Chapter 3
Defining Resilience Across Disciplines

The etymology of resilience is the Latin term *resilio*, meaning to rebound. Although published accounts of its use date back to ancient Rome in Cicero's *Orations* (Alexander 2013), and some physicists and psychologists in the early twentieth century (Manyena 2006), ecologists were the first to embrace and make extensive use of the general concept of resilience more than 30 years ago (see, e.g., Holling 1973). Since then, it has been adapted or re-invented for the case of short-term disasters (see, e.g., Tierney 1997; Bruneau et al. 2003; Rose 2004, 2007) and long-term phenomena, such as climate change (see, e.g., Dovers and Handmer 1992; IPCC 2007). The analysis of resilience can benefit from a comparison of its definitions in ecology, engineering, organizational behavior, planning, psychology, sociology and economics over the past 40 years. In the discussion below, we focus on points of agreement. This is the basis for establishing criteria for operational metrics that are consistent with fundamental principles, the needs of potential users, and the practical matters of data availability and computational manageability.

3.1 Ecological Origins

Ecologists have pioneered a useful, broad definition of resilience relating to the survival of complex systems. Holling's (1973; p. 17) definition is "the ability of systems to absorb changes … and still persist." He sometimes refers to it as "buffer capacity," and resilience is measured in this paradigm in relation to the size of the shock that is absorbed. Pimm (1991) is usually cited as the source of an alternative ecological emphasis in the definition of resilience in terms of the speed at which the system returns to equilibrium. In most disciplines, the term *resilience* is more in line with the buffer concept, as the ability to mute the influence of the external shock. It is not just the decrease in activity, but rather the decrease relative to the potential decrease from the external shock. Perrings (2001; p. 322) also defines resilience in

A. Rose, *Defining and Measuring Economic Resilience from a Societal, Environmental and Security Perspective*, Integrated Disaster Risk Management,
DOI 10.1007/978-981-10-1533-5_3

a relative manner: "As a first approximation, this may be measured by an index of the level of pollution or depletion relative to the assimilative or carrying capacity of the ecological system concerned." Subsequently, Perrings (p. 323) defines it in terms of the "gap between current and critical loads" to the ecosystem and even the ecological-economic system.

Here and below we distinguish the concept of resilience and related terms. For example, Holling (1973; p. 17) defines *stability* as "the ability of a system to return to equilibrium after a temporary disturbance." This definition is often put forth as the essence of resilience or at least a special dimension. However, it is clear that resilience and stability are distinct. As Handmer and Dovers (1996) point out, a stable system may not fluctuate significantly, but a resilient system may undergo significant fluctuation and return to a new (and possibly improved) equilibrium.

3.2 Individual Resilience

At the most fundamental level, resilience pertains to how individuals cope with crises, ranging from the death of a family bread winner by everyday occurrences to the less common but broader infrequent events affecting the entire community characterized as disasters. Likewise, children may have their education interrupted by a range of phenomena, including family pressures to work, as well as the destruction of their school by a hurricane. Resilience is applicable to the range of human experience coping with threats to human security, livelihoods and overall well-being. Resilience gets to the heart of the survival instinct that has been demonstrated consistently over eons. While mass panic is often attributed to such situations, research indicates that this is the exception rather than the rule (Mileti 1999). People everywhere are very adept at self-preservation and extending help not only to their families and neighbors, but also to complete strangers.

Another source of individual resilience stems from various economic roles, including producer, consumer, and provider of labor and capital services. Economic incentives help promote resilience, though this is affected by two key considerations. First, workers and managers only focus on the enterprise once they know their families are safe and receiving the proper care. Second, many disasters instill fear in people, which affects some of their behavior. This is all the more pronounced because of media attention and/or rumor, which contribute to the *social amplification of risk* in the short-run, and because of *stigma effects* for locations that have been hit by some disaster (such as those affected by accidental or intentional biological, chemical, or a radiological contamination) in the long-run. For example, the largest single factor contributing to the economic losses arising from a September 11, 2001, attack on the World Trade Center was the nearly 2-year reduction in air travel and related tourism (Rose et al. 2009). Another example is the study by Giesecke et al. (2012), which analyzed the effects of a simulated dirty bomb (radiological dispersion device) attack scenario on the financial district of Los Angeles in terms of potential demand for increased wages and rates of return, as well as shopper/

tourist discounts. The study found that these behavioral impacts were fifteen times the size of the ordinary economic losses typically measured. Recent research has focused on ways to reduce this fear through improved risk communications, which is yet another way of strengthening resilience (Rosoff et al. 2013)

Flynn (2008) has emphasized the key role of individuals in resilience, and sees resilience as empowering. It provides people the opportunity to reach their full potential in a crisis. It also provides cohesion to the community and nation. Flynn points out that "a terrorist chooses battlegrounds that are likely to be occupied by civilians, not soldiers" He notes the importance of resilience as a weapon against the spread of fear, one of terrorists' greatest objectives. One of the dividends of empowering individuals is that it releases an enormous amount of energy and skills to cope with disasters. Flynn also notes that empowering individuals lessens the paternalistic role of government in this disaster response. The actions of many governments that consistently bail out disaster victims, even if they have engaged in moral hazard (e.g., continuous rebuilding in flood plains), is a classic example (see, e.g., Mileti 1999).

Another strong role for the individual stems from a major theme of human development – public participation in decisions and processes. A related key theme is fairness, or equity, one version of which is the basis for promoting equality in both the participation and in the outcomes of resilient activities. It includes special consideration for the aged, the infirm, women, and racial/ethnic minorities.

Synergies and economies of scale and scope arise when individuals band together to address a crisis. Specialization, organizational memory, and official sanctioning are some of the many reasons for the formation of institutions in this area. Similar motivations, as well as motivations relating to social cohesion are the basis for community resilience at the neighborhood, town/city, province/state and national levels.

3.3 Community Resilience

Adger (2000) was one of the first to extend the ecological definition of resilience to human communities as a whole. He measured *social resilience* as related to social capital and in terms of economic factors (e.g., resource dependence), institutions (e.g., property rights), and demographics (e.g., migration). Norris et al. (2008) have approached the matter in a similar fashion for *community resilience*. They developed a framework for it that encompasses stress, adaptation, wellness and resource dynamics. They state that "community resilience is a process linking a network of adaptive capacities (resources with dynamic attributes) to adaptation after a disturbance or adversity." Adaptive capacities include economic development, social capital, information and communication, and community confidence. Community is defined in a broad sense to include both the built and natural environments and the economy in addition to the social structure. Still, the major focus is less on community organization than on preventing injury, both physical and mental.

Norris et al. (2008) defined population wellness as "a community-level outcome indicative of a successful adaptation, defined as high and non-disparate levels of

mental and behavioral health, role functioning, and quality of life in constituent populations." They use "wellness" as an indicator of the success of adaptive resilience at the individual level. Psychological wellness is in turn defined according to four criteria: absence of psychopathology, healthy patterns of behavior, adequate role functioning, and high quality of life. They acknowledge that the community as a whole is greater than the sum of the parts. Community adaptation is then defined as population wellness, linked to a high prevalence of individual wellness in the community. They acknowledge, however, the "prevention paradox", where increases in individual wellness are marginal but lead to major improvements in community wellness, as all the individual advances are added up.

Norris et al. (2008) emphasized that resilience in general and resource mobilization in particular can be deteriorated by the presence of lingering threats. They cite the example of community's proximity to the Israel-Lebanon border and their exposure to political violence. This is consistent with Hobfoll's (1998) theory that stress is basically related to threats to resources, broadly defined. Compounding the problem is that the loss of resources in a disaster is shared by community members (Erickson 1976). Norris et al. (2008) emphasize that disasters affect entire communities, not just individuals.

In the Norris framework, resilience stems from a set of networked adaptive capacities. The adaptive aspect stems from a combination of resources themselves and community responses to crises. With regard to network resources, Norris et al. (2002) emphasize the importance of the resource base in economic development and note that socioeconomic status is a main indicator of vulnerability, especially in developing countries. Resilience is a function of the size and diversity of the resource base and also of resource equity. Social capital is a second important type of adaptive capital and stems from people using social networks primarily for personal gain. Support networks are especially important in disaster communication and recovery. For example, those linked into networks are more likely to evacuate and those connected to networks are more likely to engage in mutual support and cohesive behavior. Public participation is also a key feature of community resilience, as it is in other forms of resilience mentioned in this chapter.

3.4 Engineering

Bruneau et al. (2003) provide a comprehensive analysis of the many aspects of earthquake loss reduction, all under the heading of resilience. The authors apply the concept at four levels: technical, organizational, social, and economic. They contend that resilience has four dimensions: robustness (ability to withstand a shock), redundancy (e.g., parallel or back-up systems), resourcefulness (stabilizing measures), and rapidity (with respect to rebuilding and recovery). Bruneau et al. also stipulate that the resilience of a system has three aspects: reduced probability of failures, reduced consequences from failures, and reduced time to recovery. These

pertain more to the general risk equation but have obvious overlaps with the four dimensions.[1]

A major criticism of the definition of Bruneau et al. (2003) is that they include all aspects of hazard loss reduction under the banner of resilience, including mitigation (see also Linkov et al. 2013). This is not surprising, as the greatest effectiveness of engineering is in protecting the built environment, as opposed to the individual, organizational, and community activities involved in post-disaster recovery. This is in contrast to the position of Klein et al. (2003) (and many others) to keep the definition of resilience from becoming too broad. They propose the concept of "adaptive capacity" as the more appropriate umbrella concept that covers many of the features identified by Bruneau et al. This is also more consistent with defining resilience as an outcome or system attribute rather than as a tactic like mitigation. Chang and Shinozuka (2004; p. 741) state that: "It is useful to view robustness and rapidity as the desired *ends* of resilience-enhancing measures. Redundancy and resourcefulness are some of the *means* to these ends."

It would appear that Bruneau et al., as well as non-engineers such as Mileti (1999), have envisioned a goal of a community that is able to take many steps to minimize its vulnerability to hazards. Resilience has become a convenient term to characterize all of these possibilities. However, this broad usage is inconsistent with the etymology of the term in general and its use in ecology, economics and other areas of research. Ideally, another term can be found to characterize this ideal community, so that the term "resilience" can be applied to the sub-set of characteristics to which it is best suited.

3.5 Organizational Behavior

Organizational (and the closely related area of institutional) behavior focuses on resilience as a process (Hill and Paton 2005). As such, it is a strategy in risk management under the sub-heading of crisis and continuity management. Paton and Johnston (2001) define resilience in this dimension as "a capacity of people and systems that facilitate organizational performance to maintain functional relationships in the presence of significant disturbances as a result of a capability to draw upon their resources and competencies to manage the demands, challenges and changes encountered." This viewpoint extends even more fundamentally to natural ecosystems, whereby The Resilience Alliance (2005) includes as one of its three dimensions of resilience "the degree to which the system is capable of reorganization." Adger et al. (2005) extend this to the social-ecological nexus.

Comfort (1994) confines resilience to actions and processes after the event occurs, or, to the *consequences* of failure. This also relates to process-oriented counterparts of the concept of dynamic resilience, where the focus is not on attaining a target level of output but rather a target level of "functioning." However, the trajec-

[1] The important role of human factors, especially in light of mounting technological complexity of engineered systems, should not be overlooked in this and other general frameworks (see, e.g., Meshkati and Yalda (2015).

tory of this functioning is clear from the major themes of non-linear and adaptive dynamics (Comfort 1999). It also leaves no doubt that the dynamic version of resilience (the rapidity to bounce back) is uniquely applicable to the post-disaster stages. Moreover, the recovery process this characterizes is another way of reducing the consequences of the hazard ensuing from structural or system damage. Manyena (2006) contends that resilience has evolved from an emphasis on outcomes to an emphasis on process in holistic terms (see also Pfefferbaum et al. 2005).

Klein et al. (2003) have taken this even further to suggest that resilience goes beyond the Holling definition to include the functioning and interaction of interlinked systems (see also UN/ISDR 2002). However, this still does not go as far as suggesting that resilience includes all aspects of adaptation or mitigation.

In contrast to resilience activities emphasized in the economics literature, the focus of organizational theory is on "competencies and systems" (Hill and Paton 2005; see also an extension of this theme to the community as a set of networked adaptive capacities). The relationship between the two approaches can be viewed as follows: most standard treatments of resilience in engineering and economics identify a set of options and assume that managers can optimize among their choices (see, e.g., Rose and Liao 2005). Organizational analysis identifies vulnerabilities and limitations in managerial abilities and how they can be overcome through resilience. The economics approach to reconciling these two views would be to assume some form of "bounded rationality" (see, e.g., Gigerenzer and Selten 2002) and to view managerial resilience as an improvement over the basic outcome. Hill and Paton (2005) analyze several aspects of the theory and practice of business continuity management and how it relates to resilience. They emphasize that a major prerequisite of success in this area is the willingness of an organization to adapt to its new environment.

3.6 Planning

Sustainable communities and the supporting theme of smart growth emanate from the collaborative visions of ecologists, sociologists, geographers, economists, and planners. Thus far, the planners have been most prominent at practical approaches to the broader design, while the other disciplines have been more niche-oriented, including the nexus of ecological economics in reorienting individual business operations to principles of industrial metabolism (see, e.g., Ayres and Simonis 1989; Daly and Farley 2004).

The planning profession has as a goal the creation of hazard-resilient communities (Burby et al. 2000; Godschalk 2003), primarily through comprehensive land-use strategies known as "smart growth." This holistic approach is superior to the piecemeal way that ordinary hazard mitigation is usually promulgated, which has actually enticed development in hazardous areas. For example, the presence of dikes and levees in New Orleans gave residents a feeling of false security. Many similar examples have led to the general trend of fewer disaster events, but the ones now taking place have relatively much larger damages. Smart growth has tended to

avoid such outcomes. Mileti (1999) has stated that "no single approach to bringing sustainable hazard mitigation into existence shows more promise at this time than increased use of sound and equitable land use management."

Burby et al. (2000) identify four major themes related to integrating mitigation into land-use planning in promoting community resilience, but only one of them, and only in part, pertains to the post-disaster period. This is an example of the tension in the planning field about terminology, similar to the discussion in other fields. Godschalk (2003; p. 137) concludes that "Traditional hazard mitigation programs have focused on making physical systems resistant to disaster forces." He goes on to state, however, that "future mitigation programs must also focus on teaching the city's social communities and institutions to reduce hazard risk and respond effectively to disasters, because they will be the ones most responsible for building ultimate urban resilience." In fact, Geis (2000) has explicitly stated a preference for the term "disaster-resistance" with respect to planning themes and practices in this area, concluding it is more appropriate and attractive than is "disaster resilient." At the same time, other planners have come to apply the term "resilient" to the interaction of physical and social systems (Olshansky and Kartez 1998).

Godschalk (2003) makes the point, however, that "Resilient cities are constructed to be strong and flexible, rather than brittle and fragile." It is this flexibility (adaptability) that is the key to resilience as interpreted by others (e.g., Comfort 1999; Rose 2007; Zolli and Healy 2012). Foster (1997) interprets this in terms of coping with contingencies. He has put forth 31 principles for achieving resilience, among them in the general systems realm are such characteristics as "being" diverse, renewable, functionally redundant, with reserve capacity achieved through duplication, interchangeability, and interconnections." Godschalk summarizes the work of several researchers to identify eight categories of resilience responses, seven of which have been emphasized by Rose (2004, 2007) and in this report: redundant, diverse, efficient, autonomous, strong, adaptable, and collaborative. Finally, Godschalk proposes a more enlightened set of mitigation measures for social and institutional resilience through the reduction of business interruption impacts, though the specific policy instruments he mentions are limited to loans and general government assistance, rather than the self-motivated coping behavior emphasized by most other analysts.

References

Adger WN (2000) Social and ecological resilience: are they related? Prog Hum Geogr 24(3):247–364

Adger WN, Hughes TP, Folke C, Carpenter SR, Rockstrom J (2005) Social-ecological resilience to coastal disasters. Science 309:1036–1039

Alexander D (2013) Resilience and disaster risk reduction: an etymological journey. Nat Hazards Earth Syst Sci Discuss 1:1257–1284

Ayres R, Simonis U (1989) Industrial metabolism. United Nations Press, Tokyo

Bruneau M, Chang S, Eguchi R, Lee G, O'Rourke T, Reinhorn A, Shinozuka M, Tierney K, Wallace W, von Winterfeldt D (2003) A framework to quantitatively assess and enhance seismic resilience of communities. Earthq Spectra 19:733–752

Burby R, Deyle R, Godschalk D, Olshansky R (2000) Creating hazard resistant communities through land-use planning. Nat Hazards Rev 1(2):99–106

Chang S, Shinozuka M (2004) Measuring and improving the disaster resilience of communities. Earthq Spectra 20:739–755

Comfort L (1994) Risk and resilience: inter-organizational learning following the Northridge earthquake of 17 January 1994. J Conting Crisis Manag 2(3):157–170

Comfort L (1999) Shared risk: complex seismic response. Pergamon, New York

Daly H, Farley J (2004) Ecological economics. Island Press, Washington, DC

Dovers R, Handmer J (1992) Uncertainty, sustainability and change. Glob Environ Chang 2(4):262–276

Erickson K (1976) Loss of communality at Buffalo Creek. Am J Psychiatry 133:302–305

Flynn S (2008) America the resilient: defying terrorism and mitigating natural disasters. Foreign Aff 87(2):2

Foster H (1997) The Ozymandias principles: thirty-one strategies for surviving change. UBC Press, Victoria

Geis D (2000) By design: the disaster-resistant and quality-of-life community. Nat Hazards Rev 1(3):151–160

Giesecke JA, Burns WJ, Barrett A, Bayrak E, Rose A, Slovic P, Suher M (2012) Assessment of the regional economic impacts of catastrophic events: CGE analysis of resource loss and behavioral effects of an RDD attack scenario. Risk Anal 32(4):583–600

Gigerenzer G, Selten R (eds) (2002) Bounded rationality: the adaptive toolbox. MIT Press, Cambridge, MA

Godschalk D (2003) Urban hazard mitigation: creating resilient cities. Nat Hazards Rev 4(3):136–143

Handmer JW, Dovers SR (1996) A typology of resilience: rethinking institutions for sustainable development. Organ Environ 9(4):482–511

Hill R, Paton D (2005) Managing company risk and resilience through business continuity management. In: Paton D and Johnston D (eds) Disaster resilience: an integrated approach. Charles C Thomas Publishers, Ltd., Springfield, Illinois

Hobfoll S (1998) Stress, culture, and community: the psychology and philosophy of stress. Plenum, New York

Holling C (1973) Resilience and stability of ecological systems. Annu Rev Ecol Syst 4:1–23

Intergovernmental Panel on Climate Change (IPCC) (2007) Climate change 2007: mitigation of climate change. Working Group III contribution to the fourth assessment report of the IPCC. Cambridge University Press, Cambridge

Klein R, Nicholls R, Thomalla F (2003) Resilience to natural hazards: how useful is this concept? Environ Hazards 5:35–45

Linkov I, Eisenberg D, Plourde K, Seager T, Allen J, Kott A (2013) Resilience metrics for cyber systems. Environ Syst Decis 33:471–476

Manyena S (2006) The concept of resilience revisited. Disasters 30(4):433–450

Meshkati N, Yalda K (2015) Operators' improvisation in complex technological systems: successfully tackling ambiguity, enhancing resiliency and the last resort to averting disaster. J Conting Crisis Manag 23(2):90–96

Mileti D (1999) Disasters by design: a reassessment of natural hazards in the United States. Joseph Henry Press, Washington, DC

Norris F, Friedman M, Watson P (2002) 60,000 disaster victims speak: part II, summary and implications of the disaster mental help research. Psychiatry 65:240–260

Norris F, Stevens S, Pfefferbaum V, Whyche K, Pfefferbaum R (2008) Community resilience as a metaphor, theory, set of capacities and strategy for disaster readiness. Am J Community Psychol 41:127–150

Olshansky R, Kartez J (1998) Managing land use to build resilience. In: Burby R (ed) Cooperating with nature: confronting natural hazards with land-use planning for sustainable communities. Joseph Henry Press, Washington, DC

Paton D, Johnston D (2001) Disasters and communities: vulnerability, resilience and preparedness. Disaster Prev Manag 10:270–277

Perrings C (2001) Resilience and sustainability. In: Folmer H, Gabel HL, Gerking S, Rose A (eds) Frontiers of environmental economics. Edward Elgar, Cheltenham

Pfefferbaum B, Reissman D, Pfefferbaum R, Klomp R, Gurwitch R (2005) Building resilience to mass trauma events. In: Doll L, Bonzo S, Mercy J, Sleet D (eds) Handbook on injury and violence prevention interventions. Kluwer Academic Publishers, New York

Pimm SL (1991) The balance of nature. University of Chicago Press, Chicago

Resilience Alliance (2005) Research on social–ecological systems: a basis for sustainability. http://www.resilience.org

Rose A (2004) Defining and Measuring Economic Resilience to Disasters. Disaster Prev Manag 13:307–314

Rose A (2007) Economic resilience to natural and man-made disasters: multidisciplinary origins and contextual dimensions. Environ Hazards 7(4):383–395

Rose A, Liao S (2005) Modeling resilience to disasters: computable general equilibrium analysis of a water service disruption. J Reg Sci 45(1):75–112

Rose A, Oladosu G, Lee B, Beeler-Asay G (2009) The economic impacts of the 2001 terrorist attacks on the World Trade Center: a computable general equilibrium analysis. Peace Econ Peace Sci Public Policy 15(2):Article 4

Rosoff H, Siko R, John R, Burns W (2013) Should I stay or should I go? An experimental study of health and economic government policies following a severe biological agent release. Environ Syst Decisions 33(1):121–137

Tierney K (1997) Impacts of recent disasters on businesses: the 1993 Midwest floods and the 1994 Northridge Earthquake. In: Jones B (ed) Economic consequences of earthquakes: preparing for the unexpected. National Center for Earthquake Engineering Research, Buffalo, pp 189–222

United Nations International Strategy for Disaster Reduction (UN/ISDR) (2002) Living with risk: a global review of disaster reduction initiatives by the ISDR. United Nations, Geneva

Zolli A, Healy AM (2012) Resilience: why things bounce back. Free Press, New York