vatsa, 2004).

⁴ Resilience is a result of the social capital of the communities, their history in dealing with hazards and disasters, and the disaster subculture that has been created over time to deal with these events. In our view, resilience is a key element that is not sufficiently emphasized in present day discussions of vulnerability. We should note that this emphasis on resilience and the emergence of groups and resources from the communities that allow them to deal with disasters is a key signature of the DRC tradition.

⁵ There are a variety of factors, presented throughout this paper, that impact the communication of risk. Elaborate models, based on social science research and theoretical and methodological developments, have been generated and present risk communication as a process which consists of individuals going through multiple stages including hearing, understanding, believing, confirming, and responding to a hazard warning. There are a diverse set of variables which impact this process and the multiple stages within these models (see Lindell and Perry, 2004; Mileti, 1999; and Blanchard-Boehm, 1998).

⁶ Quarantelli (1991) argues that researchers primarily write for other researchers implying that they do not communicate very effectively with others, particularly non-researchers, given that they generally provide information that is not relevant or of very little practical use (i.e., over-emphasizing the methodological procedures or the type of data analysis carried out, among others) to the end-user community. Further, Tierney, Lindell, and Perry (2001) argue that while researchers have had a disciplinary approach to the field of disasters, practitioners or end-users have had a broader or even an interdisciplinary approach. According to these authors, this difference in the approach to disasters, between researchers and practitioners, has been an impediment in the generation of an adequate communication process between these two groups. Quarantelli (1991) proposes the use of “translators” to bridge the gap between researchers and practitioners, thus promoting effective communication systems.

⁷ Another important issue which needs extensive consideration and discussion is related to the philosophical and ethical implications of using (or misusing) new and emerging technology, designed to enhance weather and climate monitoring and prediction, for other “unintended” purposes. For example, earth observation systems have been extensively used to monitor weather and climate events, nationally and internationally. However, are they also been used for other military, tactical or for “national security” purposes, particularly in a post 9/11 environment?

References

- Adya, A., Bahl, P. and Qiu, L. (2002). "Characterizing Alert and Browse Services for Mobile Clients." USENIX Annual Technical Conference, Monterey, CA, June 2002.
- Anderson, M.B. (1991). "Which Costs More: Prevention or Recovery?" Pp. 17-27 in Kreimer, A. and Mchan M., (Eds.) *Managing Natural Disasters and the Environment*. World Bank.
- Balluz, L., Schieve, L., Holmes, T., Kiezak, S. and Malilay, J. (2000). "Predictors for People's Response to a Tornado Warning: Arkansas, 1 March 1997." *Disasters* 24(1):71-77.
- Bimber, B. (2003). *Information and American Democracy: Technology in the Evolution of Political Power*. Cambridge: Cambridge University Press.
- Blaikie, P., Cannon, T., Davis, I., and Wisner, B. (1994). *At Risk: Natural Hazards, People's Vulnerability, and Disasters*. New York: Routledge.
- Blanchard-Boehm, R.D. (1998). "Understanding Public Response to Increased Risk from Natural Hazards: Application of the Hazard Risk Communication Framework." *International Journal of Mass Emergencies and Disasters* Vol. 16, No. 3:247-278.
- Britton, N.R. (1987). "Towards a Reconceptualization of Disaster for the Enhancement of Social preparedness." Pp. 31-55 in Dynes, Russell, Bruna de Marchi and Pelanda Carlo (Eds.), *Sociology of Disasters: Contributions of Sociology to Disaster Research*. Milan, Italy: Franco Angeli.
- Cannon, T. (1994). "Vulnerability Analysis and the Explanation of 'Natural' Disasters." Pp. 13-30 in Ann Varley (Ed.). *Disasters, Development, and the Environment*, New York, John Wiley and Sons.
- Cutter, S.L., Boruff, B.J., Shirley, W.L. (2003). "Social Vulnerability to Environmental Hazards." *Social Science Quarterly*, Vol. 84, No. 2:242-261.
- Curson, P. (1989). "Introduction." Pp. 1-23 in Clarke, J. I., Curson, P., Kayastha, S. L., y Nag, P. (Eds.). *Population and Disaster*. United Kingdom: Basil Blackwell, Ltd and Institute of British Geographers.
- Dash, N., Peacock, W.G., and Morrow, B.H. (1997). "And the Poor Get Poorer: A Neglected Black Community." Pp. 206-225 in Peacock, W.G., Morrow, B.H., and Gladwin, H. (Eds.). *Hurricane Andrew: Ethnicity, Gender, and the Sociology of Disasters*. USA: Routledge.
- Dynes, R.R. (1998). "Coming to Terms with Community Disaster." Pp. 109-1126 in Quarantelli, E.L. (Ed.). *What is a Disaster: Perspectives on the Question*. New York: Routledge.

Dynes, R.R. and Drabek, T.E. (1994). "The Structure of Disaster Research: Its Policy and Disciplinary Implications." *International Journal of Mass Emergencies and Disasters* Vol. 12, No 1:5-25.

Dynes, R.R. and Drabek, T.E. (1991). "Contemporary Uses of Sociological Research: Sociology of Disasters." Paper presented at the Conference on Contemporary Uses of Sociological Research, International Sociological Association, Onati, Spain, April 6-10, 1992.

Enarson, E. and Meyreles, L. (Forthcoming, 2004). "International Perspectives on Gender and Disaster: Differences and Possibilities." *International Journal of Sociology and Social Policy*.

Enarson, E. and Morrow B.H. (Eds.). (1998). *The Gendered Terrain of Disaster: Through Women's Eyes*. Westport, CT: Greenwood Publications.

Fischer, H.W. III. (1994). *Response to Disaster: Fact Versus Fiction and Its Perpetuation: The Sociology of Disaster*. New York: University Press of America.

Gilbert, C. (1998). "Studying Disaster: Changes in the Main Conceptual Tools." Pp. 11-18 in Quarantelli, E.L. (Ed.). *What is a Disaster: Perspectives on the Question*. New York: Routledge.

Gillipsie, D.F. and Streeter, C.L. (1987). "Conceptualizing and Measuring Disaster Preparedness." *International Journal of Mass Emergencies and Disasters* 5, (2): 155-176.

Golden, J. and Adams, C. (2000). "The Tornado Problem: Forecast, Warning, and Response." *Natural Hazards Review*, 1 (2): 107-118.

Heinz Center. (2002). *Human Links to Coastal Disasters*. Washington, DC: The H. John Heinz III Center for Science, Economics, and the Environment.

Hewitt, K. (1998). "Excluded Perspectives in the Social Construction of Disaster." Pp. 75-92 in Quarantelli, E.L. (Ed.). *What is a Disaster: Perspectives on the Question*. New York: Routledge.

King, D. (2004). "Understanding the Message: Social and Cultural Constraints to Interpreting Weather Generated Natural Hazards." *International Journal of Mass Emergencies and Disasters* Vol. 22, No. 1: 57-74.

Lindell, M.K. and Perry, R.W. (2004). *Communicating Environmental Risk in Multiethnic Communities*. Thousand Oaks: Sage Publications.

Mileti, D.S. (1999). *Disasters by Design: A Reassessment of Natural Hazards in the United States*. Washington, DC: Joseph Henry Press.

Mileti, D.S. and Sorenson, S. (1990). "Communication of Emergency Public Warnings: A Social Science Perspective and the State-of-the-Art Assessment." Oak Ridge, TN: ORNL-6609. Oak Ridge National Laboratory, Department of Energy."

Morrow, B.H. and Enarson, E. (1996). "Hurricane Andrew through Women's Eyes: Issues and Recommendations." *International Journal of Mass Emergencies and Disasters* 14 (1): 1-22.

National Research Council (NRC). (2003). **Communicating Uncertainties in Weather and Climate Information**. (Friday, E.W.. Rapporteur). Washington, DC: National Academy Press.

National Research Council. (1999). *Making Climate Forecasts Matter*. P.C. Stern and W.E. Easterling (Eds.): Washington, DC: National Academy Press.

National Science Foundation (NSF). (2002). "Workshop Report: Integrated Research in Risk Analysis and Decision Making in a Democratic Society." Workshop held in Arlington, Virginia, July 17-18, 2002. NSF03209. URL: www.nsf.gov/pubs/2003/nsf03209/nsf03209.pdf. Posted May 22, 2003.

Nigg, J. M. (1995). "Risk Communication and Warning Systems." Pp. 369-382 in T. Horlick-Jones, A. Amendola, and R. Casale (Eds.), *Natural Risk and Civil Protection*. London: E & FN Spon.

Nigg, J. M. (1987). "Communication and Behavior: Organizational and Individual Response to Warnings." Pp. 103-118 in R. Dynes, Bruna de Marchi, and Pelanda, C. (Eds.), *Sociology of Disasters: Contributions of Sociology to Disaster Research*. Milan, Italy: Franco Angeli.

Paul, B.K., Brock, V.T., Csiki, S. and Emerson, L. (2003). "Public Response to Tornado Warnings: A Comparative Study of the May 4, 2003 Tornadoes in Kansas, Missouri, and Tennessee." Quick Response Research Report No. 165, Natural Hazards Center, University of Colorado.

Peacock, W.G., and Girard, C. (1997). "Ethnic and Racial Inequalities in Hurricane Damage and Insurance Settlements." Pp. 171-190 in Peacock, W.G., Morrow, B.H., and Gladwin, H. (Eds.). *Hurricane Andrew: Ethnicity, Gender, and the Sociology of Disasters*. USA: Routledge.

Peacock, W.G., Morrow, B.H., and Gladwin, H. (Eds.). (1997). *Hurricane Andrew: Ethnicity, Gender, and the Sociology of Disasters*. USA: Routledge.

Pérez-Lugo, M. (2001). "The Mass Media and Disaster Awareness in Puerto Rico: A Case Study of the Floods in Barrio Tortugo." **Organization and Environment** Vol. 14, No. 1, p. 55-73.

Perry, R.W. and Greene, M.R. (1982). "The Role of Ethnicity in the Emergency Decision-Making Process." *Sociological Inquiry* 52 (4): 306-334.

Pew Research Center for the People and the Press. (2002). "Internet Sapping Broadcast News Audience." *Survey Reports*, Released on June 11, 2000. (<http://people-press.org/reports/display.php3?ReportID=36>, Sept/28/02).

Platt, R.H. (1999). *Disasters and Democracy: The Politics of Extreme Natural Events*. Washington, DC: Island Press.

Pielke, R.A. Jr. and Pielke, R.A. Sr. (1997). **Hurricanes: Their Nature and Impacts on Society**. New York: John Wiley and Sons.

Quarantelli, E.L. (2003). "A Social Science Research Agenda for the Disasters of the 21st Century: Theoretical, Methodological, and Empirical Issues and their Professional Implementation." Disaster Research Center, University of Delaware.

Quarantelli, E.L. (1994a). "Disaster Studies: The Consequences of the Historical Use of a Sociological Approach in the Development of Research." *International Journal of Mass Emergencies and Disasters* Vol. 12, No 1: 25-50.

Quarantelli, E.L. (1994b). "Draft of a Sociological Disaster Research Agenda for the Future: Theoretical, Methodological, and Empirical Issues." DRC Preliminary Paper No. 228, Disaster Research Center, University of Delaware.

Quarantelli, E.L. (1991). "Converting Disaster Scholarship into Effective Disaster Planning and Managing: Possibilities and Limitations." DRC Preliminary Paper No. 162, Disaster Research Center, University of Delaware.

Quarantelli, E.L. (1987). "What Should we Study?: Questions and Suggestions for Researchers About the Concept of Disasters." *International Journal of Mass Emergencies and Disasters* 5, 7-32.

Quarantelli, E.L. (1985). "The Need for Planning, Training, and Policy on Emergency Preparedness." DRC Preliminary Paper No. 101, Disaster Research Center, University of Delaware.

Rodríguez, H., Díaz, W., and Donner, W. (2004, Work in progress). "Technology, Weather Forecasts, and Warnings: A Perspective from the Oklahoma Emergency Management Organizations." DRC, University of Delaware.

Rodríguez, H. (2002). "¿Por qué los Desastres No Son "Naturales"?: Riesgo, Vulnerabilidad y Desastres en el Contexto Puertorriqueño" (Why are disasters not "natural." Risk, Vulnerability, and Disasters in the Puerto Rican Context". In Sonia Ruíz (ed.). *Themes in the Social Sciences*, Publications Office, College of Arts and Sciences, University of Puerto Rico-Mayagüez.

Rodríguez, H. (1997). "A Socioeconomic Analysis of Hurricanes in Puerto Rico: An Overview on Disaster Mitigation and Preparedness." Pp. 121-143 in Diaz, H.F. and Pulwarty, R.S., (Eds.). *Hurricanes: Climate and Socioeconomic Impacts*. Berlin, Heidelberg, New York: Springer.

Slovic, P. (2000). "Trust, Emotion, Sex, Politics and Sciences: Surveying the Risk-Assessment Battlefield." Pp. 390-412 in Slovic, P. (Ed.). *The Perception of Risk (Risk, Society and Policy Series)*. UK and USA: Earthscan Publications Ltd.

Slovic, P. (1993). "Perceived Risk, Trust, and Democracy: A Systems Perspective." *Risk Analysis* 13:675-682.

Slovic P., Flynn, J. and Layman, M. (1991). "Perceived Risk, Trust, and the Politics of Nuclear Waste." *Science* 254:1603-1607.

Steinberg, T. (2000). *Acts of God: The Unnatural History of Natural Disaster in America*. New York: Oxford University Press, Inc.

Sood, R., Stockdale, G., and Rogers, E.M. (1987). "How the News Media Operate in Natural Disasters." *Journal of Communications* 37(3):27-41.

Tierney, K.J., Lindell, M.K., and Perry, R.W. (2001). *Facing the Unexpected: Disaster Preparedness and Response in the United States*. Washington, DC: Joseph Henry Press.

Tierney, K.J. (1989). "Improving Theory and Research on Hazard Mitigation: Political Economy and Organizational Perspectives." *International Journal of Mass Emergencies and Disasters* 7, (3): 367-396.

Varley, A. (Ed.). (1994). *Disasters, Development, and the Environment*. New York: John Wiley and Sons.

Vatsa, K.S. (Forthcoming, 2004). "Risk, Vulnerability, and Asset-based Approach to Disaster Risk Management." *International Journal of Sociology and Social Policy*.

Waugh, W.L. Jr. (1988). "Current Policy and Implementation Issues in Disaster Preparedness." Pp. 111-125 in Louise K. Comfort (Ed.), *Managing Disaster: Strategies and Policy Perspectives*. Durham and London: Duke University Press.

Weber, E.U. and Hsee, C.K. (1998). "Cross-cultural Differences in Risk Perception but Cross-cultural Similarities in Attitudes Towards Risk. *Management Science* 44:1205-1217.

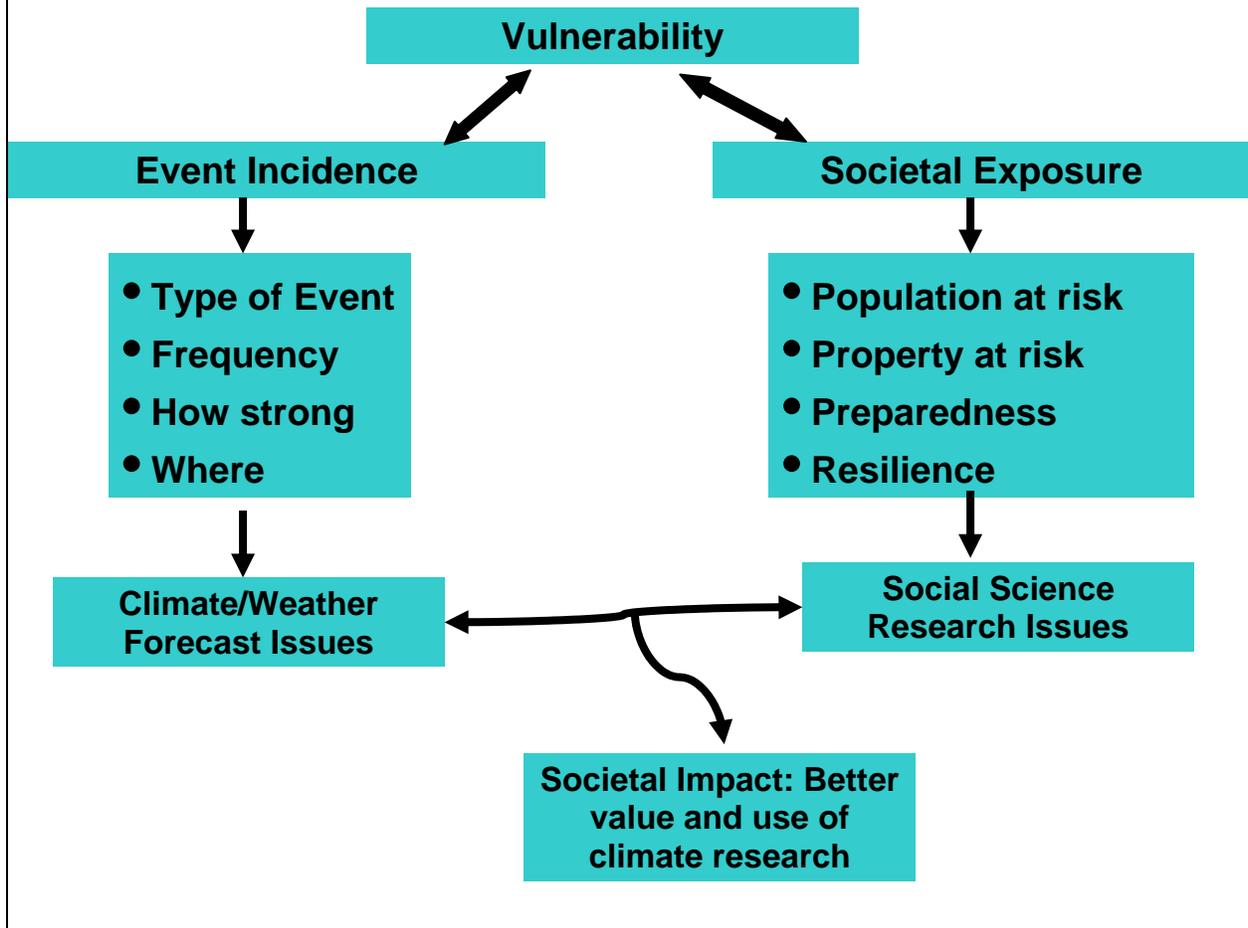
Wenger, D.E., Dyke, J.D., Sebok, Thomas, D. and Neff, J.L. (1980). "It's a Matter of Myths: An Empirical Examination of Individual Insight into Disaster Response." Pp. 65-78 in *Collective Behavior: A Source Book*. Meredith David Pugh (Ed.), New York: West Publishing Co.

White, G.F. (1974). *Natural Hazards: Local, National, Global*. New York: Oxford University Press.

Wijkman, A. and Timberlake, L. (1988). *Natural Disasters: Acts of God or Acts of Man?* Philadelphia, PA: New Society Publishers.

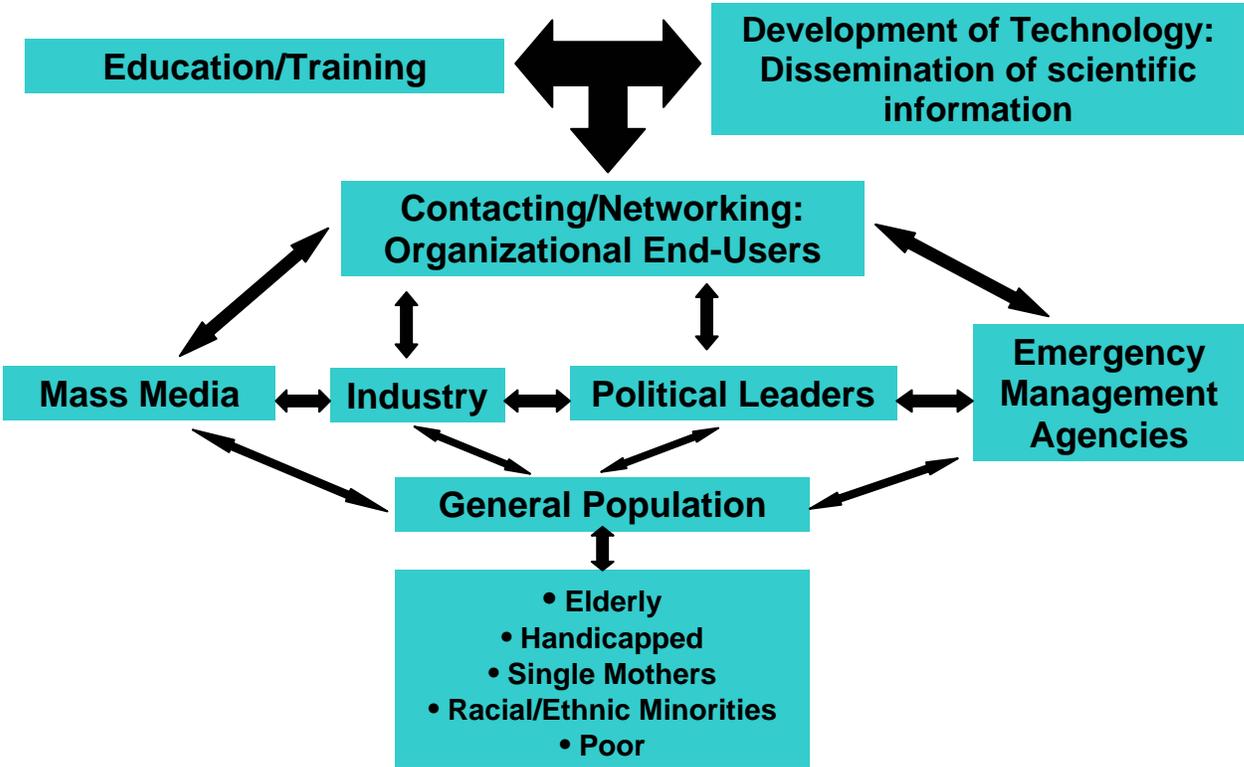
Wildavsky, A. (1979). *Speaking the Truth to Power: The Art and Craft of Policy Analysis*. Boston: Little Brown.

Figure 1: A Vulnerability Model*



* This model builds and expands on Pielke and Pielke's (1997) detailed elaboration on vulnerability.

Figure 2: A Model for Communicating Hazard Risk and Warnings



Note: This is a modified model based on Nigg's (1995) Components of an Integrated Warning System.