# Community and Regional Resilience: Perspectives from Hazards, Disasters, and Emergency Management

## CARRI Research Report 1

Community & Regional RESILIENCE Initiative

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# COMMUNITY AND REGIONAL RESILIENCE: PERSPECTIVES FROM HAZARDS, DISASTERS, AND EMERGENCY MANAGEMENT

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## RESEARCH FINDINGS ABOUT COMMUNITY AND REGIONAL RESILIENCE

One of the commitments of the Community and Regional Resilience Initiative (CARRI) is to understand what resilience is and how to get there, based on research evidence.

As one resource for this effort, CARRI has commissioned a number of summaries of existing knowledge about resilience, arising from a number of different research traditions. This paper is one in a series of such summaries, which will be integrated with new resilience explorations in several CARRI partner cities and with further discussions with the research community and other stakeholders to serve as the knowledge base for the initiative.

For further information about CARRI's research component, contact Thomas J. Wilbanks, wilbankstj@ornl.gov, or Sherry B. Wright, wrightsb@ornl.gov.

## COMMUNITY AND REGIONAL RESILIENCE INITIATIVE

Oak Ridge National Laboratory's (ORNL) Community and Regional Resilience Initiative (CARRI) is a program of the Congressionally funded Southeast Region Research Initiative. CARRI is a regional program with national implications for how communities and regions prepare for, respond to, and recover from catastrophic events. CARRI will develop the processes and tools with which communities and regions can better prepare to withstand the effects of natural and human-made disasters by collaboratively developing an understanding of community resilience that is accurate, defensible, welcomed, and applicable to communities across the region and the nation.

CARRI is presently working with three partner communities in the Southeast: Gulfport, Mississippi; Charleston/Low Country, South Carolina; and the Memphis, Tennessee, urban area. These partner communities will help CARRI define community resilience and test it at the community level. Using input from the partner communities, lessons learned from around the nation, and the guidance of ORNL-convened researchers who are experts in the diverse disciplines that comprise resilience, CARRI will develop a community resilience framework that outlines processes and tools that communities can use to become more resilient. Of critical importance, CARRI will demonstrate that resilient communities gain economically from resilience investments.

From its beginning, CARRI was designed to combine community engagement activities with research activities. Resilient communities are the objective, but research is critical to ensure that CARRI's understanding is based on knowledge-based evidence and not just ad hoc ideas—we want to get it right. To help with this, CARRI has commissioned a series of summaries on the current state of resilience knowledge by leading experts in the field. This kind of interactive linkage between research and practice is very rare.

In addition to its partner communities and national and local research teams, CARRI has established a robust social network of private businesses, government agencies, and non-governmental associations. This network is critical to the CARRI research and engagement process and provides CARRI the valuable information necessary to ensure that we remain on the right path. Frequent conversation with business leaders, government officials, and volunteer organizations provide a bottom-up knowledge from practitioners and stakeholders with real-world, on-the-ground, experience. We accept that this program cannot truly understand community resilience based only on studies in a laboratory or university. CARRI seeks to expand this social network at every opportunity and gains from each new contact.

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# 1. INTRODUCTION

There has been a long-term engagement between academia, practitioners, and the policy communities in reducing the human suffering and losses of lives and property from hazards and disasters. Following the 1964 Alaskan earthquake, for example, the federal government requested an assessment of the state of the knowledge and practice regarding human activity in hazardous areas, the range of existing adjustments to hazards, society's acceptance of risks and hazards, and the dissemination of the research information to practitioners. Known as the first assessment, co-authors Gilbert F. White and Eugene Haas found that losses and potential losses from natural disasters were rising and would continue to do so because of societal choices and lack of individual responsibility for risk-taking behavior (White and Haas 1975). In 1994, 20 years after the first assessment was completed, a second assessment began. Rather than taking a reactive approach to disaster losses, the second assessment argued that the path towards reducing disaster losses was through the development of disaster-resistant or resilient communities (Mileti 1999). Like its predecessor, the new report also emphasized the interaction between the natural, human, and built environment systems and the role of human agency in producing hazards and disasters.

The formal publication of the second assessment, *Disasters by Design* (Mileti 1999), came on the heels of the Federal Emergency Management Agency (FEMA)'s National Mitigation Strategy announced in 1995 and the establishment in 1997 of Project Impact: Building a Disaster-Resistant Community initiative. The ideas for both programs were born from the collective efforts of the research and practitioner communities involved in the second assessment.

Project Impact was discontinued after the 2000 presidential elections (Rubin 2007); its legacy lives on in the federal Subcommittee on Disaster Reduction (SDR). Consisting of representatives from the federal mission agencies, the SDR published its grand challenges report, outlining the areas for federal investments that were critical to achieving loss reduction and community resilience in the face of disasters (Subcommittee on Disaster Reduction (SDR) 2005). The priority investments include six general areas: (1) provide hazard and disaster information where and when it is needed; (2) understand the natural processes that produce hazards; (3) develop hazard mitigation strategies and technologies; (4) recognize and reduce the vulnerability of critical and interdependent infrastructure; (5) assess disaster resilience; and (6) promote risk-wise behavior.

While there is considerable research and federal activity in the area of disaster resilience, there is no common definition of resilience. Without such a common framework or understanding of the concept, even at a very basic level, progress towards measurement and implementation of strategies to achieve community resilience to hazards will be slow.

# 2. UNDERSTANDING VULNERABILITY AND RESILIENCE

This paper uses broad definitions of vulnerability and resilience, although we acknowledge that numerous meanings of vulnerability and resilience exist, beyond those found in hazards, disasters, and emergency management literatures. For a review of vulnerability definitions, see (Adger 2006; Cutter 1996; Eakin and Luers 2006). Table 1 provides a selected culling of definitions of resilience from the hazards and disasters perspective.

**Table 1. Selected definitions of resilience drawn from the hazards and disaster literature**

| Definition | Source |
|---|---|
| "..the capacity of a system, community, or society potentially exposed to hazards to adapt, by resisting or changing, in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures (p. 17)." | (Subcommittee on Disaster Reduction (SDR) 2005) |
| "a community or region's capability to prepare for, respond to, and recover from significant disturbance-driven changes: while maintaining community character, cohesion and capacity, and without permanent impairment of the community's public safety and health, economic, social, and national security functions, thus, accelerating recovery." | SERRI (www.serri.org/ community_resilience.html) |
| "Community seismic resilience is defined as the ability of social units to mitigate hazards, contain the effects of disasters when they occur, and carry out recovery activities in ways that minimize social disruption and mitigate the effects of future earthquakes (p. 735)." | (Bruneau et al. 2003) |
| "Social resilience is the ability of groups or communities to cope with external stresses and disturbances as a result of social, political, and environmental change (p. 347)… ability of communities to withstand external shocks to their social infrastructure (p. 361)." | (Adger 2000) |
| "…the amount of disturbance a system can absorb and still remain within the same state…the degree to which the system is capable of self-organization (p. 35)…the degree to which the system can build and increase the capacity for learning and adaptation (p. 40)." | (Klein, Nicholls, and Thomalla 2003) |

For our purposes we use the following definitions that apply more directly to hazards and disasters. **Vulnerability** is the pre-event, inherent characteristics or qualities of systems that create the potential for harm or differential ability to recover following an event. Vulnerability is a function of the exposure (who or what is at risk) and the sensitivity of the system (the degree to which people and places can be harmed) (Cutter et al.2008). We acknowledge that vulnerability is a dynamic construct that changes over time and across space. However, in order to operationalize or measure vulnerability, we examine it as a static phenomenon. **Resilience** refers to the ability of a human system to respond and recover. It includes those inherent conditions that allow the system to absorb impacts and cope with the event, as well as post-event adaptive processes that facilitate the ability of the system to reorganize, change, and learn in response to the event (Cutter et al. 2008). Resilience is also dynamic, but for measurement purposes, it is viewed as a static property.

We also recognize that the terms vulnerability and resilience can be applied to many systems—social, natural, economic, engineering—and at different units of analysis (individual, household, community, region). For this paper, we examine vulnerability and resilience at the community and regional levels, focusing primarily on those systems most relevant to the hazards and disasters research and practitioner communities—social, engineered, and natural systems.

## 3. WHAT MAKES PEOPLE AND PLACES VULNERABLE?

Vulnerability arises from the intersection of human systems, the built environment, and the natural environment. The most obvious factor contributing to community vulnerability is location or proximity to hazard-prone areas such as coasts, floodplains, seismic zones, potential contamination sites, and so forth. The physical exposure, described by the characteristics of the initiating event (magnitude, duration, frequency, impact, rapidity of onset), defines the physical vulnerability of places. For example, communities on barrier islands are more physically vulnerable to flooding and hurricane-related damages than those inland. Considerable research efforts within the hazards and disasters community have focused on the delineation and probability of physical exposure using a combination of statistical and GIS-based modeling approaches (FEMA 1997; Carrara and Guzzetti 1996; Diaz and Pulwarty 1997; Goldman 1991; Pielke, Jr. and Pielke, Sr. 2000; Ramsey et al. 2001). Plume exposure models for hazardous contaminants, storm surge models, numerically based hurricane wind forecasting, and probabilistic as well as deterministic seismic risk approaches also represent advances in our understanding of physical process contributing to vulnerability and likely exposure (Hill and Cutter 2001). Similarly, the private sector, especially the insurance industry, utilizes catastrophe modeling which couples actuarial estimates of exposure with the hazards as a means for manage their financial risks (Heinz Center 2000).

The vulnerability of the built environment also is related to location and proximity to the source of the hazard or threat. Poorly constructed buildings and infrastructure, inadequately maintained public infrastructure, commercial and industrial development, and certain types of housing stock (e.g., manufactured homes) all enhance the vulnerability of the built environment in communities (Borden et al. 2007). The density of the built environment is another contributing factor to community vulnerability as there is more exposure and thus a greater potential for damage. Public infrastructure and lifelines (sewers, water, bridges, roads) are especially critical for communities as the loss of such important assets may place an insurmountable financial burden on smaller communities that often lack the resources to rebuild (Heinz Center 2002a; Chang 2003; Chang, Svekla, and Shinozuka 2002). Equally important is the economic health of the community, which is closely tied to commercial and industrial development (Chang and Falit-Baiamonte 2002). Communities that solely rely on a single economic sector for their livelihoods (e.g., tourism) are more vulnerable than those that have a more diversified economy. These vulnerable communities often are slower to recover from a disaster.

Finally, there are demographic and social characteristics of residents that make some communities more vulnerable than others. The most widely accepted social indicators are age, gender, race, socioeconomic status, special needs populations (physical or mentally challenged, homeless, transients), non-English speaking immigrants, and seasonal tourists (Enarson and Morrow 1998; Peacock, Morrow, and Gladwin 1997; Tierney 2006; Tierney, Lindell, and Perry 2001). Additional factors have been enumerated elsewhere (Burby, Steinbert, and Basolo 2003; Cutter and Finch 2008; Cutter, Boruff, and Shirley 2003; Enarson 2007; Laska and Morrow 2007). The social vulnerability of communities is borne from inequalities, which affect access to resources and information, the ability to absorb the impacts of hazards and disasters without governmental interventions, housing choice and location, and the political marginalization of impoverished residents. Social vulnerability is one of the foremost explanations for the differential preparedness, impact, and response to Hurricane Katrina within New Orleans (Cutter 2005; Hartman and Squires 2006; Laska and Morrow 2007) and along the Mississippi Gulf Coast (Cutter et al. 2006).

## 4. WHAT MAKES COMMUNITIES RESILIENT TO HAZARDS AND DISASTERS?

There is some overlap in those characteristics of communities that make them vulnerable and those that improve their resilience to hazards and disasters. However, we should not assume that just because a community is vulnerable, that it also lacks resilience (Enarson 2007). Within the hazards and disasters literature, there are a number of clearly defined characteristics of resilient systems. For example, the SDR (2005, p. 1) suggests that the characteristics of resilient communities include the following.

- Relevant hazards are recognized and understood.
- Communities at risk know when a hazard event is imminent.
- Individuals at risk are safe from hazards in their homes and places of work.
- Disaster-resilient communities experience minimum disruption to life and economy after a hazard event has passed.

Elasticity (or the ability to bounce back or rebound) is a common adjective used to described resilient systems or communities (Bruneau et al. 2003; Folke 2006; Klein, Nicholls, and Thomalla 2003). In their historical review of devastated cities that re-emerged following disasters, Vale and Campanella (2005) cite that connectivity and decentralization were important characteristics of resilient cities as were decentralized and distributed networks (economic, social, etc.). They provide a number of resilience traits that are useful for understanding reconstruction following disasters. These include resilience is underwritten by resources external to the affected area; remembrances and monuments drive resilience; resilience entails more than rebuilding; resilience is site specific and exploits the power of place; resilience casts opportunism as opportunity; and resilience does not result in radical changes in urban form or public policy post-disaster.

## 5. FOSTERING RESILIENCE THROUGH HAZARDS MITIGATION PLANNING

Much of the literature on resilience from the perspective of hazards and disasters falls within the domain of hazard mitigation planning. Federal, state, and local governments throughout the United States are slowly coming to realize that planning is an important tool for increasing resilience and reducing losses following natural disasters because no two areas are alike in their capacities to sustain and recover from future disasters (Burby et al. 2000). The need to balance environmental and development issues while promoting safe and livable places is the key to local success in fostering resilience. This is a sharp reversal in policy from the past where governments at all levels have encouraged development in hazardous areas through measures such as beach nourishment, flood control works, disaster relief, cost sharing, and other initiatives that have increased exposure and loss (vulnerability) but have not improved resilience.

Planning can be a powerful tool for building resilience and reducing losses from natural disasters (Burby et al. 1999). Planning programs, including those pertaining to pre-disaster recovery plans, reduce losses and impact resilience by affecting both the location and design of urban development (Burby et al. 1999; Godschalk, Kaiser, and Berke 1998) and land use planning and development management for sustainable hazards mitigation (Burby 1998).

Hurricane Katrina opened a window of opportunity for reducing future loss while facilitating the opportunity to create more resilient communities (Campanella 2006; Godschalk 2005). The urgency of residents and business owners to return to normalcy following a disaster builds quickly and is amplified by a substantial inflow of capital for reconstruction. Thus, such windows of opportunity do not typically stay open long following a disaster (Berke and Campanella 2006; Birkland 1997). The contested nature of recovery in New Orleans highlights the conflict between the immediacy of reconstruction and longer term efforts to enhance local resilience. It also draws attention to the inherent conflict between local desires (immediate recovery) and regional and national concerns (more sustainability and resilience at the local level).

## 5.1 Providing Planning Guidance

Local governments have historically utilized two approaches in planning for natural hazards (Berke and Campanella 2006; Burby et al. 1999). In the first, resilience may be enhanced through special stand-alone hazard mitigation plans. The second is comprehensive planning, where hazard mitigation is but one small element within broader development guidance for an entire municipality, county, or region. Both have their advantages and disadvantages. Stand-alone plans, for example, may focus solely on areas exposed to hazards, yet they may inadvertently promote increased occupancy in hazardous areas by making them safer for development as well as by ignoring opportunities to promote development at hazard-free sites. Comprehensive plans, on the other hand, have the advantage of taking into account community goals linked to broader economic, social, and environmental sustainability concerns. The scope of a comprehensive plan provides increased access to a wider slate of planning and regulatory tools, although the comprehensive plan is less hazard and hazard-location specific, and may require more resources to execute. The most effective choice is likely to be a combination of the two where databases, policies, and procedures are compatible (Berke and Campanella 2006).

Historically, local governments have played a pivotal role in community development within the United States. Local governments, however, have not placed an overwhelming emphasis on hazard reduction. When natural hazard reduction is addressed, it is often the result of state or federal level mandates and incentives (Olshansky and Kartez 1998). Recently, states have assumed increasing responsibility over planning matters formally delegated to local governments (Dalton and Burby 1994). Sensitivity to environmental concerns, regional growth impacts, and societal issues such as human vulnerability resulted in several forms of intervention. These include regulation mandates such as the need for building standards and fostering local commitments to development management through land-use planning.

## 5.2 Managing Land Use and Development

Local governments have a variety of techniques at their disposal to enhance a community's resilience by guiding the location, type, quality, and intensity of urban development. These include zoning and subdivision powers, which guide construction away from hazardous areas or to limit the density of development thereby reducing exposure in hazard-prone areas.

Olshansky and Kartez (1998) and Burby et al. (2000) classify land-use management tools into the following categories:

- *Building standards* that regulate the details of construction (traditional building codes, flood-proofing requirements, seismic standards and retrofit requirements)
- *Development regulations* (zoning, flood-zone regulations, setbacks, and sensitive lands protection)
- *Critical and public facilities policies* (long-term capital improvement programs, siting public facilities and schools at hazard-free sites, incentives to private facilities to discourage siting in sensitive or hazardous areas)
- *Land and property acquisition* (development rights, transfer of development rights, and the relocation of buildings and uses)
- *Taxation and fiscal policies* (shift public costs to owners or developers of property within hazardous areas such as water and sewer lines)
- *Information dissemination* (sharing public information, hazard disclosure requirements for real estate sellers, and the posting of warning signs in high-hazard areas)

Land-use management tools, whether regulatory or voluntary, focused on current or future land use, or aimed at reducing exposure and vulnerability (development in hazardous areas), afford a mix of opportunities for building resilience. Most of the land management initiatives, however, seek to regulate or influence private development. Local control over community-based planning, and by inference, private development, is essential for building disaster-resilient communities.

## 5.3 Barriers to Planning for Resilience

There are three primary constraints in planning for resilience identified in the literature. These include state and federal barriers to planning in general, flawed and reactive federal policies towards hazards and development, and a crisis of commitment among governments at all levels (Berke and Campanella 2006). For example, only half of the states in the United States even mentioned natural hazards and disaster loss reduction in local comprehensive plans (Schwab 1998) prior to the passage of the Disaster Mitigation Act of 2000. Moreover, only 11 states mandate pre-disaster or post-disaster assessments as an element in a comprehensive plan or in the form of hazards-related content within the plan. Planning as a means of creating disaster resilience is therefore nonexistent in many places. And it has deterred the adoption of sensible controls on development that may prevent loss during future events. Burby (2006) indicates that no Gulf states, Florida being the only exception, have passed local planning mandates for hazards or disaster reduction.

States are not the only significant barrier to local planning (Berke and Campanella 2006). The federal government has historically exercised strong support for encouraging intensive development in areas exposed to natural hazards while exercising weak support for land-use planning initiatives. Greater federal emphasis is placed on risk-reduction and risk-sharing strategies rather than risk-avoidance initiatives. Risk reduction facilitates high-risk development through federally constructed projects such as seawalls, dams, levees, and costly beach re-nourishment programs that provide the veil of safety but ultimately may not provide protection from powerful hazard events (Burby et al. 1999). As a result, hazardous areas are viewed by landowners and developers as reasonably safe and profitable places for development, while mitigation strategies are often viewed by economic interests or local governments pursuing economic growth as a threat to be avoided rather than an opportunity to be embraced. Homeowners and local decision makers often do not fully understand the risk of loss from natural disasters, frequently perceiving it as zero, or at least lower than they would discover had they undertaken an objective analysis of risk. The levee effect (Tobin 1995) provides one such example. The levee effect invokes a false sense of security among floodplain inhabitants, which is reflected in the perception that all flood risk has been eliminated with the construction of the levee. Building levees can increase vulnerability to flooding in two ways (Pielke 1999). First, it creates a sense of complacency, which reduces preparedness and mitigation action in the event of a flood. Second, the levee effect provides incentives to continue to build structures in harm's way.

The second governmental flaw pertains to federal policies that undermine hazard mitigation planning. Local governments often ignore the potential for loss, operating under the premise that the federal government will blunt any economic costs that occur by offering income tax write-offs, disaster relief payments, and insurance subsidies following a damaging event. Finally, the discouragement of development in hazard-prone locations fails when the federal government underwrites rebuilding and rapid recovery in local communities by providing federal dollars to reconstruct critical infrastructure such as roads, power, and water facilities at the same pre-disaster location.

With the lack of mandates and commitment from state and federal agencies, few local governments may be willing to protect against natural hazards (Burby 1998). When pressed with local concerns such as unemployment, crime, housing affordability, and education, natural hazards may be viewed as a minor problem where local officials only become interested in disaster management after communities suffer chronic loss. By then, of course, planning for resilience is much less effective. The political will to enhance local capacity for resilience through planning is simply not there.

## 6. MEASUREMENT AND INDICATORS FOR RESILIENCE

While there is some consensus in the literature regarding the factors that produce hazards vulnerability and those that enhance community resilience to disasters, there is less agreement on how to measure them. While we conceptually or sometimes intuitively understand vulnerability and resilience, the devil is always in the details, and in this instance, the devil is measurement.

Indicators are quantitative measures intended to represent a characteristic or a parameter of a system of interest. An indicator may be composed of a single variable (e.g., income) or a combination of variables (e.g., gross domestic product). Multiple indicators can be combined to construct composite indicators, or indices, which attempt to distill the complexity of an entire system to a single metric. By necessity, indicators are generalizations and never completely represent all facets of vulnerability or resilience (Birkmann 2006; Villagrán de León 2006). Instead, they are approximations that can be used to set policy goals and measure progress towards them (Carreño, Cardona, and Barbat 2007; Parris and Kates 2003) or as screening tools to set baselines through mapping distributions and assessing temporal and spatial changes (Cutter and Finch 2008).

Indicators have been used since the 1960s to examine social and health disparities within cities. In the 1970s environmental indicators were used to monitor progress towards achieving pollution reduction in urban areas, while in the late 1990s research focused on environmental sustainability indicators (Esty et al. 2005), and more recently on global environmental health.

For example, the Millennium Ecosystem Assessment evaluated the current conditions of the world's ecosystems, the services they provide, and the consequences of ecosystem change for human well-being (Millennium Ecosystem Assessment 2005).

The primary dimensions influencing vulnerability and resilience include physical, social, political, economic, institutional, and ecological components. The availability of indicators, however, varies significantly by dimension. Only within the last decade has there been a concerted research effort to develop vulnerability indicators (Birkmann 2006; Cutter, Boruff, and Shirley 2003; King and MacGregor 2000). The majority of these studies are global in scope such as the Disaster Risk Index and the World Bank's Global Hotspots or focused on specific causal agents such as drought or earthquakes. The availability of indices for sub-national-scale assessments or those involving social, political, economic, or institutional components remain relatively scarce. More research has focused on the integration of social and physical indicators in measuring vulnerability in specific places such as Mexico, India, the Caribbean, and within the United States (Boruff and Cutter 2007; O'Brien et al. 2004; Polsky 2004; Turner et al. 2003; Wu, Yarnal, and Fisher 2002).

In engineering, recent efforts to quantify community resilience use four dimensions: technical, organization, social, and economic (TOSE); however, these performance indicators are better suited for assessing the resilience of both physical systems and critical infrastructure (Bruneau et al. 2003). The technical and organizational measures of resilience refer to the capability of both the physical system and the organization to absorb the shock and recover quickly from an event. Large-scale hazard events like the Oklahoma City bombing and the September 11th attacks have highlighted both the interdependencies of our nation's critical infrastructure (lifelines and services) and our societal vulnerabilities. It is crucial that these elements be included in measures of resilience (Hardenbrook 2005). Performance indicators of organizational resilience may include components such as incorporating resources from a multitude of sources, improvisational flexibility, and physical access to resources (Kendra and Wachtendorf 2003). Social and economic measures, on the other hand, are more oriented towards the community's ability, rather than the physical system, to resist and recover quickly from an impact (Bruneau et al. 2003). For example, improvements in construction practices and the retrofitting of homes may serve as a means to enhance community resilience. In order for measures of resilience are to be effective, both indicators and standards for measuring them must be defined and developed in cooperation with decision makers and the public (Chang and Shinozuka 2004), but have not been as yet.

Metrics for assessing economic resilience to hazard events take a different approach. These measures typically have employed the use of loss estimation models to measure property loss and the effects of business disruption in regional economies in the aftermath of an event (Chang and Shinozuka 2004; Rose 2004). Business disruption refers strictly to the human role in the operation of businesses, organizational, and institutional entities (Rose 2004). This differs from the measures of property loss in terms of the temporal scale. Property losses are typically seen during the short-term phases of the disaster, whereas the business interruptions occur during the longer period of recovery. The role of economic resilience in reducing economic losses in disasters is only achieved through the adoption of mitigation strategies that aim to lessen the probability of failure and vulnerability (Rose 2004). Researchers in this arena frequently identify the difficulties encountered in gathering data on resilience for input into these econometric models (Rose 2004, 2007).

## 6.1 Empirically Based Approaches

A review of the literature finds considerable variability in the metrics used in empirical studies of vulnerability and resilience. There is consensus on the role of gender, race and ethnicity, age, and income or wealth, but the proxies or specific variables used to measure these are highly diverse. Similarly, there is consensus in the literature about lifelines, but again there is considerable diversity in how lifelines (and which ones) are measured.

## 6.2 Qualitatively Based Perspectives

A pilot program on the development of coastal community resilience indicators is currently under way with support of the National Oceanic and Atmospheric Administration (NOAA)'s Coastal Services Center. A series of Resilience Salons were held during 2007 to develop a basic understanding of coastal resilience and stakeholder needs for its assessment. While the three salons represented different stakeholders, there was some agreement in those characteristics that define resilient communities. Among those qualities are communities learning from previous experiences with hazards and disasters; economic risk reduction (the value of mitigation); business size (larger is more resilient); shared values and sense of place (personal and community); leadership (or a local champion); and local understanding of risk and responsibility (NOAA 2007).

The establishment of the Gulf of Mexico Alliance with its working group on coastal community resilience (www2.nos.noaa.gov/gomes/coastal_resil/welcome.html) is another NOAA-based effort designed to develop a pilot Coastal Resilience Index. A community index score card is one effort to marry quantitative assessments of exposure with qualitative assessments of capacity to recover. Designed as an efficient, cost-effective way for communities to gauge their likely functioning after a disaster, the scorecard is based on self-assessments of four elements. These include (1) the location and likely impacts of the "storm of record" on critical facilities (sewage treatment, power grid, water purification, transportation, city hall, police and fire stations, communications, emergency operations center, evacuation shelters, hospitals); (2) evacuation route problems post-event; (3) access to or implementation of hazard planning guidance; and (4) the use of hazard mitigation measures (Emmer 2007).

# 7. FRAMEWORKS FOR COMMUNITY RESILIENCE ASSESSMENT

In returning to the central question of this paper, what makes a community resilient, we offer a number of insights from the hazards and disaster literature. Most of the scientific literature points to the resilience of natural systems (keeping wetlands and sand dunes intact, maintaining open space, controlling development) as mechanisms for fostering resilience and reducing the impacts of hazards. Many argue that the need to balance environmental and development issues while promoting safe and livable communities is the **key** to fostering resilience (Burby et al. 2000; Subcommittee on Disaster Reduction (SDR) 2005). From the perspective of the built environment, improvement in construction practices, building codes, and mitigation of homes (retrofitting or elevating) are measures that enhance resilience as is the building of redundancy in critical infrastructure. Social resilience can be enhanced through wealth, insurance, access to other financial resources, social networks, community engagement and participation, and the local understanding of risk.

## 7.1 Community and Regional Resilience Initiative (CARRI)

The CARRI framework and its four dimensions of resilience (anticipate; reduce vulnerability; respond effectively, efficiently, and equitably; and recover faster, better, safer, and fairly) embodies many of these ideas. We know that resilience is dynamic and changes over time and across space. The concept can be applied to many different systems—ecological, social, economic, engineering, institutional, cultural, infrastructure—and to varied units of analysis ranging from individuals or a single structure, to households, social groups, communities, counties, regions, or states. To implement the CARRI framework from the perspective of hazards and disasters research requires a consistent set of factors or resilience indicators that can be deployed to compare places. However, ambiguities in the definitions of resilience have led to measurement difficulties, and thus there are few, if any, systematic, integrated, or comparative assessments of hazard resilience (either pre- or post-event). The systematic development of community resilience baseline indicators is the first step in the CARRI framework—anticipate. Once we know where and how communities are vulnerable, we can develop strategies for reducing the vulnerability and enhancing resilience to ensure an effective response and faster recovery.

## 7.2 Resilience Baseline Assessments

There are four key sets of metrics needed to build a profile or baseline of community resilience (Figure 1). Each of these components is briefly described and list of candidate variables is provided derived from our review of the literature.[1]

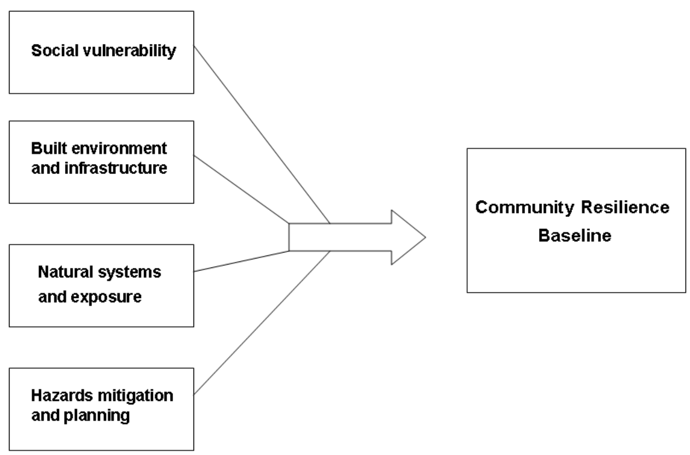


**Figure 1. Data requirements for baseline assessments of community resilience.**

### 7.2.1 Data Inputs

#### Social Vulnerability

The most often used metric for social vulnerability is the Social Vulnerability Index (SoVI) (Cutter, Boruff, and Shirley 2003; Cutter and Finch 2008), which uses a broad set of indicators to explore differences in social vulnerability among places using census geography (counties, census tracts, census block groups). SoVI graphically illustrates the uneven capacity for preparedness and response and highlights areas where differences in underlying social vulnerabilities are the greatest. The exact procedures for constructing SoVI are available online as is the list of variables used (http://www.sovius.org). Table 2 presents an abbreviated list of variables for conducting census-tract-level social vulnerability analyses.

[1] Much of this section is derived from a white paper by Susan L. Cutter prepared for the Urban Coast Institute, "A Framework for Measuring Coastal Hazard Resilience in New Jersey Communities," February 2008.

**Built Environment and Infrastructure**

Measures of the built environment and infrastructure provide an overall assessment of the amount of public and private property that could be damaged by disasters, and the likely economic losses. It also provides an indicator of the community response capacity (e.g., public safety structures, shelters, health care facilities), as well as the identification of critical infrastructure such as pipelines, roads and bridges, water treatment and storage, communications, and power transmission. For example, coastal communities accessible only by a two-lane bridge over the inter-coastal waterway may be more vulnerable than those with a number of different access routes. Should that bridge get destroyed in a hurricane, for example, the community would remain isolated and dependent on airlifts or boatlifts for vital supplies until such time as alternative access routes could be constructed. If the transportation route in question is a main arterial, such as Interstate 10 along the Gulf Coast, closure of such vital roadways results in interruptions in the movement of goods, people, and relief supplies to the affected area, and increases recovery time. There is no standard index for built environment vulnerability, as there is for social vulnerability, but some initial work is being done (Borden et al. 2007).

A list of candidate variables for determining built environment vulnerability is provided in Table 3. The most appropriate scale for these variables is at the census tract or census block group. Not all of these may be available, but the goal is to obtain as many as possible within each broader category. It is important, however, to have data representation within each category.

**Table 2. Candidate variables for social vulnerability assessments**

| Category | Variables |
|---|---|
| Race and ethnicity | % African American; % Native American; % Asian or Pacific Islanders; % Hispanic |
| Age | % population under 5 years old; % population 65 or older; median age |
| Socioeconomic status | Per capita income; % families earning more than $100,000; median dollar value of owner-occupied housing |
| Gender | % female; % females in civilian labor force |
| Employment | % of the civilian labor force unemployed; % civilian labor force participation |
| Education | % population over 25 with less than high school education |
| Household structure | Average number of people per household; % families living in poverty; % female-headed households, no spouse present |
| Access to services | Number of physicians per 100,000 population; % rural farm population; % urban population |
| Occupation | % employed in fishing, farming, forestry; % employed in transportation, communications, public utilities; % employed in service occupations |
| Housing | % housing units that are mobile homes; % renter-occupied housing units; median gross rent ($) for renters |
| Special needs | Nursing home residents per capita; % Social Security recipients; % migrate to the United States from abroad in last 5 years |

**Table 3. Candidate variables for built environment and infrastructure assessment**

| Category | Variable |
|---|---|
| Residential | Median age of housing units, Housing units built before 1960, Density of housing units, Density of mobile homes, Number of building permits for new housing units, Daily water usage, Value of all residential property |
| Commercial and industrial development | # commercial establishments, # manufacturing establishments, Value of sales for all businesses ($), value of all sales for all farms, Industrial earnings ($), Banking offices, Private non-farm business establishments, Hazardous materials facilities, # Small businesses, # marinas |
| Lifelines | Hospitals, Schools, Electric power facilities, Potable water facilities, Wastewater facilities, Dams, Police stations, Fire stations, Oil and natural gas facilities, Nuclear facilities, Emergency centers, Number of hospital beds, Communications towers/antennae |
| Transportation infrastructure | Airports, Bus terminals, Ferry facilities, Interstate miles, Other principal arterial miles, Fixed transit and ferry network miles, Rail miles, Highway and rail bridges, Ports |
| Monuments and icons | Churches, Landmark and Historic registry buildings, parks, social organizations |

## Natural Systems and Exposure

There is more research on natural systems indicators of sustainability and resilience than on any other component. In coastal areas, for example, wetlands and dunes offer a buffer against impending storm surges, while biodiversity enables the system to recover more quickly after a disturbance. Species at risk from over-harvesting, pollution, or habitat degradation influence the economic vitality of communities dependent upon them for their livelihoods and thus incur an economic loss when nature's services are diminished. The best place to begin with assessments of natural systems is the Heinz Center's report, *The State of the Nation's Ecosystems* (Heinz Center 2002b) and its subsequent web updates (http://www.heinzctr.org/ecosystems/report/html). In addition to national indicators, the report lists candidate indicators for coastal ecosystems. The majority of these are focused on the natural ecosystem, not the human use of it.

While ecosystem services are one aspect of natural systems that are important for coastal communities, there are others (McFadden, Nicholls, and Penning-Rowsell 2007). The following candidate variables (Table 4) provide a more comprehensive view of coastal vulnerability and resilience from a disasters perspective.

## Hazards Mitigation and Planning for Resilience

There is considerable evidence in the literature that risk reduction and hazards mitigation planning offer the best path towards enhancing community. As communities consist of physical infrastructure, emotional ties, and cultural institutions, it is difficult to adequately measure many of these less tangible components that foster resilience. These include elements such as local leadership, social capital and networks, the role of faith-based institutions within the community, non-governmental organizations, and most importantly, the values, ethics, and

**Table 4. Candidate variables for natural systems and exposure**

| Variables |
|---|
| • Area of dunes<br>• Average dune height<br>• Average beach width<br>• Erosion rates<br>• Acreage of wetlands<br>• Wetland/habitat loss (% change from previous decade)<br>• Acreage of undisturbed habitat<br>• Coastal subsidence (rate per year)<br>• Sediment supply (estimated berms and offshore bars)<br>• # and location of coastal defenses (groins, jetties, seawalls, revetments)<br>• # and size of storm water detention basins<br>• Water contamination (surface and ground)<br>• 100-year and 500-year flood zones delineations<br>• Storm surge inundation zones<br>• Land cover classification<br>• Amount of impervious surfaces<br>• Projected Sea Level rise from Intergovernmental Panel on Climate Change reports IPCC |

collective responsibility toward disaster reduction within the community. Table 5 lists those variables that lend themselves to measurement at the community level and thus provide a baseline for measuring progress toward resilience.

### 7.2.2 Constructing the Baseline

Each of the four components within the resilience assessment framework (social vulnerability, built environment/infrastructure, natural systems and exposure, and hazards mitigation) are represented within a GIS as separate data layers using the hazards of place model of vulnerability (Cutter, Mitchell, and Scott 2000). Through the analytical procedures within the GIS, these layers can be combined to illustrate the composite pattern for the entire county (Figure 2). For example, the composite maps of social vulnerability and built environment can be mapped where high values illustrate greater levels of vulnerability. A composite of the natural systems and exposure can be created where high values represent more exposure or greater hazard-proneness. When all three layers are combined, they represent the intersection of values for social, built, and natural systems and clearly identify areas that are high on each of them. The final part of the analysis is to incorporate the mitigation component. Here, higher values represent progress towards resilience and vulnerability reduction. Within the GIS, the mitigation values are thus subtracted from the total vulnerability scores because of their role in lessening the impact of disasters.

**Table 5. Candidate variables for hazards mitigation and planning for resilience**

| Variables |
|---|
| • Disasters/emergency response plans (household and community) |
| • Building standards, codes and enforcement |
| • Hazard mitigation plans and hazard vulnerability assessments (required by the Disaster Mitigation Act of 2000) |
| • Comprehensive plans (land use and growth management) |
| • Zoning ordinances prohibiting development of high hazard areas |
| • Continuity of operations plans for local governments |
| • Interoperable communications among police, fire, and emergency responders |
| • Disaster recovery plans |
| • Participation in the National Flood Insurance Program (NFIP) |
| • Coastal setbacks for development |
| • Dune management districts |
| • Transfer of development rights to discourage development in sensitive areas |
| • Fiscal policies to shift public infrastructure costs (water, sewer, roads) to developers |
| • Provision of risk/hazard information to the public |
| • Tabletop and mock exercises and drills for disaster response |

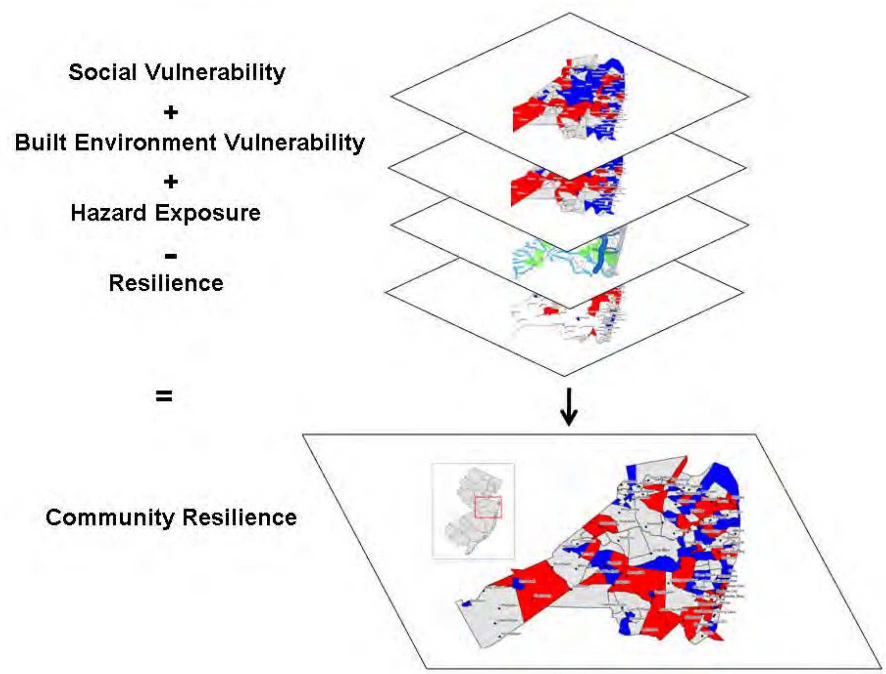


**Figure 2. Schematic representation of resilience baseline GIS integration and methodology.**

## 8. SUMMARY

Hazards and disaster research provides a fertile field and rich tradition in both the conceptual understanding of hazards vulnerability and community resilience in the face of disasters and the empirical place-based evidence to support geographic and temporal variability in community vulnerability and resilience. Drawing from the social sciences, natural sciences, and engineering, hazards and disasters scholars and practitioners have enabled a richer understanding of the impacts of hazards and disasters on places and the requisite monitoring required for the effective implementation of vulnerability reduction and resilience-enhancing public policies. The NOAA salons also emphasized that geographic scale and unit of analysis are critical components in developing resilience metrics, especially given the underlying questions of resilience to what and for whom.

The development and actual deployment of coastal resilience indicators is still in the nascent stage, but there is considerable local, state, regional, and national interest in such measures. The desire is to create the equivalent of "an index of leading resilience indicators" for the nation—indicators that combine the best science and practice that are available. While we are not there yet, the perspectives from the hazards, disasters, and emergency management communities show considerable promise and illuminate the path forward.

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