Evolving Approaches to Understanding Natural Hazards

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Edited by

Graham A. Tobin and Burrell E. Montz

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The editors would like to thank all those who have participated in the Applied Geography Conferences over the years. The conference began in 1978 established thanks to the efforts of John Frazier and Bart Epstein who saw the need for applied research that focused on societal problems and their solutions. The conference has published 36 volumes (1978 and 2013) edited by a number of scholars: Tom Bell, Dawna Cerney, Bart Epstein, John Frazier, Ed Hillsman, John Harrington, Lisa Harrington, Ken Jones, Jay Lee, Dennis Lord, Burrell Montz, Henry Moon, Andy Schoolmaster, and Graham Tobin. In addition, we are grateful to the many reviewers who have spent time going through articles and of course the paper presenters, all of whom have added to the quality of the Applied Geography Conferences.

Burrell E. Montz
Graham A. Tobin

CHAPTER ONE

NATURAL HAZARDS: EVOLVING APPROACHES

BURRELL E. MONTZ AND GRAHAM A. TOBIN

Introduction

The 21st century presents many challenges to the hazard manager; dynamic climatic conditions, with many possible outcomes, combined with seemingly unlimited population growth, rapid urbanization and changing socio-economic relationships are reshaping disaster impacts, community responses, and social safety mechanisms. Indeed, the many facets of human vulnerability are being constantly restructured with the ongoing interplay of the physical environment and social, economic and political forces (Montz and Tobin, 2012; Tobin and Montz, 2009). At the same time, reducing vulnerability and enhancing community resilience require policies aimed at mitigating the consequences of disasters as they affect different locations and different groups. As a result, sound scientifically-based research of an interdisciplinary nature is required to further our understanding of the forces at play, and to devise appropriate means to counter them (Montz and Tobin, 2012).

There is a kaleidoscope of realities to confront and one set of strategies will not fit every geographic location, social, political, and economic context. Our models must be flexible to address such moving targets and at the same time provide an understanding of the interactions between people, natural hazards, and disaster events. These are issues that have been addressed for some time, and we have made progress – but there is much more to be done. It is in this context that we look at evolving approaches to natural hazards.

Evolving Traditions

Research into natural hazards has had a long tradition beginning with a focus on physical processes and gradually evolving into a full-blown interdisciplinary agenda with the recognition of the interactions between the physical and human environments. It was Gilbert White's pioneering work (see White, 1945; 1961; 1964; White et al., 1958) that demonstrated unambiguously the fundamental significance of the human element in determining disaster settings and outcomes. As a result, the hazard agenda now embraces initiatives ranging from the physical, to the socio-economic, to the political, and incorporates a broad array of methodological approaches and technological advances, and employing both quantitative and qualitative procedures.

For much of the second half of the twentieth century, hazards research adopted two foci: 1) furthering knowledge of the physical and spatial dimensions of natural events and 2) understanding individual decision-making and responses to natural hazards and disasters (Montz and Tobin, 2012). Much of this research was applied, seeking to solve societal problems -- a laudable goal but for many academics it lacked a sound theoretical foundation (Alexander, 1997; Hewitt, 1997) and tended to overlook the systemic causes of disasters (Pidgeon et al., 2003). As the twentieth century progressed, these criticisms were addressed and increasingly research was directed at understanding differences in human vulnerability and community resilience (Cutter et al., 2003; Smith and Petley, 2009; Tobin and Montz, 1997).

These concepts, firmly established by Blaikie et al. (1994) (see also Wisner et al., 2004), have now become the *modus operandi* for much hazard research. Montz et al. (2004) demonstrated that hazards research had evolved from looking at individual risks and one-off, extreme events, to understanding complex events that include political, social, and economic forces that impact the vulnerability of individuals and communities, to a range of hazards at different geographic scales and at various governmental levels. Disasters, therefore, are now understood to have systemic root causes embodied in socio-economic and political systems that place people, often marginalized groups, in hazardous locations, in unsafe structures, and with few resources available for them to respond with security to events. There has indeed been a paradigm shift, turning attention to more general principles of hazardousness, risk, vulnerability, and resilience. Part I of this book reflects this shift, with papers that illustrate the changing approaches to the study of risk and vulnerability.

At the same time as concepts of hazards, vulnerability and risk were evolving, so too were new technologies coming to the fore which vastly increased the arsenal of tools available to the researcher and practitioner. The development and expansion of geographical information systems (GIS) have provided new ways to explore multiple aspects of hazards and disasters. Investigations of dynamic forces, whether they are geophysical, social, economic or political, can now be visually represented over time and space. In addition, improvements in statistical techniques that examine spatial patterns and correlations have brought a scientific rigor to many studies. Along with GIS, the refinement of remote sensing, such as LiDAR, now promote more sophisticated models of landforms and human activities. Furthermore, others have utilized web-based resources and sophisticated statistical modeling to further academic and practical advances in hazards research. In Part II of the book, the reader will find examples of articles that incorporate these technologies as they have been applied to hazards research over several decades.

The combination of these new hazard concepts and frameworks and the incorporation of innovative technologies and analytical techniques has encouraged a more systematic approach to problem solving. Applied research has taken a prominent place in the academy as hazard researchers have sought to explain and ultimately reduce the impacts of disasters. Questions regarding appropriate mitigation practices that account for both the geophysical event and the human landscape have been addressed. For example, consider the nature of hazards, both those which have long been the subject of geographic research, such as floods, earthquakes, hurricanes, and tornadoes, and those which have more recently been recognized to be of increasing significance. These include slow-onset, pervasive hazards such as drought, chronic hazards associated with continued exposure to, for example, repeated ash-fall from relatively frequent volcanic eruptions, and changing hazardousness due to climate change. How do we mitigate these impacts? In a way, we have come full circle; White's arguments are just as pertinent today as they were in the mid-twentieth century. The advantage we have now, however, is superior technology and a better grasp of those root causes and conditions that exacerbate or ameliorate disaster impacts, risk, vulnerability and resilience. In Part III of the book, therefore, we provide some articles to illustrate how impacts and mitigation have been examined by geographic scholars.

The collection of papers included in this book offers the reader insight into the development of applied hazards research, as it has built on previous work, evolving technologies, improved understanding of the factors involved, and increased awareness of the needs of those who make decisions with respect to hazard management. The interplay of factors contributing to disaster losses has become ever more complex, as too has our ability to incorporate those complexities into a coherent response strategy, as we strive to reduce losses and increase resilience. It is hoped that this volume provides not only an appreciation for the foundation that has been set (as illustrated by the examples here), but also inspires future researchers as they look to address these very pressing issues.

Editors' Note: Because the papers included in this volume cover more than three decades of hazards research, tools, techniques, and even office software have changed significantly. As a result, the figures included in the chapters are of the best quality possible. Tables could be recreated but figures could not, explaining the variable quality of figures found in this volume.

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PART I

RISK AND VULNERABILITY

INTRODUCTORY COMMENTS

GRAHAM A. TOBIN AND BURRELL E. MONTZ

As hazards research has evolved, both risk and vulnerability have evolved into key themes that now dominate the literature. In this regard, much attention has been paid to establishing and further developing a sound conceptual foundation for understanding, differentiating, characterizing, and measuring risk and vulnerability. At the same time, recognition of the significance of addressing both risk and vulnerability, separately and in combination, in emergency management, hazard mitigation, and loss reduction has captured the attention of applied geographers. The collection of papers in this section illustrates the varying concerns, methodologies, and approaches through which both risk and vulnerability have been studied.

The first two papers in this section, originally published in 2001 and 2002 respectively, set the stage by focusing on risk as created by the interplay of forces of the geophysical environment and human vulnerability as defined by the locations of populations. Mulligan and Barbato mapped frequency and spatial distribution of tornadoes in the state of Texas to evaluate patterns of risk while Springer and Blanchard-Boehm evaluated differing perceptions of risk to flooding in one Texas city, San Marcos. This article is centered on risk communication, arguing that only through understanding of the risk perceptions of different ethnic groups can the risk be successfully communicated. A year later, we incorporated both geo-physical risk and socio-economic vulnerability and found that, at least in the Tampa, Florida region, vulnerable populations do not live in the most hazardous locations – contrary to what had often been assumed. Together, the case studies in these three papers reflect important aspects of understanding risk and vulnerability: what is likely to happen where, to whom, and how might that influence emergency management.

The next set of papers in this section was originally published in 2006 and 2007 and focuses on how we might characterize risk and how people understand the risk to which they are exposed. Erik Bowles makes the case for a classification scheme for heat stress, as a means of communicating the potential risk. He also undertook an analysis of the frequency and probability of heat stress occurrences for the study area – again with an eye to communicating risk. This theme is followed later in Bell's work that evaluates how different ways of describing or defining the 100-year flood influences perceptions of risk. Communicating risk is based on understanding both the nature of the hazard and the characteristics and perceptions of the populations who are at risk. Webb focused on the elderly in Columbia County, Pennsylvania, an area that has a long flood history. One would probably assume, then, that the elderly understand the risks to which they are exposed, given their longevity in the county – however, this proves not to be the case. These findings have important applications to emergency management and planning. In her contribution, He evaluates the risk perceptions and vulnerability of international students – an often overlooked segment of the population. Knowing that both local knowledge and social networks can be important to understanding one's risk and preparation options, she presents and tests a model to explain the evacuation decisions of international students. The theme of local knowledge, social networks and evacuation decisions is continued in the research that Tobin and his colleagues undertook in Mexico, in this case with respect to risk from a chronic hazard, a volcano.

Published between 2009 and 2012, the final set of papers in this section, all of which are GIS-based, addresses measurement questions in evaluating both risk and vulnerability, each based on the argument that differing emphases on one or another of the relevant variables contributing to risk or vulnerability will lead to different results. Together, these papers make the case that significant thought and care must be used in selecting and measuring variables. Abel and Lein evaluated the extent to which anticipated patterns of losses, as determined by vulnerability maps developed using varying weighting strategies, compared to actual losses following Hurricane Katrina in New Orleans. Similarly, using one county in Texas, Liu and Gong illustrate how focusing on different socio-economic characteristics leads to very different spatial patterns of vulnerability. Finally, Wu and Lu sought to refine the spatial prediction of frequencies and probabilities of hurricane strikes in South Carolina in order to assist emergency managers, planners, and insurance companies with detailed spatial information that has direct application to their responsibilities. Their results clearly illustrate the spatial dimensions of risk to hurricanes.

Taken together, the papers in this section cover spatial and perceptual aspects of risk and vulnerability to a range of hazards, with various applications to emergency management, hazard mitigation, and planning. The methods used, including GIS, surveys, and focus groups, and the case study approach are common to hazards research as it has been undertaken for decades. The lessons learned from the papers presented here have influenced subsequent research as we continue to improve our understanding of risks and vulnerabilities as they play out in different places.

CHAPTER TWO

THE MAGNITUDE, FREQUENCY, AND SPATIAL DISTRIBUTION OF TORNADOES IN TEXAS: AN ASSESSMENT OF TORNADO RISK*

KEVIN R. MULLIGAN, LUCIA S. BARBATO AND STEPHEN WEINBECK

Introduction

Understanding the risk posed by tornadoes is an important component of emergency planning and management efforts. In any given year tornadoes have the potential to cause millions of dollars in property damage and, in some cases, a significant number of injuries or loss of life. To understand the risk posed by tornadoes, it is important to understand the frequency and spatial distribution of tornadoes of varying magnitudes. Moreover, any assessment of tornado risk must take into account the density and spatial distribution of the population.

The purpose of this paper is to analyze the magnitude, frequency and spatial distribution of tornadoes in the State of Texas and then apply this knowledge to an assessment of tornado risk. In the first part of this paper, maps are generated to show the spatial distribution of tornadoes in the state. These data are then used to create a map showing the density of strong or violent tornadoes by county. The aim is to identify those regions of the state that have a higher probability of significant tornadoes.

In the second part of this paper, the county tornado data are combined with county population data to create a spatial model of tornado risk. The purpose of this analysis is to create a composite variable for tornado risk that takes into account: 1) the historical frequency of strong or violent

* *Papers and Proceedings of the Applied Geography Conferences (2001) 24: 121-129*

tornado events, and 2) the likelihood that a tornado will cause significant property damage, injuries, or loss of life, given the population density within a county.

Tornado Data

Background

In 1987, Fujita published an exceptional map showing the spatial distribution of tornadoes in the United States (Fujita, 1987). The map was based on a dataset containing the magnitudes and locations of 23,264 tornadoes observed between 1930 and 1978. Given such a large dataset, the map was exceptional insofar as each tornado event was mapped by hand and the map took three years to construct.

After Fujita's tornado map was completed, the University of Chicago Tornado Tape became available (Fujita, 1987). This dataset included the magnitudes and locations of 31,054 tornadoes observed between 1916 and 1985. Subsequently, Fujita used this dataset to produce computer generated grid-point tornado maps. Although Fujita used these grid-point maps to analyze both the spatial and temporal distribution of tornadoes in the United States, by today's standards, these maps appear unrefined and are difficult to interpret.

In addition to Fujita's classic work, Grazulis has published what is perhaps the most comprehensive description of tornadoes in the United States (Grazulis, 1990). In the first volume of *Significant Tornadoes*, Grazulis provides a comprehensive analysis describing the spatial distribution of tornadoes mapped by state. In the second volume, Grazulis provides an exceptional chronology of tornadoes. In this volume, the author describes the location, time of day, magnitude, path length and width, and the damage associated with every known significant tornado in the United States from 1880 to 1989.

The SPC Tornado Archive

Although the books authored by Fujita and Grazulis provide an excellent foundation for understanding the spatial and temporal distribution of tornadoes in the United States, it is difficult to analyze the original tornado data because these data are not readily available in a digital format (Fujita, 1987; Grazulis 1990). To overcome this problem, digital tornado data were obtained from the NOAA Storm Prediction Center (SPC). A project was then undertaken to assemble a tornado