Chapter 1 Introduction to Hazards Analysis

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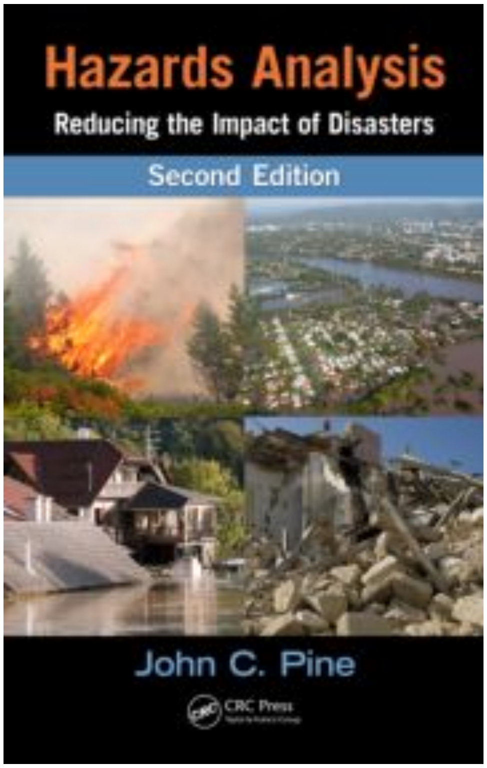

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CHAPTER 1

INTRODUCTION TO HAZARDS ANALYSIS

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Objectives

The study of this chapter will enable you to:

1. Clarify why hazards analysis is critical reducing losses from disasters.
2. Compare and contrast hazards terminology.
3. Examine extreme events as a primary driver of disasters and community losses.
4. Explain alternative hazard paradigms that include social, political, economic and environmental systems.
5. Define the hazards analysis process and its links to hazards risk management and comprehensive emergency management.
6. Explain why communicating risk is so critical in a hazards analysis.

Key Terms

Hazards
Disaster
Community
Vulnerability
Hazards Analysis
Vulnerability Assessment
Consequence Assessment
Risk

Issue

What factors influence how public officials and agencies and businesses understand the nature of hazards and their impacts?

Introduction

Disasters are natural and human caused events that have the potential to cause damage to a community, region or a nation. Events associated with a disaster can overwhelm response resources and have damaging economic, social or environmental impacts. The capacity of a community, region or nation to deal with disaster impacts provides a basis for characterizing and classifying an event as a crisis which must be addressed by local resources or that requires outside assistance and support. The process of assessing the nature and impacts of hazards as well as strategies for mitigating or adapting to potential adverse impacts from a disaster is the foundation of hazards analysis. Hazards analysis provides a comprehensive fact base for the development of emergency preparedness, response and recovery plans as well as the establishment of comprehensive community goals and public policies. Unfortunately, few communities have established a comprehensive hazards analysis framework to ensure that lead to sustainable and resilient communities (Shoubridge 2012).

Over the past twenty-five years, we have seen escalating costs associated with the direct economic impacts of natural disasters. Although the number of injuries and causalities has been dropping in recent years, the property damage has increased dramatically (Abramovitz 2001; Mileti 1999). Mileti notes that disaster losses have been increasing and will likely in the future (1999). He sees that damages will grow to an average of $50 billion annually—about $1 billion per week. Some experts believe that this is a relatively conservative estimate of losses since there is little inclusion of indirect losses (i.e., loss of jobs, market share, productivity, etc.). Mendes-Victor and Goncalves (2012) note that "disasters are not natural; they are also consequences of decision, often seemingly unconnected to their ultimate consequences, of collectivities of people, and are caused by their inability or unwillingness to adopt sustainable patterns of living.

The rising cost of disasters has also paralleled the movements of our population to coastal regions thus increasing their vulnerability to hazards. In addition, we have seen widespread adverse impacts of disasters in the form of massive displacement, economic losses, and suffering from all parts of our society. Hurricane Katrina in 2005, Irene in 2010 and Sandy in 2013 clearly demonstrated that many members of our community suffered from the flooding and storm surge. Post storm after action reports have consistently noted that governments at all levels were ill prepared to deal with such a massive disaster.

This book challenges us to first examine the nature of a community and the hazards that could impact our social, economic and ecological systems. In addition we identify an approach to the development of a broad based hazard risk management strategy to reduce risk and mitigate losses. This book provides a framework for identifying and understanding hazards and vulnerabilities, as well as the need for risk management and mitigation strategies for building sustainable and resilient communities.

Terminology of Hazards

The concepts of hazards and risks include multiple definitions of key terms such as "hazards," "disaster", "risk assessment," and "hazards analysis." The terms are complex and may require clarification as drivers of natural and human caused disasters evolve. Many experts who study hazards, disasters and risks acknowledge that our use of many terms has changed. For example, Kaplan describes two theorems of communication, which explain the confusion resulting from different and conflicting definitions of terms used in risk analysis and assessment (1997). The theorems state the following: Theorem (1) 50 percent of the problems in the world result from people using the same words with different meanings; Theorem (2) the other 50 percent comes from people using different words with the same meaning. This confusion has lead to organizations such as the Federal Emergency Management Agency (FEMA) and the

International Association of Emergency Managers (IAEM), the United States Environmental Protection Agency (1986), and other federal agencies to increase the professionalism in the field, by recognizing the need for a common set of definitions.

A hazard refers to a potential harm that threatens our social, economic and natural capital on a community, region, or country scale. Hazards may refer to many types of natural events (flood, hurricane, earthquake, wild fires, etc.), technological (hazardous materials spills, nuclear accident, power outage, etc.) or are human induced (bio-chemical, bombing, weapons, mass destruction, or terrorism, etc.). Compounded hazards are those that result from a combination of the above hazard types such as urban fires resulting from earthquakes, failures of dams or levees that result from flooding, or landslides that result from wildfires and heavy rains.

FEMA describes hazards as "events or physical conditions that have the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural losses, damage to the environment, interruption of business, or other types of harm or loss (1997)." A hazard may be measured by its physical characteristics, likelihood, or consequences. Water from heavy rains, levee breach or dam break would be the source of the hazard. The likelihood could be considered a low risk or not likely; it could be a medium risk or one that has a high likelihood of occurring. A hazard has the potential to cause fatalities, injuries, property damage, infrastructure or agricultural loss, damage to the environment, interruption of business, or other types of harm.

Cutter notes that hazards evolve from interactions between natural, human and technological systems (2001) but are also characterized by the areas of their origin. For example the hazard may arise from a hurricane but flooding magnified not only from excessive rainfall but also by long term non-sustainable agricultural or forest practices. Since a disaster could evolve from the interactions between social, natural and technological systems, the classification of a complex hazard could be difficult. As a further illustration of the difficulty in classifying disasters, a hurricane or flood occurring in a community might also lead to an accidental release of a hazardous chemical from a container in floodwaters. In this case, we have the potential of two disasters – one natural and the second human caused or technological in nature. This suggests that we view hazards within a broader social, political, historic, economic and environmental context to fully appreciate how hazards can cause damage to community resources.

The International Strategy for Disaster Reduction (2004 and 2010) defines a disaster as, "a serious disruption of the functioning of society, causing widespread human, material, or environmental losses which exceed the ability of affected society to cope using only its own resources (United Nations 1992)." All disasters, small or large, are the result of a hazard being realized. There is a caveat to this definition, however, in that the realized hazard must overwhelm the response capability of a community to be considered disastrous (FEMA 1997).

Pierce (2000) suggests that any definition of disaster must reflect a given locality's capacity to respond. He goes on to state that the hazard event must be unusual and that the social, economic, political, and ecological impacts must be significant. He defines disasters:

"A disaster is a non-routine event that exceeds the capacity of the affected area to respond to it in such a way as to save lives; to preserve property; and to maintain the social, ecological, economic, and political stability of the affected region (p. 87)."

Disasters are measured in terms of lives lost, injuries sustained, or property damaged, and must be distinguished from routine emergency events that can result in property damage or fatalities. For instance, a house fire may require a response by a jurisdiction's fire department and result in loss of life or property. However, as fires are common emergency occurrences, they are managed by local response agencies and are normally not considered a disaster. For a fire to be considered a disaster, it must overwhelm the capacity of the local responders. Common breakdown of hazards include atmospheric climatic hazards such as rain, lightning, snow, wind and dust storms, hailstorms, snow avalanches, heat waves, hail, snowstorms and fog (Bryant 2005; FEMA 1997; and Hewitt 1983). They also include geologic and seismic hazards such as landslides, avalanches, land subsidence, erosion, earthquakes, tsunamis, and volcanic and shifting sands. Hydrologic hazards make up the third type of natural hazard and include events such as flooding, storm surges, coastal erosion, waves, sea ice and sea level rise. Hewitt explains that compounded hazards include tropical cyclones, thunder storms, white-outs, tornadoes, rain and wind storms, blizzards, drought, freezing rains and wild fires; each combines several natural hazards and are not just the result from a single hazard (1998). Not all hazards result in disasters, for a hazard event could decrease potential damaging impacts so as to minimize losses (Gruntfest et al. 1978; Lindell and Meier 1994; and Hewitt 1997). The rate or speed of onset of the event could give communities notice needed to minimize deaths and injuries by ordering an evacuation for a flooded area. Availability of perceptual cues (such as wind, rain, or ground movement) provides notice of a pending disaster. The intensity of a disaster could vary spatially so as to have damage impacts in areas with no social or economic impacts. Technology such as weather radar allows us to see where a heavy storm is moving so as to provide warning to the local area. The areal extent of the damage zone or its size (geographic area influenced) and its duration could influence any damaging impacts and the community's capacity to deal with the hazard event. Wind damage from a tornado could be limited to non-populated areas and not cause injuries, or property damage. Finally, the predictability of the event or notice of occurrence is also critical in allowing those affected by the event to seek safety**.** Despite our efforts to reduce our vulnerability to disasters, we see that property losses, deaths and injuries continue to increase. Numerous studies have documented that increased losses are growing (Abramovitz 2001 and Mileti 1999).

1. Population growth in high hazard areas.
2. Marginalized land is being developed making us more susceptible to hazard impacts.
3. Larger concentrated populations in urbanized areas increase the potential for human and property loss; people are less familiar with hazards in their surroundings;

growth may not be ecologically sustainable; more buildings and infrastructure may be damaged if an event occurs.

4. Inequality: people are not impacted by hazards equally; economic disparities cause large numbers of impoverished people to be at risk.
5. Climate change: immense potential for loss as sea levels rise; weather and climate patterns will change.
6. Political change: political unrest can directly cause loss (e.g., civil war) and/or make a region more susceptible to hazard impact due to lack of preparedness and/or inability to cope.
7. Economic growth: directly related to technological hazards, producing increased levels of many pollutants; usually results in fewer deaths from hazards, but increased economic loss; more property is at risk to hazards, but preparedness and mitigation measures minimize loss of human life.

Today we see significant disruptions in social, economic and natural systems that are associated with policies and practices that evolve over different time frames. Economic disruptions can result from short-term economic drivers or prospective losses that may be associated with evolving natural conditions associated with climate change.

The terms "risk" and "hazard"' are often used interchangeably and inconsistently. Differences result as emergency managers, risk managers, urban and regional planners, insurance specialists, and lay people develop meaning of the terms independently. These definitions can even be in conflict with each other. For example, it is not uncommon for the word risk to be used informally in a way that means 'venture' or 'opportunity', whereas in the field of risk management the connotation is always negative (Jardin 1997). However, even among risk managers, the exact definition of risk varies considerably (Kedar 1970).

The risk of disaster is typically described in terms of the probabilities of events occurring within a specified period of time, e.g., five, ten, or twenty years, a specific magnitude or intensity (or higher) or a range such as low, medium or high risk. For example, the risk of floods is commonly described by FEMA in terms of 100- and 500-year floods, indicating the average frequency of major flooding over those periods of time and the maximum area that has been inundated each time. Risk has the common meaning of danger (involuntary exposure to harm), peril (voluntary exposure to harm), venture (a business enterprise), and opportunity (positive connotation – it is worth attempting something if there is potential for gain). In a business context, it refers to probability considerations but is primarily concerned with uncertainty.

Views of Extreme Natural Events as Primary Causes of Disasters

Tobin and Montz (1997) provide a very insightful perspective on how we might view natural hazards and disasters. They see that one way of viewing disasters is that all or almost all responsibility for disasters and their impacts are attributed to the processes of the geophysical world. In this approach, the root cause of death and destruction is caused by extreme natural events rather than human interface with the environment. Under this view of disasters, those who suffer losses are seen as powerless victims who have limited control and simply react to the immediate physical forces and processes associated with disasters. The physical world is thus viewed as external force, separate from human actions. This perspective was noted by Burton and Kates (1978) who see natural hazards as elements of the physical environment harmful to man and caused by forces external to him.

This perspective of disasters from Tobin and Montz is significant for the outputs of a hazards analysis. If the view of individuals in a high-risk area is just limited to the physical world, then there is little that can be done to minimize destructive hazard impacts. Quarantelli notes his early views of disasters and their origins. "The earliest workers in the area, including myself, with little conscious thought and accepting common sense views, initially accepted as a prototype model the notion that disasters were an outside attack upon social systems that 'broke down' in the face of such an assault from outside." (1998: 266)

Cook et al. (2009) comment on the linkages between natural and human systems in characterizing hazards as natural events. They examined the dust bowl drought as a human induced land degradation event rather than a natural disaster.

Steinberg (2000) also commented on this view of nature and disasters as extreme events that are beyond our control.

> "…[T]hese events are understood by scientists, the media, and technocrats as primarily accidents – unexpected, unpredictable happenings that are the price of doing business on this planet. Seen as freak events cut off from people's everyday interactions with the environment, they are positioned outside the moral compass of our culture." (2000: xix)

This view of how people view hazards is clarified by the concept of "bounded rationality," inadequate information and ability to make sound choices in the face of risk. Tobin and Montz clarify its application to disasters by explaining that "bounded rationality" refers to the fact that "behavior is generally rational or logical but is limited by perception and prior knowledge" (1997: 5). Burton et al note "…[I]t is rare indeed that individuals have access to full information in appraising either natural events or alternative courses of action. Even if they were to have such information, they would have trouble processing it and taking appropriate action to reduce losses. The bounds on rational choice is dealing with natural hazards, as with all human decisions, are numerous." (1978: 52).

An integrated assessment of risks focuses on risks from salinization, typhoon and flood, sedimentation, coastal erosion, sand drift, sea level rise, earthquake, environmental contamination, or land cracking. This type of assessment integrates multi-hazard process for a community. Schmidt et al. (2011) notes that fed studies have addressed multi-risk assessments including alternative hazard types and their impacts. Their approach provides for an assessment of alternative hazards and their impacts but does not an integrated multi-risk assessment process.

A Changing Hazard Paradigm

Our efforts to understand the nature of hazards, their impacts, the likelihood of their occurrence, and how we use this information in hazard mitigation or other public policy decisions has resulted in alternative approaches to hazards analysis. FEMA and later the NT1 approach suggests a data based quantitative emphasis on the characteristics of potential hazards, their likelihood of occurrence, and a prioritization of alternatives to address threats. A hazard in this context is viewed in single events with specific causal events.

A more quantitative approach to assessing risk was stressed by the National Research Council (1983). This approach has four elements including: risk identification, dose response assessment, exposure assessment and risk characterization. This model was used as the standard beginning in 1980 as part of the Superfund legislation and institutionalized as part of the evaluation of abandoned superfund sites. This emphasis on quantitative analysis is also reflected in United Nations vulnerability and risk assessment processes (Coburn 1994). Cutter notes that most risk assessments used probability estimators and other statistical techniques (2003). The United States Environmental Protection Agency's (EPA) approach was broadened in 1987 to look beyond just exposure as its carcinogenic potential to look at non-cancer human health risk, ecological risk and welfare risk. This process was revised in 2001 and characterized as a "relative-risk" approach that moved away from pollution control and technology fixes to one of risk reduction and sustainable approaches to pollution management. A comparative risk analysis process is now used as a basis for environmental policy priority setting (Davies 1996) and an even broader examination of ecological risk is included in many risk assessments.

Cutter (2003) notes that these processes for risk assessment are fraught with methodology concerns that include uncertainty especially with variability in individuals and ecosystems, and limited environmental data. Risk assessments must link good science with communities. This broader view of risk that includes communication and interaction between the scientist and those impacted by the assessment of hazards is very constructive.

Gaikie et al. examines disasters and their adverse impacts in two ways (1994). Two alternative models are provided to explain the complex nature of hazards and their impacts. A pressure and release model (PAR) examines the relationship between processes and dynamics that bring about unsafe conditions and their interface with disaster events such as earthquakes, floods, or tropical cyclones. The emphasis in the PAR is the driving social forces and conditions that bring about vulnerability of people in place. The second model emphasizes access to resources and takes into consideration the role of both political and economic conditions as the basic causes of unsafe conditions. Bull-Kamanga et al. stress the importance of local processes for risk identification and reduction (2003). The need for a hazards analysis to include local players enriches an accurate characterization of both the community and local conditions that may influence disaster impacts. The emphasis on underlying social conditions and its role in hazards analysis is also stressed by Weichselgartner (2001). In his view, a disaster is a product of a cumulative set of human decisions over long periods and that these decisions either create greater risk or reduce risk. Mitigation must stress the underlying human conditions and not just adjust the physical environment. Vulnerability analysis thus must take a broad view of the conditions that are present prior to a disaster as well as the physical environment of a community and the characteristics of the hazard.

Critical Thinking: We build levees and flood walls, establish building codes and base flood elevations in an effort to protect property from hazards. How can hazards analysis help to foster greater awareness of risks associated with hazards? How can a hazards analysis have a constructive influence on decision-making at the individual, family, and community levels?

Cutter (1996, 1997, 2003, and 2010) also suggests a broader perspective is needed to fully appreciate the complexities associated with hazards and their numerous impacts. This hazards of place model of vulnerability involves a comprehensive understanding of hazard potential along with an examination of the geographic context, social conditions and both biophysical and social vulnerability. A place based view of vulnerability is then determined from these elements. A set of indicators can be used to examine vulnerability and take into account population variables, infrastructure lifelines. The goal in this approach is to assess social vulnerability and community sustainability for response and recovery. Cutter stresses that in order to understand a community's hazard potential, one must consider that a disaster is influenced by socioeconomic indicators, individual characteristics, and the community's geographic context impacted by the hazard (1996). Others have also developed criteria to examine community sustainability. Miles and Chang (2006) examine community recovery capacity by using social and infrastructure variables. They stress the need for modeling recovery processes in understanding community resiliency capacity.

An emphasis of modeling hazards and measuring the resilience of communities is also seen in Bruneau (et al. 2003). The quantitative measures combined with characterization of a hazard results in information that may be used in guiding mitigation and preparedness efforts. Their measurement of the local community centers around four characteristics including: robustness of systems to withstand loss of function; redundancy of elements of the system to suffer loss; resourcefulness and the capacity to mobilize resources when the system is threatened; and rapidity or the speed to achieve goals in a timely manner.

Hazards Analysis

There are many perspectives on "hazard analysis" which vary from FEMA's approach of knowing what could happen, the likelihood of it and having some idea of the magnitude of the problems that could arise (FEMA 1983). FEMA's introduction of the HAZUS modeling software in 1997 reflects their interest in physical processes at the community or regional level (1997). This approach, unfortunately is limited to modeling one hazard at a time and fails to address a multi-hazard environment (Cutter 1996). A process approach to hazards analysis addresses adverse impacts of hazards (Long and John 1993) and stresses the role of hazard identification, risk screening and the development of mitigation measures to control losses. The Coastal Engineering Research Center and the University of Virginia along with the USGS used a quantitative hazards analysis approach in examining risk and exposure to coastal hazards

(Anders et al. 1989). They evaluated the U.S. coastline for risk and exposure to coastal hazards by examining the characteristics of the hazards, coastal geographic features, population demographics, and civic infrastructure.

Researchers from Oak Ridge National Laboratory identified a coastal vulnerability index that includes risks from sea level rise in coastal communities (Daniels et al. 1992; Gornitz and White 1992; and Gornitz et al. 1994). This study weighed the characteristics of coastal hazards, local geographic conditions, and the likelihood of extreme weather impacting local areas. Their approach to hazards analysis focused on characteristics of the hazard event, local geographic conditions, and demographic factors. They emphasized the use of model outputs in mitigating disaster impacts. Multi-hazard impacts were examined by Preuss and Hebenstreit (1991) to understand the impacts of both earthquakes and associated tsunami flood events. This risk-based urban planning approach was designed to allow assignment of risk factors for vulnerabilities on a community basis.

The United States Environmental Protection Agency along with fourteen other Federal Agencies adopted a common approach to community level hazards analysis and planning (1987). This approach uses a process format in providing communities with a broad understanding of hazards and risks. NRT-1 defines hazard analysis as a three-step process: (1) hazard identification, (2) vulnerability analysis, and (3) risk analysis. This approach to hazards analysis stresses the need for broad based information to support community decision making to reduce vulnerability and minimize risk to people and property.

Hazards Analysis		
Hazards Identification	**Vulnerability Analysis**	**Risk Analysis**
Identify hazard	Vulnerability zone	Likelihood of incident
Location	Human populations	Severity
Quantity of chemical	Critical facilities	Consequences
Nature of hazards	Environment	

Figure 1-1: U.S. Environmental Protection Agency Hazards Analysis Process

Critical Thinking: How do you ensure that an analysis of hazards is comprehensive and the potential impacts are sensitive to human, cultural, economic, political and natural systems?

Hazard Identification

Hazards identification as noted in Figure 1-1 provides specific information on the nature and characteristics of the hazardous event and the community. It further examines an event's potential for causing injury to life or damage to property and the environment. Hazard Identification takes advantage of the use of environmental modeling to characterize hazards and disaster impacts. As part of the EPA hazards analysis process, community involvement is encouraged through a broad based team represented by local response agencies, the media, community public health units, medical treatment organizations, schools, public safety and businesses. The formation of local emergency planning committees provides the basis for broad input in preparedness efforts.

Vulnerability Analysis

Vulnerability analysis in Figure 1-1 is a measure of a community's propensity to incur loss. Vulnerability analysis may focus on physical, political, economic and social vulnerability. Vulnerability is, in other words, the susceptibility to hazard risks. Vulnerability can also be a measure of resilience. According to Emergency Management Australia (2000), vulnerability is "The degree of susceptibility and resilience of the community and environment to hazards". Vulnerability analysis identifies the geographic areas that may be affected, individuals who may be subject to injury or death, and what facilities, property, or environment may be susceptible to damage from the event.

1. The extent of the vulnerable zones (i.e., an estimation of the area that may be affected in a significant way);
2. The population, in terms of numbers, density, and types of individuals (e.g., employees; neighborhood residents; people in hospitals, schools, nursing homes, prisons, and day care centers) that could be within a vulnerable zone.

Vulnerability analysis as viewed by EPA examines who and what is vulnerable and why (1986).

Critical Thinking: What types of private and public property might be damaged in a natural or human caused disaster? What essential support systems (e.g., communication or public services) and facilities and corridors could be affected? What property is more likely to be affected in a disaster?

When assessing risks, experts must factor in vulnerability. The vulnerability assessment is a measure of the exposure or susceptibility and resilience of a community to hazards. We stress that understanding vulnerability by itself is insufficient to plan for disasters. It must be accompanied by understanding the nature and characteristics of hazards. Hazards identification and characterization is thus a component of a full hazard analysis. Crozier and Glade (2006) note that vulnerability analysis is different from consequence analysis. Where vulnerability examines the potential for loss, consequence analysis clarifies what will be the impact. The analysis for consequence assessment is far more detailed and models many more factors that affect outcomes.

Risk Analysis

EPA in Figure 1-1 describes risk analysis as an assessment of the likelihood (probability) of an accidental release of a hazardous material and the consequences that might occur, based on the estimated vulnerable zones. The risk analysis is a judgment of probability and severity of consequences based on the history of previous incidents, local experience, and the best available current technological information. It provides an estimation of:

1. The likelihood (probability) of a disaster based on the history of current conditions and consideration of any unusual environmental conditions (e.g., areas in flood plains), or the possibility of multiple incidents such as a hurricane with tornadoes (e.g., flooding or fire hazards);
2. Severity of consequences of human injury that may occur (acute, delayed, and/or chronic health effects), the number of possible injuries and deaths, and the associated high-risk groups;
3. Severity of consequences on critical facilities (e.g., hospitals, fire stations, police departments, communication centers);
4. Severity of consequences of damage to property (temporary, repairable, permanent); and
5. Severity of consequences of damage to the environment (recoverable, permanent).

Risk in this view is the product of the likelihood of a hazard occurring and the adverse consequences from the event. Simply stated,

RISK=LIKELIHOOD X CONSEQUENCE

Critical Thinking: Increasing numbers of people are moving into vulnerable areas as illustrated by population growth in coastal regions, wild-land urban areas, and sensitive mountain environments. This creates stress on resources and land use. Larger numbers of people may move into more sensitive environments. The best land may be developed, leaving development in areas that are marginal and more susceptible to hazards.

Linking Hazards Analysis to Risk and Comprehensive Emergency Management

Alexander describes two approaches to dealing with risks, one a community hazard mitigation approach that is based on a comprehensive hazards analysis, large-scale planning and decisions at local community level. Hazard mitigation or comprehensive risk management strategies are developed and implemented at the local or regional community level. He suggests an additional perspective that includes extensive risk communication with the community. In this approach he suggests that we establish a greater understanding and appreciation of local hazards and risk by the public and support grass-roots democratic involvement. He suggests that communities include citizens in the hazards analysis process and proceed from non-structural to structural protection, not vice versa (2000: 27).

Alexander suggests that decision-making at the individual, household, neighborhood, organizational or community level should be made by informed individuals. Rational choices may be based on information from a comprehensive hazards analysis. Risk communication is thus a critical part of the hazards analysis process and a positive contribution to decision-making processes. Through risk communication and public participation in the hazards analysis process, risk management and hazard mitigation strategies may be adopted by citizens and the community to reduce vulnerability.

Individual citizens and communities thus make decisions that either increase or reduce our vulnerability to hazards. The key is to acknowledge the interface between environmental hazards and human actions and that actions can be initiated to reduce vulnerability through hazard mitigation and hazards risk management. As a result, the hazards analysis process must include opportunities for public involvement and risk communication and that decision-making is essential in adopting effective risk management and hazards mitigation strategies by individuals, organizations, and a community. Through this approach we reject a perspective that adopts the causality of environmental determinism where we have no power to reduce our vulnerability to environmental hazards.

This comprehensive approach to hazards analysis views disasters and hazards beyond just their geophysical processes and examine how social, economic, and political processes impact hazardousness. The importance of a community assessment as a part of hazards identification which includes a close look at social-cultural, economic and political systems may be seen vividly in the impacts from Hurricane Katrina in New Orleans. The damages from Hurricane Katrina revealed significant vulnerabilities associated with poverty, education, housing, employment, and governance. Unfortunately, what was revealed in New Orleans is present in many urban coastal cities. In fact, Mileti stresses the need for a community assessment and including the delineation of hazard areas within the hazards analysis process (1999).

"Rebuilding that generally keeps people and property out of harm's way is increasingly viewed as an essential element of any disaster recovery program. Rebuilding that fails to acknowledge the location of high-hazard areas is not sustainable, nor is housing that is not built to withstand predictable physical forces. Indeed, disasters should be viewed as providing unique opportunities for change – not only to building local capability for recovery – but for long-term sustainable development as well." (Mileti 1999: 237-238)

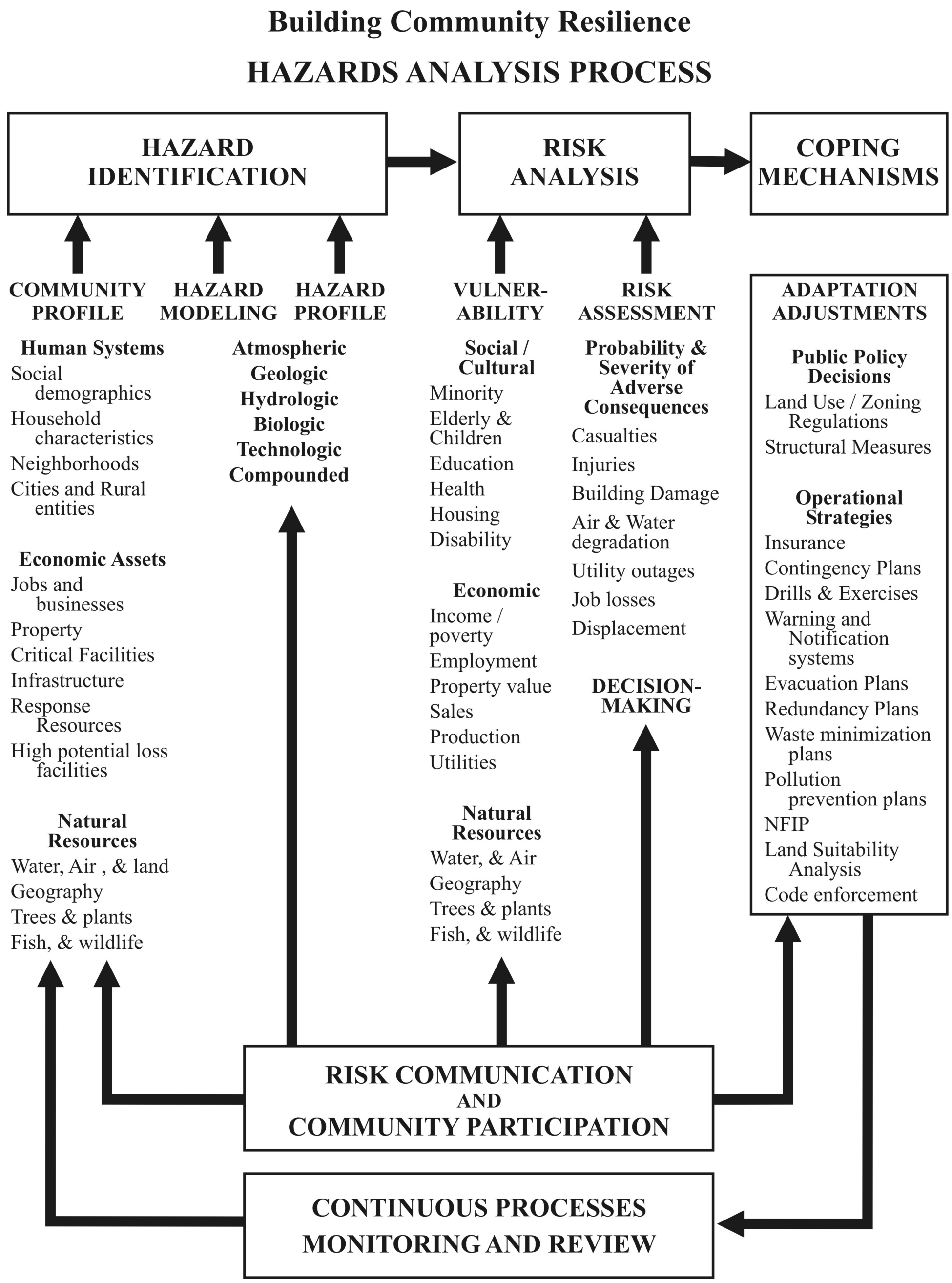

Figure 1-2: Hazards Analysis Process in building community and organizational resilience

Figure 1-2: Hazards Analysis Process builds on the U.S. EPA approach of hazard identification, vulnerability assessment and risk analysis by stressing the need for the use of the results of a risk analysis in hazard adaptation adjustments. Including risk communication, citizen participation, problem solving, risk management, hazard mitigation and ongoing assessment are all parts of comprehensive emergency management. This approach stresses an action orientation through the adoption and implementation of comprehensive hazard risk management and hazard mitigation strategies and monitoring the effectiveness of hazard

adjustments that are adopted and implemented. The ultimate goal of these hazard adjustments is to build resilient and sustainable organizations and communities.
Pelling (2011) distinguishes between short term coping capacity or coping strategies with longer-term adaptive capacity or adaptation. Short-term coping strategies focus on the design and implementation of risk management and preparedness plans that might mitigate immediate impacts from disasters. Longer-term adaptive capacity strategies concentrate on changing those practices and underlying institutions that generate the root or proximate causes of risk. Engle (2011) stresses the need to assess and measure adaptive capacity as part of the ongoing change process.

Further, we stress that the hazards analysis process includes an intentional assessment or monitoring of the impact of our hazard mitigation strategies and hazard risk management strategies. We want to know what are the short and long term results of our actions that might include increasing minimum base flood elevation requirements, strengthening building code requirements, or enhancing building inspections. Second, we stress that the hazards analysis process is not static but an on-going one. We see that the on-going review of our hazard mitigation and risk management policies could lead to program changes to strengthen or enhance opportunities to build more sustainable and hazard resilient communities and organizations.

Including adaptation and coping strategies in the hazards analysis process suggests an action-oriented element to our understanding of risk and the need to develop strategies to cope or manage our organizations and communities to reduce our vulnerability. Kalaugher (et al. 2013) stresses this emphasis on the development of strategies to deal with complex adaptive socio-ecological system interactions. They note that the scale of the systems examined may vary from national, regional or local scales but can result in specific adaptive strategies.

Critical Thinking: One of the best hazards analysis efforts conducted on a large-scale basis was completed in 2007 by the Louisiana Coastal Protection and Restoration Authority (CPRA). The plan includes a comprehensive assessment of the hazards in a coastal environment, impact assessments (social, economic, and ecological), public participating, and recommendations on strategies to protect the social, economic, and environmental assets of the state. This is an outstanding example of a region wide hazards analysis and included federal, state and local government agency collaboration.

Communicating Risk from a Hazards Analysis

Through hazard adaptation and adjustments, we stress the role of risk communication and community and organizational participation in the hazards analysis process. Understanding of hazards will not be the sole result of just telling people of hazards, but allowing them to participate in the hazards analysis process at the neighborhood, community and organizational level. People support what they help build, and citizens as well as employees will advocate risk management and hazard mitigation strategies that they understand and help formulate. They will likely oppose what is imposed on them.

Engle (2011) adds to an examination of the need for enhancing community adaptive capacity by stressing that adaptive capacity improves the opportunity of systems to manage varying ranges and magnitudes of climate impacts, while allowing for flexibility to rework approaches if deemed at a later date to be on an undesirable trajectory.

The results of a hazards analysis are not just for planning and mitigation of hazards but should be shared with the public as reflected in Figure #2. Any community has risks associated with natural or human-caused hazards. Hazards that typically cause minimal damage are usually accepted as inevitable and little is done to reduce the risk. Such hazards may be viewed as nuisances, rather than real threats to live and property (Waugh). Some communities are willing to accept more risk than others. Factors such as the political culture and the socioeconomic level of the community determine the levels and kinds of risk that may be accepted. For example, poor communities may be willing to accept more risk from environmental hazards because the economic base of the community will not directly support the allocation of resources for structural or non-structural hazard mitigation initiatives. For individual residents they may refuse to purchase flood insurance or take other measures that have associated costs because they have limited discretional financial resources. They want the insurance but just not have the funds.

Communicating information from the hazards analysis to the public can help shape perceptions of risk and elevate concern for protecting personal property. Further, by acknowledging local environmental risks, the community may initiate strategies that can overcome the individual financial limitations so as to protect the entire community from hazards. Collective action may be advisable when low-income residents who may be renters or homeowners just cannot take individual action. Individual risk assessment, risk management, and impact assessment are all part of using information from a hazards analysis to protect individual citizens and their property.

Community Involvement

The approach described in Figure 1-2 suggests that a broad-based representative methodology be used; this provides for community inputs and provides a base for the development of strategies that address community priorities and concerns. Smit and Wandel stress that a key outcome of any assessment is to identify adaptation strategies that are feasible and practical in communities (2006). A key recommendation centers on the development of adaptation initiatives that are integrated into other resource management, disaster preparedness and sustainable development efforts. Samarasinghe and Strickert (2013) suggest a methodology for using qualitative, quantitative and cognitive mapping to provide insights into public policy formulation from many diverse local stakeholder groups that include both lay and expert insights.

Some agencies and scientists see hazards analysis as a scientific process that includes only the experts. We suggest an alternative approach. Partnering experts in community planning, engineering, modeling, geography, sociology or other hazard fields with community leaders and members will establish a dialogue relating to risks to reach common goals around generating insights and strategies to build a sustainable community (Stringer 1999; Smith et al. 1997). It operates through a dialogic, hermeneutic approach, similar to fourth-generation evaluation (Lincoln and Guba 1989). An external group of experts can be well positioned to collect the right information and same local governments time in dealing with unknown areas. Engagement seeks a grass roots understanding of risk, one that is perceived as critical to risk reduction and building local capacity (Heinz Center 2002). This report suggests that the engagement process should include the following:

1. Experts (public agency representatives including emergency management and other local agencies along with consultants if used) meet with local residents to explore common goals in a hazards analysis;
2. Identify questions and issues relevant to the residents including the roles of residents or community members and agency experts (outsiders);
3. Develop, through consensus-building, common objectives and priorities for the hazards analysis beneficial to both the experts and residents;
4. Describe the hazards analysis process;
5. Develop, through consensus building, an agreed-upon strategy of how the results of the hazards analysis will be shared with the community, organizations and public officials;
6. Discuss residents' concerns;
7. Initiate the project(s);
8. Present the results to the community for their response.

Butzer (2012) notes the value of community engagement in adaptation to risks and the development of sustainable societies. He acknowledges the intricate interplay of environmental, political and sociocultural resilience in limiting the damages of the adverse impacts from risks. His model emphasizes resilience in the form of innovation and intensification on a decentralized, protracted, flexible and broadly based approach. He also stresses the slow pace of risk in the form of the degradation of soils or other biotic resources including deforestation, ground-cover removal, soil erosion, or groundwater depletion). He explains that declining resource productivity increases pressure on the environment and may be a precondition of an environmental or economic failure.

Values in Community Engagement

Greenwood and Levin (1998) suggest that this approach is context bound and deals with real-life problems. It is problem focused and joins participants and experts to generate through collaborative discussion. All participants' have meaningful dialogue; diverse points of view are welcomed and the process leads to action. The key is that actions evolve to address problems associated with hazards and both the experts and citizens have an increase awareness of options to address problems.

One of the main values in community engagement is community sustainability, characterized by environmental quality, quality of life, disaster resiliency, vibrant economies, and equity as developed through local consensus building (Mileti 1999). Sustainability implies persistence within an ecosystem's carrying capacity (Burby 1998). Systems theory guides the analysis by examining the natural, human, economic, political, and constructed systems. "Hazards researchers and practitioners would do well to take a more systems-based approach….[it] recognizes multiple and interrelated causal factors, emphasizes process, and is particularly interested in the transitional points at which a system…is open to potential change" (Mileti 1999, pp. 106-107). From this standpoint, hazards are viewed as "complex interactions between natural, social, and technological systems" (Cutter 1993, p. xiv). Those interactions result in vulnerability (Heinz Center 2003). To assess those systems and their interactions, the analysis should include an examination of the following:

Human Social and Cultural Heritage Elements: This part of the analysis attends to culture, ethnic Identity, social institutions (family, faith, economy, education, self-governance) and disaster experiences. Members of the community are encouraged to share family and community photographs and stories related to the human, natural and physical systems.

Protective Actions. (1) Risk communication (warnings); (2) Land use and zoning (life and property); (3) participatory community meetings that will involve residents in hazard identification, risk and vulnerability assessment, and planning. Data collection will center on disaster history, vulnerability, and socio-behavioral response. This focus will address interactions between the natural and human systems. We are especially interested in protective actions taken during several phases of disaster, with a particular concentration on social bonds. Kates et al (2012) comment on the potential outcomes of adaptation by stating that change may be difficult to implement because of uncertainties about risks such as climate change and adaptation benefits, the high costs of transformational actions, and institutional and behavioral actions that tend to maintain existing resource systems and policies. Implementing transformational adaptation requires effort to initiate it and then to sustain the effort over time.

The *Constructed and Physical Environment.* This part of the analysis examines how the constructed environment links to the human and natural environment. This focus examines how the community's sense of place mediates their relationship to the social, physical, and built environment. Data from a risk assessment is included such as hurricane wind and storm modeling, riverine flood hazard modeling, earthquake, wildfire, and wind models may be run to examine potential social, economic and environmental vulnerabilities. This focus addresses the built and natural systems as experienced within the human system.

Critical Thinking: Is the concept of community right to know just a legal obligation or is it based on a broader set of values? The adoption of the community planning right to know act (U.S. EPA, 1986) changed how local communities conducted hazards analysis and communicated information about hazards to the community. This legislation asserts that the community has a right to know about chemical hazards present in the community. Although this legislation focused on human-caused technological hazards, it was built upon shared societal values – the "right to know" implies other values: transparency, accountability, responsible action, democracy, and active citizen participation. This emphasis on risk communication and sharing of information freely about hazards was changed following September 11^{th}, 2001. Since that time, new restrictions have been established relating to access to chemical hazard information "in the interest of security."

Conclusions

In this book, we wish to suggest that a broader approach be used to understand the potential impacts of disasters and that the process can be used for multiple local conditions. Natural hazards have very different impacts throughout the world and the nature and extent of a disaster depends of several factors including:

- Local and regional environments including the landscape, climate conditions including the probability of an event, how often they occur, and the capacity of the hazard to do harm;
- The strength and vitality of the social, economic, and natural environments to withstand and cope with the adverse effects of a hazard; and
- Response and recovery resources that enable communities, regions and nations may need to cope and recover from disasters.

The capacity of the organization, community and region to recognize their vulnerability and initiate steps to reduce adverse impacts is critical to the hazards analysis process.

In addition to viewing hazards and disasters as part of a local condition, we wish to stress the use of hazards analysis for mitigation and prevention rather than just for response and recovery or as part of the regulatory permitting process. The results of a hazards analysis can provide information to identify hazard risk management strategies to strengthen social, economic and environmental systems and enable these systems to withstand the destructive conditions that are inherent in hazards. It may be impossible to reduce the wind or storm surge from a hurricane or the shaking from an earthquake, but we can take steps to build stronger buildings, locate our structures in less vulnerable areas, and enhance our social structures to cope with displacement, loss of jobs and critical natural resources.

We link the hazards analysis process to decision-making by local community officials, individual citizens, and private and non-profit organizations. This emphasis on decision-making is reflected in Deyle et al. (1998) where hazard assessments provide a factual rational basis for local decision-making. Their goal is to achieve safer more sustainable communities through management and informed decisions that are based on estimates of costs and benefits of efforts to reduce risks. The approach suggested in this text builds on the EPA approach of hazard identification, vulnerability assessment and risk analysis but emphasizes decision making within social-cultural, political and legal constraints. We stress that the scale of analysis is critical in establishing the type of data that is needed and the degree of precision that may be needed in a community and that data used must be current.

Lindell and Prater (2003) explain that the hazards analysis process is linked to comprehensive emergency management and hazard risk management processes through a disaster impact model. Their view suggests that there are existing conditions that reflect current hazards as well as current social and economic vulnerabilities. In addition, they note that the current physical conditions of the community will impact its resilience. They contend that the social and economic impacts from a disaster are greatly influenced by the community's level of implementing effective mitigation strategies, emergency preparedness, and recovery strategies as well as the physical characteristics of the disaster and the community's actual response and recovery efforts. This broad view of the hazards analysis process acknowledges the need to understand the nature of the community and develop a broad community profile that includes an examination of local geography, demographics, infrastructure, and response resources. They go further to stress the importance of using hazards analysis in the preparation and monitoring of hazard mitigation strategies, emergency preparedness plans and response strategies.

The nature and extent of a hazard condition thus influences the potential adverse impacts to the built and human environments. Slow moving category 4 hurricanes have a greater capacity to cause destruction than a tropical storm. Wild files that are driven by 30 mph winds have a greater destructive force than fires in low wind conditions. Each of these hazardous conditions have very different impacts on any community depending on local conditions including:

- The character of our built environment such as homes, office building, manufacturing plants, roads, bridges, dams, or levees;
- The nature and condition of the natural environment such as wetlands, flood plains, forests, cultivated areas, hills, mountains, or changes in elevation; and
- The existence of strong and connected families, neighborhood associations, non-profit groups, and individuals who are engaged in the community.

Communities with high unemployment, poverty, excessive crime and poor education may have great difficulty in coping and recovering from a hazardous event. Communities vary in the resources that may be used to deal with a hazardous event. Some communities may have large numbers of the local population living in poverty and high unemployment, high crime and limited pubic resources to deal with a disaster event. The design of built structures and the nature of natural environments can influence the damage that results from a hazard event. Healthy wetlands and forests, strengthened structures and land that are of higher ground are in a better position to withstand the destructive character of hurricane winds or flooding conditions. Existing conditions may be assessed as the community's capacity to resist damage from disasters.

Measuring a community's resilience has been examined by a growing number of hazard researchers (Bruneau et al. 2003; Turner et al. 2003, and Tierney and Bruneau 2007). Vulnerability is should be considered not just by exposure to the stresses produced by hazards alone, but also the "sensitivity and resilience of the entire social-cultural, economic, and environmental systems experiencing the hazards. They stress that vulnerability assessment must examine coupled human and envi4ronmental systems and their linkages within and without the systems that affect their vulnerability. Turner et al. presents a framework for the assessment of coupled human and environmental systems (2003).

A comprehensive hazards analysis must take this broad approach and acknowledge the human, built and natural environmental systems and their multiple connections. Hazards analysis must attempt to understand each of these systems and examine their inter-connectedness and impact on community resilience.

We do not suggest a new approach or methodology in hazards analysis in this book, but we do stress the need to embrace a broader context for viewing the hazards analysis process. There is a need for more integrative approaches in vulnerability science for understanding and responding to environmental hazards (et al. 2003). Mileti (1999) notes that a new paradigm is needed in dealing with hazards and disasters, one that addresses sustainable hazard reduction. To accomplish this, the following should be addressed:

- Sustainable Culture: We do not control nature despite our efforts to design levees, dams or buildings and in many cases we are the cause of disaster losses. We must understand the nature of hazards and build to reduce losses. The outputs of the hazards analysis process must be used to identify mitigation strategies so as to minimize our vulnerabilities socially, economically and environmentally.
- Events, Losses, and Costs: Outputs from the hazards analysis process need to characterize our vulnerability and document how disasters have affected our communities.
- The Interactive Structure of Risk**:** The hazards analysis process can characterize our vulnerability and quantify areas that could be affected by a disaster. This process must also provide a broader view so we can see the social, political, economic, environmental costs to our communities. This broader view of risk allows us to include many different interest groups in making decisions about reducing our vulnerability.
- Land-Use Management**:** Local decision makers can use outputs of a hazards analysis in land use plans. Limiting development may contribute to the social, ecological, and economic sustainability of our communities.
- Engineering Codes and Standards**:** Local government adoption of codes and enforcement process are critical in reducing our vulnerability to disasters. A comprehensive hazards analysis provides critical information to ensure that code enforcement goals are attained.
- Prediction, Forecast, Warning, and Planning**:** A detailed hazards analysis provides a sound basis for ensuring that local communities can offer citizens adequate disaster warning. Procedures for delivering timely warning for disasters can be based on alternative planning scenarios from a hazards analysis.
- Disaster Response and Preparedness: Emergency preparedness plans are prepared on a comprehensive hazards analysis. Policies and operational procedures are driven by the nature of the hazards faced by organizations and communities.

- Recovery and Reconstruction: Planning for recovery should not begin following a disaster. To be effective, it should be part of a community hazard mitigation plan and include priorities for a community's long-term recovery in the event of a disaster.
- Insurance: Insurance is not a prevention strategy, but it can be included as part of a recovery process. The question is how can we use insurance as a means of ensuring that an entity's financial stability is protected.
- Economic Sustainability: Public, private and non-profit organizations must understand the nature of risks facing them and develop strategies to reduce or eliminate losses. A hazards analysis is critical to this decision making process.

Deyle et al (1998) stress the application of a community hazards analysis in local or regional decision-making and land-use planning. Deyle agrees with the suggestions of Meletii above that analysis without action does not address the critical decision that must include a comprehensive understand of hazards, vulnerability and risk. Hazards analysis is part of a comprehensive emergency management and risk management process. Hazards analysis is not the goal but is a means towards a goal of promoting social, economic and environmental sustainability. This emphasis is on hazard risk management and mitigation so as to foster community and environmental sustainability and resiliency.

Discussion Questions

The science associated with hazards is complex and often debated at a local, regional and national level. Why do we worry when the scientist or policy makers content that risks are minimal or that there are none present?

Why are community hazard analyses necessary? Does the community have a right to know about local hazards?

What is the role of hazards analysis in organizational decision-making and public policy at a local, regional, national or international level? How are disasters and development related? What is the role of a hazards analysis in preventing people from moving into harms way?

What influences our understanding of risks from natural and human-caused hazards when we include a discussion of vulnerability and exposure to hazards?

Hazards research shows that there is the potential for significant losses from disasters. How do demographic, economic, political and environmental systems contribute to vulnerability? How could a better understanding of hazards and their impacts help us to reduce the adverse consequences associated with disasters?

What type of demographic, economic, political and environmental changes could make a community more resilient or less vulnerable to disasters?

Do you agree that citizens have a right to know about hazards in their community? Under what conditions might a community restrict information about hazards?

How are disasters and community change related? What role does community resilience and adaptation have in the hazards analysis process?

What impact could a disaster have on sensitive natural areas and endangered species?
What social groups are likely not to receive or not to understand or not to take the warning message seriously? Why?

Are there characteristics of social groups that may make it more difficult for them to be rescued, to receive adequate emergency medical care, to feel comfortable in an emergency shelter? Are there population groups that are likely to suffer to a great extent economically or emotionally in a response as well as in a recovery?

Applications

Take a look at the hazards analysis process outlined in Figure 1-2. Identify examples of how population characteristics, the local economy, the infrastructure in the community and the natural environment influence the community's vulnerability to natural hazards. What hazards appear at this first look, to be the primary threat for your community and should be addressed through a comprehensive hazards risk management and mitigation strategies?

Web Sites

Integrated Ecosystem Restoration and Hurricane Protection: Comprehensive Master Plan for a Sustainable Coast (2007). Coastal Protection and Restoration Authority (CPRA) of Louisiana. http://www.lacpra.org/index.cfm?md=pagebuilder&tmp=home&nid=24&pnid=0&pid=28&fmid=0&catid=0&elid=0 The plan includes a comprehensive assessment of the hazards in a coastal environment, impact assessments (social, economic, and ecological), public participating, and recommendations on strategies to protect the social, economic, and environmental assets of the state. This is an outstanding example of a region wide hazards analysis that included federal, state and local government agency collaboration.

FEMA (1997) *Multi-Hazard Identification and Risk Assessment: The Cornerstone of the National Mitigation Strategy*. Washington, D.C. http://www.fema.gov/library/viewRecord.do?id=2214

FEMA – risk analysis – Helping Communities Know Their Natural Hazard Risk
http://www.fema.gov/risk-analysis-helping-communities-know-their-natural-hazard-risk

Hazards Analysis of the City of New Orleans completed by the U.S. Army Corps of Engineers (2007). http://nolarisk.usace.army.mil

Technical Guidance for Hazards Analysis Emergency Planning for Extremely Hazardous Substances12-14-2006 http://www.epa.gov/osweroe1/docs/chem/tech.pdf

Hazardous Materials Emergency Planning Guide - NRT-1 (Updated 2001)02-07-2002
NRT-1 Hazardous Materials Emergency Planning Guide Updated 2001 NATIONAL RESPONSE TEAM The ... planning, preparedness, and response actions related to oil discharges and hazardous substance releases. http://www.epa.gov/osweroe1/docs/chem/cleanNRT10_12_distiller_complete.pdf

USGS Natural Hazards http://www.usgs.gov/natural_hazards/

USGS - National Seismic Hazard **Mapping Project.**
http://earthquake.usgs.gov/hazards/

NOAA Risk and Vulnerability Assessment Tool (RVAT). Hazards Analysis **...** an easy-to-use, adaptable, multi-step process that includes the hazard Identification.
http://www.cakex.org/tools/noaa-risk-and-vulnerability-assessment-tool-rvat

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