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Resilience and Sustainability in Relation to Natural Disasters: A Challenge for Future Cities

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Preface

The development of contemporary society is strongly dependent on its sustainability. The global sustainability is strongly dependent on the sustainability of the urban environment. Cities are quickly growing, and mankind is rapidly concentrating in urban areas. Since 2007, the world urban population had exceeded the rural population and the number of megacities is rapidly increasing. Cities are connected by a dense and complex web of relationships and represent the heart and the engine of the global development of contemporary society.

However, cities are also increasingly vulnerable and any adverse event can rapidly evolve into a catastrophe. Contemporary cities are becoming risk attractors because of the increasing technological complexity of urban systems, along with the increasing population density. A natural event of medium intensity occurring in any given area will threaten more human lives and produce much greater economic loss than a century ago, if proper mitigation actions have not been implemented. Some climate change-related natural hazards (floods, hurricanes, windstorms) are expected to increase with time almost everywhere. A city growing without an urban planning carefully considering such events will enhance its effects and will become a risk trap. In order to increase the resilience of cities against catastrophes the urban transformation processes must be also aware of the importance of extreme events and must be addressed to mitigate their effects on the vital functions of cities and communities. Redundancy and robustness of the components of the urban fabric are essential to restore the full efficiency of the city's vital functions after an extreme event has taken place. Hence, sustainability and resilience are the main keywords for future cities.

The present publication is the result of a Networking Event, held during the 6th UN-World Urban Forum, in September 2012, in Naples, Italy, and entitled "Resilience and Sustainability in Relation to Disasters: A Challenge for Future Cities." The Networking Event was arranged by the research center Analysis and Monitoring of the Environmental Risk (AMRA) and the Department of Structures for Engineering and Architecture of the University of Naples "Federico II." The Networking Event was aimed at presenting different approaches to the issues of resilience and sustainability of future cities. Scholars from different disciplines, including sociologists, economists, scientists involved on natural risks and physical vulnerability, and provided their own perspectives. This publication represents the final product of that event. Its objective is to share knowledge and experience

with the hope to offer a thoughtful interdisciplinary view to sustainable development of future safe cities.

Adam Rose, economist, professor at the University of South California and Coordinator for Economics of the Center for Risk and Economic Analysis of Terrorism Events, illustrates the role of economic resilience in the survival of cities. He highlighted how experience with disasters can be transformed into actions that promote sustainability.

Graham Tobin, professor of Geography, Environment and Planning at the University of South Florida, showed how social networks are related to vulnerability and sustainability, affecting community resilience in all the phases of a disaster, from the exposure to an incoming event, to evacuation, to resettlement.

Gertrud Jorgensen, professor of Architecture at the University of Copenhagen, presents the results of the FP7 CLUVA project (CLimate change and Urban Vulnerability in Africa), focusing on climate change adaptation in African urban areas.

Kalliopi Sapountzaki, professor of applied geography at the University of Athens, highlights the need for both "collective resilience" and "individual resilience for all the citizens."

Edith Callaghan, professor at the School of Business at the Acadia University, contributes to the final chapter of this publication with his experience on how community engagement into decision-making processes can improve resilience and risk management of urban areas.

Gaetano Manfredi and Domenico Asprone, respectively, professor and assistant professor of Structural Engineering at the University of Naples "Federico II" link the concepts of urban resilience and sustainability and explain how urban resilience can be introduced as a fundamental aspect of social sustainability in future cities.

Paolo Gasparini, professor emeritus of geophysics at the University of Naples "Federico II," and CEO of AMRA, together with Angela Di Ruocco and Raffaella Russo, respectively, Senior Researcher and Junior Researcher at AMRA, analyze natural hazards impacting on future cities. He indicated that the participation of citizens, along with advanced technologies, can play a fundamental role for effective real-time risk mitigation.

This publication collects all these contributions addressing different issues and scientific points of view to urban resilience in relation to natural disasters. The final chapter provides an integrated perspective to this issue along with a list of

recommendations for decision makers to promote and enhance urban resilience, emphasizing that resilience in the short term is necessary to ensure sustainability in the long term.

Naples, Italy, October 2013

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Chapter 1
Economic Resilience and Its Contribution to the Sustainability of Cities

Adam Rose

Abstract Economic resilience is a prerequisite for sustainability. If cities cannot cope with short-run natural and man-made disasters, they will not thrive in the long run. This presentation will explain the role of economic resilience in the survival of cities and how experience with disasters can be transformed into actions that promote sustainability. I begin with a discussion of features of cities that make them both vulnerable and resilient. I then define economic resilience and offer an operational metric. Next I discuss individual tactics to implement it at the micro, meso, and macroeconomic levels. Then I summarize studies of the relative effectiveness of resilience tactics and their costs. I conclude with a discussion of broader strategies to make cities more resilient in the short-run and emphasize the importance of translating them into adaptations for the long-run. A key strategy is to translate ingenuity in coping with disasters into decisions and practices that continuously promote sustainability.

Keywords Economic resilience · Sustainability · Business interruption · Disaster recovery

1.1 Introduction

Cities represent agglomerations of population and economic activity. Their very existence and size is an indication of their economic vitality. However, it is not guaranteed that any given city will thrive forever. A city may deplete critical resources within its own boundaries or its hinterlands, lose its comparative

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advantage in cross-border trade, or suffer severe social ills. It may also be subjected to external shocks from natural and man-made disasters. Recent examples include Detroit's downturn due to structural changes in the auto industry in the U.S. and abroad and New Orleans being the bulls-eye of Hurricane Katrina. Thus, in addition to long-term concerns about a lasting resource base and adequate community infrastructure, cities must be resilient, or able to rebound from short-run disasters to be sustainable.

This paper examines the role of resilience in the sustainability of cities. It first identifies features of cities that make them both vulnerable and resilient. I then define economic resilience and offer an operational metric. Next, I discuss individual tactics to implement it. Then I summarize studies about the relative effectiveness of resilience tactics and their costs. I conclude with a discussion of broader strategies to make cities more resilient in the short-run and emphasize the importance of translating them into adaptations for long-run sustainability.

1.2 Vulnerability and Resilience

Cities are vulnerable to disasters for a number of reasons: First they represent large concentrations of population in the built environment, including complex infrastructure. This concentration makes them more susceptible to contagion effects associated with the spread of disease, fire, and building collapse. Concentration also makes evacuation in anticipation of disasters more difficult. The complexity of cities stems primarily from their overall interdependence and the more sophisticated nature of economic and social activity than in other areas. This, together with the faster pace of life, makes cities relatively rigid, thus leading to less flexibility and hence less resilience.

The economic rationale for cities in the first place often places them in more highly vulnerable locations, such as along coasts or major rivers. They represent larger targets for terrorists as well. In the case of major disasters, the very size of cities makes them more likely to be overwhelmed in providing emergency response services, such as fire and health care.

Despite their overall and average wealth, cities typically also house large percentages of low-income and other disadvantaged population groups. These groups have lower resilience capacities than others in terms of education, social connectivity, material resources, and political clout.

At the same time, cities also have some distinct advantages with respect to resilience. They are more diversified economically, and thus more likely to be able to withstand a severe shock to any given sector. While overall they may not have a higher proportion of excess capacity at a given point in time than population centers of other sizes, unless the disaster is especially widespread, cities have a greater absolute amount of excess capacity to absorb displaced businesses and residents. They also contain a greater amount of resources for recovery and reconstruction, as well as more specialized skills and expertise. Cities typically are

centers of innovation, a key ingredient of resilience, as will be discussed below. Cities are also likely to have greater prominence and political power, and thus are able to command greater transfers of resources from outside their boundaries.

At the same time, all of the examples provided in the previous paragraph are effective up to some threshold, at which point resilience can be overwhelmed. In these cases the sheer size of the city becomes a liability. However, these instances are rare.

Several striking examples exist of the grand resilience of cities, including the rapid rebuilding following the Chicago fire of 1876 and San Francisco earthquake of 1906. This also includes the enormous resilience of the New York City area following the September 11, 2001, terrorist attacks, where 95 % of the businesses located in the World Trade Center area were able to relocate relatively rapidly nearby because of the large supply of excess office space (Rose et al. 2009). New Orleans is an excellent example of a city whose resilience was overwhelmed by a major Hurricane and subsequent technological failure that resulted in massive flooding. Subsequently, however, New Orleans, which lost a large percentage of its population, perhaps permanently, has had its downtown and tourist business cores rebound because of the strong demand for goods and services produced there (Robertson 2009).

1.3 Resilience and Sustainability

Several ecologists and ecological economists have linked resilience to the concept of *sustainability*, which refers to long-term survival and at a non-decreasing quality of life. A major feature of sustainability is that it is highly dependent on natural resources, including the environment. Destroying, damaging, or depleting resources undercuts our longer-term economic viability, a lesson also applicable to hazard impacts where most analysts have omitted ecological considerations. Klein et al. (2003) note that, from an economic perspective, sustainability is a function of the degree to which key hazard impacts are anticipated. However, I agree with the position that it is also a function of a society's ability to react effectively to a crisis, and with minimal reliance on outside resources (Mileti 1999).

In the context of longer-term disasters, such as climate change, Timmerman (1981) defined resilience as the measure of a system's capacity to absorb and recover from the occurrence of a hazardous event. In the climate change context, however, most researchers now refer to this as *adaptation* (IPCC 2007). Dovers and Handmer (1992) note an important feature that distinguishes man from the rest of nature in this context—human capacity for anticipating and learning. They then bifurcate resilience into reactive and proactive, where the latter is uniquely human. I maintain that proactive efforts can enhance resilience by increasing its capacity prior to a disaster, but that resilience is operative only in the response/recovery/reconstruction (often referred to as "post-disaster") stages. Adaptability is not just applicable to long-term events, but is a major attribute of resilience to disasters.

Moreover, this adaptability requires that we consider a revised equilibrium state in measuring stability and resilience. Most ecological economists view flexibility and adaptability as the essence of resilience (Levin 1998). This makes intuitive sense for natural disasters as well given their "surprise" nature in terms of infrequency and large consequences.

Godschalk (2003) makes the point 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 (Comfort 1999). Foster (1997) interprets this in terms of coping with contingencies. He put forth 31 principles for achieving resilience, among them in the general systems realm, such characteristics as "being diverse, renewable, functionally redundant, with reserve capacity achieved through duplication, interchangeability, and interconnections."

What is the relationship between resilience and sustainability? Resilience is usually used in the context of responding to specific shocks, and thus relates to short-run survival and recovery. This contributes to long-run survival, a key aspect of sustainability along with improving the quality of life and the environment. However, the distinction is blurred in several key ways:

- Resilience in the short-run can be carried over to adaptation in the long-run.
- Disasters open up opportunities to rebuild and improve outcomes, including mitigating against future disasters.
- Disasters provide a valuable learning experience of how to cope with extreme stress.
- Disasters provide outside economic stimulus to the affected economy through insurance and through private and public sector assistance.

1.4 Defining Economic Resilience

Previously, I have defined economic resilience in a manner that builds on considerations from other disciplines but focuses on the essence of the economic problem (Rose 2004, 2009):

Static Economic Resilience. The ability of a system to maintain function when shocked. This is the heart of the economic problem, where ordinary scarcity is made even more severe than usual, and it is imperative to use the remaining resources as efficiently as possible at any given point in time during the course of recovery.

Dynamic Economic Resilience. Hastening the speed of recovery from a shock. This refers to the efficient utilization of resources for repair and reconstruction. Static resilience pertains to making the best of the existing capital stock (productive capacity), while this aspect is all about enhancing capacity. As such, it is about dynamics, in that it is time-related. Investment decisions involve diverting resources from consumption today in order to reap future gains from enhanced production.

Note that the definition is couched in terms of function, typically measured in economics as the "flow" of goods and services, such as Gross Domestic Product (GDP), as opposed to property damage. It is not the property (capital stock) that directly contributes to economic well-being but rather the flows that emanate from these stocks. Two things should be kept in mind. First, while property damage takes place at a point in time, the reduced flow, often referred to as business interruption (BI), just begins at the time of the disaster but continues until the system has recovered or attained a "new normal." Second, the recovery process, and hence the application of resilience depends on the behavior of economic decision-makers and public policy.

Ability implies a level of attainment will be achieved. Hence, the definition is contextual—the level of function has to be compared to the level that would have existed had the ability been absent. This means a reference point or type of worst case outcome must be established first. Further discussion of this oft-neglected point is provided below.

Another important distinction is between *inherent* and *adaptive* resilience. The former refers to aspects of resilience already built into the system, such as the availability of inventories, excess capacity, input substitution, contractual arrangements accessing suppliers of goods from outside the affected area (imports), and the workings of the market system in allocating resources to their highest value use on the basis of price signals. Adaptive resilience arises out of ingenuity under stress, such as Draconian conservation otherwise not thought possible (e.g., working many weeks without heat or air conditioning), changes in the way goods and services are produced, and new contracting arrangements that match customers who have lost their suppliers with suppliers who have lost their customers.

1.5 Quantification of Economic Resilience

In this section, I provide admittedly crude mathematical definitions of resilience in both static and dynamic contexts. Direct static economic resilience (DSER) refers to the level of the individual firm or industry (micro and meso levels) and corresponds to what economists refer to as "partial equilibrium" analysis, or the operation of a business or household entity itself. Total static economic resilience (TSER) refers to the economy as a whole (macro level) and would ideally correspond to what is referred to as "general equilibrium" analysis, which includes all of the price and quantity interactions in the economy throughout its integrated supply chains (Rose 2004).

An operational measure of *DSER* is the extent to which the estimated direct output reduction deviates from the likely maximum potential reduction given an external shock, such as the curtailment of some or all of a critical input. In essence *DSER* is the percentage avoidance of the maximum economic disruption that a particular shock could bring about. A major measurement issue is what should be used as the maximum potential disruption. For ordinary disasters, a good starting

point is a linear, or proportional, relationship between an input supply shortage and the direct disruption to the firm or industry. Note that while a linear reference point may appear to be arbitrary or a default choice, it does have an underlying rationale. A linear relationship connotes rigidity, the opposite of the "flexibility" connotation of static resilience defined in this chapter.

Analogously, the measure of TSER to input supply disruptions is the difference between a linear set of indirect effects, which implicitly omits resilience and a nonlinear outcome, which incorporates the possibility of resilience.

Also, while the entire time-path of resilience is key to the concept for many analysts, it is important to remember that this time-path is composed of a *sequence of individual steps*. Even if "dynamics" are the focal point, it is important to understand the underlying process at each stage, i.e., why an activity level is achieved and why that level differs from one time period to another. As presented here, static resilience helps explain the first aspect, and changes in static resilience, along with repair and reconstruction of the capital stock, help explain the second.

We illustrate the application of the definition with the following case study. Rose et al. (2009) found that potential business interruption losses were reduced by 72 % from a worst case scenario by the rapid relocation of firms in the World Trade Center area in the aftermath of September 11 terrorist attacks. Moreover, this resilient strategy, dependent of course on excess office capacity, saved an expensive rebuilding campaign. This more intensive use of resources is also the theme of the recovery in the current great recession in the U.S. and other countries, as employment recovery significantly lacks the recovery of output. The experience of New Orleans and New York City thus signal a significant change in approaches to disaster recovery and long-run sustainability in the U.S. to disaster recovery, which typically emphasized prompt rebuilding. Coupled with stronger requirements for mitigation, and hopefully some general accumulated wisdom, we are recovering less by reflex action and more by intelligent planning (Vale and Campanella 2005).

Of course, what is ultimately important in the 9/11 case is that New York City, and the U.S. as a whole, clearly survived (Chernick 2005). Any single disaster taking place in a large, vital city is unlikely to threaten its sustainability because of its various capacities to rebound. Of course, severe repeated disastrous events in a concentrated area have not readily been experienced, and this would open up other possibilities. This is one of the reasons that climate change is so important, in that it lays open the possibility of a greatly increasing number of short-run disasters, such as hurricanes and floods, or the likelihood of long-run disaster such as would be caused by sea level rise.

1.6 Economic Resilience Options

There are many ways to achieve and enhance economic resilience relative to the use of inputs and the production of outputs at the *microeconomic level* of individual firms, households, or organizations. Economic resilience operates at two

Table 1.1 Resilience effectiveness and cost

Resilience tactic	Effectiveness	Cost
Conservation	Minor	Savings
Input substitution	Minor	Minor
Inventories	Minor	Minor
Excess capacity	Moderate	Minor
Relocation	Moderate to major	Minor to moderate
Resource independence	Minor to moderate	Zero
Import substitution	Moderate	Minor to moderate
Technological change	Minor	Minor to moderate
Production recapture	Major	Minor to moderate
Delivery logistics	Minor to moderate	Minor to moderate
Management effectiveness	Minor to moderate	Minor
Removing operating impediments	Minor to moderate	Minor

other levels of the economy as well: the *mesoeconomic* refers to economic sector, individual market, or cooperative group, and *macroeconomic* is all individual units and markets combined, including interactive effects.

Table 1.1 lists several resilience options or tactics operational at the microeconomic level. Individual businesses and supply chains are also highly resilient (Sheffi 2005). Recent disasters have caused firms to rethink strategies such as just in time inventories, and to focus on a broader picture, including improved emergency planning; however, they have not radically changed the way of doing business. Economies are composed of many atomistic decision-makers, and their adaptive behavior is likely to lead to a smooth transition in the aftermath of disasters. Below we will discuss their effectiveness and cost.

Resilience at the mesoeconomic (sector or market) level includes pricing mechanisms, industry pooling of resources and information, and sector-specific types of infrastructure such as railroad tracks. What is often less appreciated by disaster researchers outside economics and closely related disciplines is the inherent resilience of market prices that act as the "invisible hand" to guide resources to their best allocation in the aftermath of a disaster. Some pricing mechanisms have been established expressly to deal with such a situation, as in the case of non-interruptible service premia that enable customers to estimate the value of a continuous supply of electricity and to pay in advance for receiving priority service during an outage. The price mechanism is a relatively costless way of redirecting goods and services. Those price increases, to the extent that they do not reflect "gouging", serve a useful purpose of reflecting highest value use, even in the broader social setting. Moreover, if the allocation does violate principles of equity (fairness), the market allocations can be adjusted by income or material transfers to the needy.

At the macroeconomic level, there is a large number of interdependencies through both price and quantity interactions that influence resilience. That means resilience in one sector can be greatly affected by activities related to or unrelated to resilience in another. This makes resilience all the more difficult to measure and

to influence in the desired manner. In this context, macroeconomic resilience is not only a function of individual business or household actions but also all the entities that depend on them or that they depend on directly or indirectly. There are also several other types of macro resilience. Macroeconomic structure refers to features such as economic diversity, which reduces vulnerability to overall impacts when some individual sectors are greatly affected. Geographic proximity to other economies makes it easier to import goods and receive aid from neighboring communities. Agglomeration economies refer to advantages of large city size in reducing costs of production that can remain intact and keep the city competitive after as disaster (Chernick 2005). All of these forms of static resilience have dynamic counterparts as the macroeconomy changes during the reconstruction process.

The role of markets in disaster recovery is not often appreciated. Horwich (1995) and Boettke et al. (2007) have emphasized their important role in recovery following the Kobe Earthquake and Hurricane Katrina, respectively. The market has actually served as a stabilizing influence in these cases and has usually set resource allocation on the right course. This implies that there are in fact features in economies that will keep them from being entirely transformed by a disaster. A related feature is the growing use of insurance, as well as broader re-insurance markets, to spread the losses from disasters. This is yet another stabilizing influence that helps ensure survival.

Of course, many local and even regional markets are especially challenged in the aftermath of a major disaster. Some short-term centralized planning may be required. Otherwise, the major long-term role of planning applies during the course of repair and reconstruction, when a comprehensive approach may be preferred to the patchwork quilt outcome of economic decisions (Blanco et al. 2009). The planning approach in this instance has the advantage of being able to incorporate the various aspects of externalities and public goods so that the built environment is structured in society's overall best interest.

1.7 The Effectiveness and Cost of Economic Resilience

Column 2 of Table 1.1 lists the effectiveness of various resilience tactics as measured in several recent studies (Rose et al. 2007, 2009; Rose and Lim 2002; Chang and Shinozuka 2004; Rose and Liao 2005; Kajitani and Tatano 2007).

Many resilience tactics are low cost and some are even cost saving. Conservation often more than pays for itself, the exception being the few instances where, for example, energy-saving equipment must be purchased and where these costs cannot entirely be recouped from the savings. However, the case of adaptive conservation in a crisis is likely to be a more straightforward example of doing more with less. Other tactics are relatively inexpensive. Input substitution imposes a slight cost penalty, as in most cases the substitute was not the cheapest alternative in the first place. For import substitution, the penalty may simply be

additional transportation costs. Production recapture (rescheduling) only requires overtime pay for workers. Relocation costs may only involve moving costs or additional travel cost for workers; also some of the costs may be offset by lower rents in the new location as in the case of the relocation after the September 11 attacks. Inventories need to be built up ahead of time, but they are not actually used until after the event; hence, the cost is only the opportunity cost (interest payment on the set-aside for the stockpile), rather than the value of the inventory itself.

Many of these options are much cheaper than mitigation measures, which generally require widespread interdiction or "hardening" of many and massive targets (e.g., electric power plants, steel mills, major bridges). Moreover, a major cost advantage that resilience offers over mitigation stems from the fact that resilience is implemented after the event is known to occur, thereby allowing for fine-tuning to the type of threat and character of a particular event, rather than being a "one-size-fits-all" approach. The major cost advantage of resilience, however, comes from the fact that it need not be implemented until the event has actually occurred. Thus the risk factor need not involve the multiplication of the benefit term by the probability of occurrence, which reduces the potential benefits in the case of mitigation for major events in the range of 10^{-2}–10^{-3}.

One way to lower the cost of resilience, as well mitigation, is to make it multi-purpose, so it applies to a broad range of hazard threats. Emergency planning drills are amenable to this, as are inventory-buildup and backup information technology systems.

1.8 Conclusion

I conclude by offering a broader definition of economic resilience that is intended to promote sustainability:

> The process by which businesses and households within a *community* develop and *efficiently* implement their *capacity* to *absorb* an initial shock through *mitigation* and to *respond* and *adapt* afterward so as to *maintain function* and *hasten recovery*, as well as to be in a better position to reduce losses from *future disasters.*

Cities can be made less vulnerable to disasters through decentralization of key infrastructure services, reduction of transportation bottlenecks, and more rapid emergency response systems. They can more readily bounce back from a disaster if they have back-up systems, alternative business locations, and broader supply chains. A key strategy is to translate ingenuity in coping with disasters in the short run into long-run decisions and practices that continuously promote sustainability. Resilience tactics to address resource shortages in the face of disasters, such as conservation, input substitution, and technology modification can be further refined for long-run application. Disasters can also provide opportunities for transitions to more sustainable paths in the reconstruction process through revised

land-use planning, down-sizing, and industrial targeting, in addition to enhanced structural mitigation.

Resilience offers many important lessons for sustainability. As noted by Zolli (2012), it places greater emphasis on flexibility and responding effectively to disequilibria, as opposed to smooth equilibrium time paths. At the same time, resilience and its sustainability counterpart—adaptation—do not mean that we are giving up on sustainability or denigrating mitigation to short-run and long-run challenges, such as climate change. It simply means, we are taking a more pragmatic approach to inevitable crises.

Following are some guideposts for implementing resilience in the short-term and transforming it into capacity that will promote sustainability in the long term:

- Identify effective resilience tactics at the micro, meso and macro levels based on actual experience.
- Develop resilience indicators to monitor progress on resilience capacity based on this evidence.
- Disseminate findings on best-practice resilience tactics and community response.
- Evaluate the cost-effectiveness of resilience.
- Analyze the strategic tradeoffs between mitigation and resilience in terms of effectiveness and cost.
- Identify ways to make resilience in the face of crises enduring, so as not to repeat previous mistakes.
- Identify ways to transform short run resilience responses into sustainability strategies.
- Steer the economy and related systems to greater flexibility in terms of resource provision and utilization.

Although the world has witnessed a large number of major disasters in recent years, only those related to nuclear contamination seem to have threatened the survival of the host region (e.g., Chernobyl and Fukushima). Improvements in conditions underlying sustainability have helped in this regard, as has inherent and adaptive resilience associated with disaster recovery. Sharp breaks from the past do not appear to be the norm, but opportunities for major transitions that promote sustainability do increase in the aftermath of disasters.

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Chapter 2
Modeling Social Networks and Community Resilience in Chronic Disasters: Case Studies from Volcanic Areas in Ecuador and Mexico

Graham A. Tobin, Linda M. Whiteford, Arthur D. Murphy, Eric C. Jones and Christopher McCarty

Abstract A social network framework was used to examine how vulnerability and sustainability forces affect community resilience through exposure, evacuation and resettlement. Field work, undertaken in volcanically active areas in Ecuador and Mexico, involved structured questionnaires and ethnographic studies of residents and their social networks, and interviews with government officials and political leaders. Networks were categorized into: (i) closed networks–everybody interacts with everybody else; (ii) extended networks–relatively closed cores with ties to more loosely connected individuals; (iii) subgroup networks–at least two distinct groups that are usually connected; and (iv) sparse networks–low densities that have relatively few ties among individuals. Additionally, it was found that

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people with less dense networks in the least affected site were better adjusted to chronic disasters and evacuations, while those with more dense networks had better mental health in the most affected sites.

Keywords Chronic disasters · Social networks · Community resilience · Ecuador · Mexico

2.1 Introduction

Understanding social networks can help explain much of human behavior and social phenomena (Kadushin 2012). How people are connected and interact, how they support each other (or not), and how individuals play different roles within a network can significantly impact decision-making and eventual outcomes. Sociologists, anthropologists and others have focused on the significance of social networks for some time, but it is only recently that attention has been devoted to such networks in the context of natural disasters and community resilience. Indeed, research suggests that turning to social networks may enhance individual and group recovery from hazard exposure, evacuations, and community resettlement (Ibañez et al. 2004; Hurlbert et al. 2001), and international resettlement policies explicitly refer to the need to avoid destroying 'social capital' by preserving social networks (World Bank 1990; Cernea 2003). This study applies methodological developments in personal networks in such disaster contexts (McCarty 2002).

Hazards research has focused on human vulnerability and sustainability (Wisner et al. 2004) advancing our appreciation of the interplay of environmental, social, economic and political forces (Tobin 1999). The picture is complicated, however, in chronic disaster settings. A concern of our research has been to address this—exploring how exposure to chronic hazards has a cascading and cumulative effect on the recovery, coping ability, and sustainability of people who live in exposed, evacuated, and resettled communities, and in this regard, to examine the extent to which social networks mitigate or exacerbate community resilience (Tobin et al. 2010a). It is argued that chronic exposure to on-going disasters may influence social network structures, which in turn may shape individuals' abilities to adapt to the hazardous conditions.

Natural disasters still exert a significant toll on society; even though the global death toll from natural disasters has been declining relative to population (other than notable exceptions of major events such as the recent Japanese tsunami or the Haitian earthquake) losses continue to climb (Economist 2012). With 3.4 billion people now residing in hazardous areas, exposed to landslides, violent storms, floods, earthquakes, and volcanic eruptions such studies can add to our ideas regarding mitigation strategies and may ultimately enhance community resilience (Dilley 2005).

In this chapter, we expound on some of the findings we have discovered in our research focusing here on the general outcomes. The specifics on methods, disaster context, and results are described in detail elsewhere as cited in several references.

2.2 Study Sites

Our research has been conducted in Ecuador and Mexico around two active volcanoes and a landslide/flood area. The primary focus in Ecuador was Tungurahua Province, about 120 km south of Quito, an area that has been affected by ongoing ash falls and pyroclastic activity associated with Mount Tungurahua since 1999. The continuing eruptions have had severe impacts on agricultural practices, on economic and business activities, and on the health and well-being of many living in the shadow of the volcano (Lane et al. 2004). There have been several evacuations of populations, some long-term, which have led to high levels of stress associated with leaving homes, possessions, livelihoods, friends and familiar surroundings. In many cases, individuals have experienced a decline in their health (Whiteford et al. 2009). These physical, economic and emotional losses have been exacerbated by a loss of faith in both the local and national political leadership and by a struggling national economy (Tobin et al. 2011).

The research has extended over the last 12 years, and has investigated concerns in number of communities situated around the volcano. Discussed here are: (i) Penipe Viejo: Penipe Viejo has been affected notably through ash falls but has not been evacuated. It has served as a base for emergency response operations during major eruptions and several local buildings have been converted to shelters for evacuees from the high risk zone to the north. The on-going disaster, however, has affected Penipe economically, politically, demographically, and in terms of health and well-being (Whiteford et al. 2010); (ii) Penipe Nuevo: Penipe Nuevo is a newly constructed resettlement community built as a new section in Penipe. It consists of 285 houses, constructed by the Ministry of Housing and Urban Development and a multinational, faith-based NGO, Samaritan's Purse. The resettlement is an urban resettlement populated by smallholding rural agriculturalists displaced from a number of northern parroquias in the wake of the 2006 eruptions; (iii) Pusuca: Pusuca is a resettlement community, built by the NGO, Fundación Esquel 5 km south of Penipe. It comprises 45 houses occupied by smallholding rural agriculturalists displaced primarily from Puela, and a few residents from Bilbao and El Altar. (iv) Pillate and San Juan: Pillate and San Juan are two small communities of approximately 35 households each. The communities have suffered extensive damages as a consequence of heavy ash falls and landslides and been evacuated on several occasions. In spite of this, approximately 70 % of the residents have returned to live in and rebuild the communities (Jones 2010).

In Mexico, two study sites were selected, one, San Pedro Benito Juarez, which has been directly affected by the volcano Popocatépetl, and Teziutlán which has been impacted by a landslide and flood. San Pedro, a community of 4,340, is located approximately 11.5 km east of Popocatépetl. The town is the closest population to the cone and is prone to ash fall, volcanic bombs and pyroclastic flows. While the volcano has been relatively quiet over the last 100 years, it entered a new phase in 1994 when an eruption triggered the evacuation of 75,000 residents in the region. Eruptions have continued since then, and a large event in 2000 necessitated a second evacuation (Tobin et al. 2007). Teziutlán a community of 60,000, experienced a mudslide in 1999, following heavy rains and flooding, that forced the evacuation and eventual relocation of many residents to a new community, Ayotzingo, which is a neighborhood within the municipality of Teziutlán, where the Instituto Poblano de la Vivienda purchased four hectares of land on which to build starter homes for relocated families (Alcantara-Ayala et al. 2004).

2.3 Methods

Three questionnaire surveys were conducted in each community along with in-depth interviews and focus groups to collect information about adaptations to the hazards and stresses of resettlement. A socio-demographic survey was used to gather basic data on the community characteristics and this was followed by the network and well-being surveys administered to a random selection of one participant per household from the socio-demographic survey (Table 2.1). To determine networks, participants (ego) were asked to list 45 contacts (alters) from which 25 were randomly selected and classified according to sex, age, socioeconomic status relative to interviewee (ego), ethnicity, number of household members, degree of emotional closeness to ego (higher, lower), whether affected by the hazard, last contact with interviewee, and whether social, personal, financial or material support had been provided by them to ego or vice versa (Jones et al. 2013). Finally, the interviewee indicated how much each of the people in their personal network interacted with one another from the interviewee's perspective.

Survey questions were arranged into several variable groups, including demographic, evacuation data and beliefs toward the hazard (either volcano or flood/mudslide), household conditions, recent life changes, closeness to people, material possessions and resources, physical health traits, depression symptoms, and stress. In terms of the dependent variables (risk perception and evacuation experiences), several questions were asked about evacuation experience and likelihood of evacuating again; four risk perception questions were asked—concern about living near a hazard, perception that the hazard posed a risk to life during eruptions/landslides, whether the hazard continues to pose a risk to health, and whether they are generally attentive to or concerned about health.

Table 2.1 Community type and number of survey participants in surveys

Community	Hazard type	Socio-demographic	Well-being/network
Ecuador			
Penipe Viejo	Exposed-ash	53	44
Penipe Nuevo	Resettlement	116	99
Pusuca	Resettlement	42	40
Pillate	Evacuated-returned	54	48
San Juan	Evacuated-returned	37	30
Mexico			
San Pedro	Evacuated-returned	155	61
Teziutlán/Ayotzingo	Resettlement	139	139

The social network framework was used to examine how such traits affect hazard exposure, evacuation and resettlement outcomes (Tobin et al. 2010b). Four main network types were identified recognizing that in reality these points lie along one or more continua:

a. Tight/Closed Networks: nearly everybody interacts with everybody else forming a tight, often dense group, likely with high cultural homogeneity;
b. Extended Networks: relatively closed cores but with some ties or bridges to more loosely connected individuals;
c. Subgroup Networks: at least two distinct groups or cores—these may or may not be well-bridged or connected; and
d. Sparse Networks: relatively few ties among individuals and few bridges—low density.

The role of social networks in resilience and recovery efforts can be highlighted through these four types (Fig. 2.1) based on participants from San Pedro. Figure 2.1a shows a tight/closed network; the individual has few contacts outside the community, but all are of relatively equal socio-economic status and constitute close ties or somewhat close relationships. In contrast, the extending network shown in Fig. 2.1b illustrates a network with contacts that spread beyond the local community, although there is no connectivity among subgroups. This individual also has several contacts with relationships that are not considered close. The network in Fig. 2.1c, shows greater connectivity (bridging) among the different subgroups, all contacts are considered close or somewhat close and are of similar socio-economic standing. Finally, Fig. 2.1d illustrates a sparse network where the participant has few close contacts and limited connectivity.

It was hypothesized that participants with networks composed of strong subgroups and relatively robust bridging would be more successful than those with closed or extremely sparse (disconnected) networks in accessing appropriate information and resources.

In considering disaster impacts, therefore, support mechanisms as provided through such networks may prove crucial. For example, if resources are not

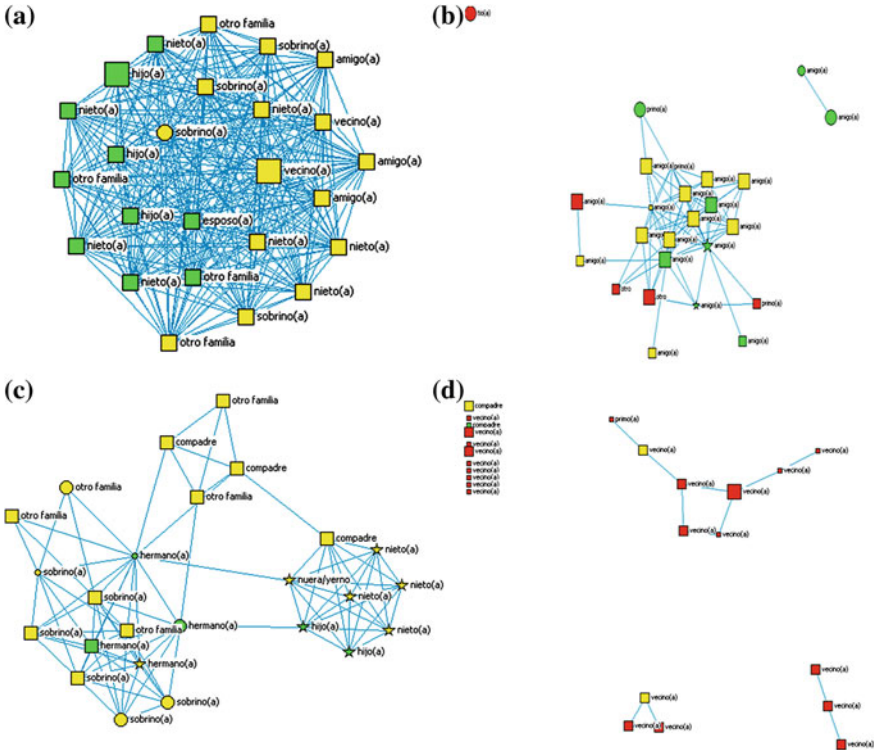

Fig. 2.1 Personal networks: **a** Tight, **b** Extending, **c** Subgroup, **d** Sparse (from Mexico). *Key*: Symbols *Square*—Community; *Circle*—Region; *Star*—Outside Region/International. *Size*: *Large*—Better off than Ego; *Medium*—Same as Ego; *Small*—Worse off than Ego

available locally, then strong outside connections may be essential to support the local community. Similarly, close ties with those from higher socio-economic levels may be advantageous under such conditions.

2.4 Results

Over the past decade or so, all the study communities, whether exposed or resettled, have faced considerable hardships with socio-economic conditions progressively deteriorating in a cascade of impacts as the disasters have intensified. In Ecuador, the destruction of basic crops and livestock from ash falls has culminated in a modified agricultural landscape, altered economic conditions, and compromised human health and welfare. Recovery has been varied reflecting differential resilience capabilities, with most households worse off than prior to the disaster. For example, residents who evacuated their homes for long periods often experienced poorer health and faced greater economic challenges than those who

remained in place, whereas those who evacuated on several occasions, and for short periods, had fewer health problems than those who either did not evacuate or stayed away from home for longer periods. The long-term consequences have been, and continue to be, severe (Whiteford and Tobin 2004).

The conditions are similar in Mexico where chronic conditions have served to exacerbate problems in both evacuated and resettlement communities. Ash has contaminated water and food, harvests have declined, and fertilizers are now needed to increase crop yields particularly for fruit trees. Also, stock animals and pets have been lost because feeding of such became difficult during evacuations (Tobin et al. 2012). At the same time, more respondents from the resettlement site, Teziutlán, believed that it is dangerous to live close to the hazard and stated that they had been negatively affected by a disaster. In comparison with San Pedro Benito Juárez respondents, more believed that the hazard poses a health risk to them and their families. Overall, significantly more problems were reported by the Teziutlán resettlement site respondents, including issues with living space, problems with heat, lack privacy, and fear of criminal activity–all possibly related to residing in small high-density housing.

Results show that disaster recovery in Ecuador and Mexico has been significantly impacted by social network type and that these play different roles depending on the prevailing conditions in the community (Table 2.2). Evacuated, exposed and resettlements present specific challenges and should not necessarily be considered as simply hazard prone.

Table 2.2 Social networks by community

Study Site	Tight	Extended	Sub-groups		Sparse	Total
			Connected	Not connect		
Penipe Viejo	13	11	10	6	4	44
Penipe Nuevo	37	22	22	9	9	99
Pusuca	17	14	7	2	0	40
Pillate	29	7	9	3	0	48
San Juan	15	5	7	3	0	30
Total	111	59	55	23	13	261

2.4.1 Mexico Networks

In general, our results suggest that medium density, sub-group networks (type c) with good bridging or connectivity to different sub-groups were better adapted to the demands of the disasters and evacuations than those with denser networks and limited bridging (Murphy et al. 2010). On the other hand, participants with sparse or open/weak networks (type d) may not have sufficient social influence to act in emergency situations and hence were often more vulnerable and showed lower

levels of well-being. Indeed, those networks with tight/close ties, such as found in types a and c, provided greater support mechanisms fostering reciprocal relationships amongst their contacts. Those participants within such networks reported more sharing, including that of materials, labor, tools, and food, than other networks. Disaster context and patterns of resettlement, however, demonstrate degrees of variation in these findings.

Conflicting results are found regarding network density. In many circumstances, dense networks are highly advantageous providing important support within communities, but in San Pedro Benito Juarez they predicted higher symptoms of stress and depression. Understanding the nature of such relationships may further complement our understanding of network structures and their changes. For instance, 94 % of respondents who provide or received labor with their network members reported reciprocal labor activities. In very few cases did someone give or receive labor on others' fields and not experience reciprocation. Where there are differences in socio-economic status between the participant and the contacts, there often exists a patron-client relationship which permits less wealthy individuals to have access to the support provided by the richer ones.

Nevertheless, networks that incorporate subgroups (type c) that extend well beyond the local community often provide additional benefits. Tight, dense networks generate multiple and often reciprocal benefits, but they do not offer a diversity of resources or information. For instance, if all a person's contacts reside in the same community, as in type a, then material support may be limited especially if the network consists of persons of equal economic status. Persons with well-connected sub-groups outside the disaster area have distinct advantages that may facilitate recovery. This is apparent in the case of San Pedro where remittances sent by migrant workers working in Mexico City or the USA played an important role in supporting the local economy. Having networks that extend beyond the community, therefore, can be important and enhance resilience.

Other personal traits of networks were found to predict impacts and emotional and material well-being. Those personal networks with higher proportions of older people and females in their networks received greater emotional and material support (the opposite was found in Ecuador). In addition, geographic distance was negatively correlated with frequency and the strength of contact; not surprisingly there was greater or stronger contact amongst those closer individuals. In San Pedro this was especially important since all the community was impacted by the volcano and individuals relied heavily on material support from outside the community. The balance, then, between geographic distance and the significance of sub-groups within a network needs to be addressed more fully.

Respondents' perceptions and awareness of the disasters were also correlated with social networks. Participants with sub-groups and networks with high levels of linkages, type c, demonstrated a moderate awareness of the hazards, but at the same time exhibited strong well-being and tended to participate in the evacuations. In contrast, those with dense networks had greater concern regarding the risk and more concerns that the events will recur. This may reflect the perceived lack of support available from outside the community.

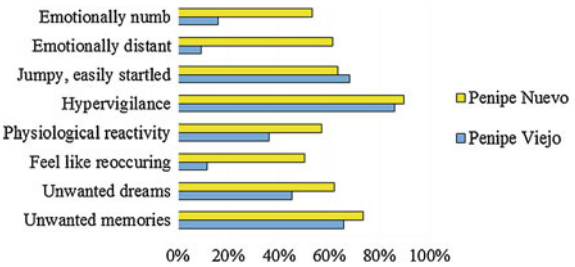

Fig. 2.2 Incidence of some PTSD symptoms in Penipe Viejo and Penipe Nuevo

2.4.2 Ecuador Networks

It is clear that the chronic conditions associated with the eruptions of Mount Tungurahua have had a profound bearing on all communities in the region. The impacts appear to be cumulative with conditions for many individuals getting significantly more difficult. For example, household conditions, physical health, stress levels were all worse in the resettlement and evacuated communities than in the exposed, non-evacuated community. In part, this appeared to be related to social networks and differences were evident between Ecuador and Mexico. Those dense personal networks with strong ties and close relationships tended to be associated with greater levels of support and hence recovery, than those with looser networks. More support, such as food and supplies, emotional support, and information, was reported as having been provided in these networks.

The dissimilarities between established and new communities can be highlighted by looking at Penipe Viejo, Penipe Nuevo and Pusuca. Respondents in Penipe Nuevo exhibited significantly higher levels of stress and depression than those in Penipe Viejo (Fig. 2.2), although they also reported higher levels of support. Also, those social networks with higher densities and where ties were closer were negatively correlated with stress and depression in Penipe Nuevo, which suggests that more dense networks with close ties are related to lower depression levels in this site. In Pusuca, however, increased closeness was correlated with higher levels of stress and difficulties in functioning.

In the resettlement communities, it is possible that traditional support networks had broken down as individuals relocated and that new connections had not been fully established. In the resettlement community of Penipe Nuevo, for example, new residents had, for the most part, come from a number of different communities and probably did not know each other prior to relocation. An exception was the other resettlement site, Pusuca, where the new site was inhabited largely by residents from one community, which suggests that resettlement strategies may play significant roles in maintaining sustainability and fostering resilience.

Those networks with only a few unique connections, such as found in type b, were especially important with individuals receiving higher levels of support (material, emotional and informational) than those with more complex networks. Such relationships were not found in exposed or evacuated communities. Also,

males received more support in the resettlement communities than females, whereas there were no significant differences in the other communities between males and females. Support from families differed amongst the communities. Evacuated individuals cited the highest levels of family support, followed by those in the exposed community. Again, it appears that social networks had been negatively impacted by the resettlement and it may take time before new relationships are constructed.

2.5 Conclusions

Social networks influence impact and well-being and can have significant repercussions for communities prone to disasters. This research started with the hypothesis that residents with social networks comprised of strong subgroups and relatively robust bridging would be more successful than those with closed or extremely sparse (disconnected) networks in accessing varied and appropriate information and resources. The results from Mexico and Ecuador indicate that the structure of networks is indeed important in disaster recovery, but that its mechanism depends on context. We must also consider the degree to which network structure is a product of the chronic hazards themselves. Overall, social networks serve important purposes in disaster environments and appear to influence levels of vulnerability and resilience. However, continued analysis and follow-up research will determine if differences among research sites is a result of the nature of the events or variations in cultural, historical, political and economic contexts in which the hazards occur.

It is anticipated that a full understanding of social networks will enhance hazard response and facilitate community resilience. For instance, when reflecting on the lasting outcomes of the eruptions, Ecuadorian respondents spoke of the displacement and dissolution of their communities. They reported that their communities were tight-knit and organized prior to 1999, but that since then, and especially after 2006, resettlement and migration have severely disarticulated their communities. Taking different social networks into account when responding to further eruptions, then, may assist the transformation of disaster survivors to safe environments.

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Chapter 3
Climate Change Adaptation in Urban Planning in African Cities: The CLUVA Project

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Abstract Resilience of urban structures towards impacts of a changing climate is one of the emerging tasks that cities all over the world are facing at present. Effects of climate change take many forms, depending on local climate, spatial patterns, and socioeconomic structures. Cities are only just beginning to be aware of the task, and some time will pass before it is integrated into mainstream urban governance. This chapter is based on work in progress. It covers urban governance and planning aspects of climate change adaptation as studied in the CLUVA project (CLimate change and Urban Vulnerability in Africa), as well as some experiences from Denmark. Focus is on the responses and capacities of urban authorities, strengths and weaknesses of the efforts, data needs and possible ways forward. The chapter concludes that many adaptation activities are taking place in the CLUVA case cities, but that they need integration at city level to form strategic adaptation plans. A combined rational and pragmatic approach is advisable as is involvement of stakeholders in the production of relevant knowledge.

Keywords Climate change adaptation · Urban planning · Urban governance · African cities

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3.1 Introduction

During the last 10–15 years, cities worldwide have been confronted with the problem of adapting to local impacts of climate change. A general list of effects include rising sea levels, rising temperatures, and an intensification of the hydrological cycle, entailing hazards such as more frequent and intense rainfall as well as longer drier periods causing droughts (Loftus et al. 2011). The specific hazards and impacts differ widely between cities due to local topography, spatial development pattern, and socio-economic characteristics (Davoudi and Crawford 2009; OECD 2010), but in the case cities of this chapter, flooding is widely recognized as a hazard connected to climate change and already effective. Therefore this specific hazard is in focus in the work presented here.

Cities have been highlighted as being more vulnerable to the impacts of climate change than rural areas due to their dependence on complicated and extensive infrastructure, the high density of buildings, and the concentration of population (OECD 2010). Most of the cities facing the highest risks from climate change are found in low-income countries, among them many cities in Sub-Saharan Africa, and most of them have serious constraints on their capacity to adapt to these effects (Bicknell et al. 2009). In this chapter the CLUVA case cities form the background cases (St. Louis, Ougadougou, Addis Ababa, Douala and Dar es Salaam, see Fig. 3.1).

African cities clearly need to become more resilient towards climate change. But even in developed countries, adaptation to climate change is a new task for the cities, and although both administration and the political level is increasingly aware of the need, no routine or commonly agreed practises have been developed yet. Two studies of practise in Danish municipalities (Hellesen et al. 2011; Lund et al. 2012) supplement the African cases seen from a developed-world perspective.

Climate change adaptation, including disaster risk management, covers a variety of different sub-tasks: e.g. plans for relief in crisis situations, establishment

Fig. 3.1 Case cities of the CLUVA project

of warning systems, and preventive measures connected to well-functioning infrastructures, social networks, and integration of adaptation measures into land use planning (UNISdR 2005). Adaptation needs policies which are both integrated into existing policy fields and across sectors, levels, and administrative functions, and which include civil society. When we add that knowledge and methods are still sought for, this makes climate change adaptation a difficult challenge for cities, not least in Sub-Saharan Africa.

3.2 The African Urban Context and the Cluva Project

Developing countries, especially those in Sub-Saharan Africa, are highly vulnerable to impacts of climate change, both because of their reliance on climate-sensitive sectors for development such as agriculture and because they lack adequate economic and institutional capacities to adapt to the impacts of climate change (Boko 2007).

The CLUVA project[1] investigates local impacts of climate change in five African case cities as well as the possibilities to increase resilience (see Fig. 3.1). Six African and six European universities and research institutes participate in the project, which includes downscaling of IPCC scenarios, studying vulnerability, and investigating land use based urban strategies as an element of creating resilience, which is the basis for this chapter. The work is now halfway, and includes baseline reports for two selected cities (Jørgensen et al. 2012) an analysis of the governance structure in two selected cities (Vedeld and Kombe 2012) an exemplary of adaptation measures at city level based on four cities (Herslund et al. 2012), and a system of geographical indicators of vulnerability to climate change (Nyed and Herslund 2012). The empirical basis for these products includes study visits, interviews, document studies, expert evaluations and meetings with key stakeholders.

The urban context as found in Sub-Saharan Africa is decisive for the options of adaptation to climate change: Rapid urbanisation coupled with economic stagnation leads to poverty, informality and spatial fragmentation (Roy 2005; Watson 2009; Cheru 2005; Kyessi 2005), making the task of providing infrastructure, service, planning and management to the marginalised majority of the urban population very difficult (Watson 2009). Climate change related hazards pose a further complicating factor. They threaten economic development; increase the stress and vulnerability of already impoverished the households, and probably will place even more pressure on an already compromised infrastructure. However, the same urban characteristics may provide an opportunity to adopt adaptation measures, which are uniquely innovative, such as community-level coping strategies and the use of low-technology infrastructure, and thus developing African cities in a more context-appropriate, innovative and possibly more democratic way as more

[1] SEVENTH FRAMEWORK PROGRAMME, Grant agreement no. 265137: "CLimate change and Urban Vulnerability in Africa", 2010–2013, www.cluva.eu.

stakeholders at various levels and within different sectors as well as inhabitants in vulnerable areas will need to participate (Bicknell et al. 2009).

3.3 Climate Change Adaptation and Urban Planning

Adaptation to climate change may appear to be an overwhelming task to city managers who already struggle to address other urban challenges. However, instead of seeing adaptation to climate change as a "stand alone" task, integration into existing urban policies seems to be a more feasible way. Urban planning and management is a key policy area, and adaptation based on urban planning has the potential to adapt (over time) the building stock, the infrastructure, the industrial and economic base, and the spatial patterns of urban development to the risks that may be brought on by climate change (Bicknell et al. 2009).

Satterthwaite et al. (2009) highlight four important measures to be taken in planning for urban adaptation to climate change; (1) channel new growth away from high risk areas, (2) implement land use restrictions in high risk areas, (3) improve drainage, and (4) introduce higher building and infrastructure standards. Such measures may sound simple, but they require knowledge, adequate planning and implementation instruments, and economic power. The highly informal urban development in African cities clearly raises challenges in relation to such measures.

Incorporation of climate change adaptation into policy-making across governance levels poses another challenge (Bicknell et al. 2009). Many African countries have been engaged in making National Adaptation Programmes of Action (NAPA's) as recommended by the UNFCCC. Such programmes are largely concerned with climate change impacts on agriculture, forestry and water management. Few governments have managed to downscale the national programmes to the city level despite the fact that there is an urgent need to develop city-level adaptation frameworks (Bicknell et al. 2009). City governments should form a nexus, linking community-based adaptation to the funds and skill of the national level, with strategic adaptation plans at city level in a key role, linking also climate change adaptation to the general economic and urban development agendas of cities (see Fig. 3.3) (UN-Habitat 2011).

3.4 Planning Approaches to Climate Change Adaptation

As planning for climate change adaptation at city level is a new field cf. e.g. (Katich 2009), there is no generally accepted tool-kit for how to develop a climate change adaptation plan or incorporate adaptation into relevant sector planning. But experiences do exist from the cities which have made adaptation strategies and plans, and planning theory offers different approaches to city-level adaptation.

Urban planning throughout the last century was generally dominated by *the rational planning approach*, characterized—in its pure form—by logic and progressive stages, clear goals and comprehensive assessments giving exact and reliable knowledge of present conditions and projections of the future, followed by plans and implementation carried out by professionals. Scientific and expert knowledge is seen as the most reliable and legitimate type of knowledge (Allmendinger 2009). While this approach has obvious strengths in relation to climate change adaptation (not least in the focus on a reliable knowledge base for action), the model is also problematic as a sole approach, because (1) it is difficult to predict the exact consequences of climate change and adaptation measures, (2) immediate action is needed, and (3) the issue involves several sectors and many different stakeholders.

Elements of the rational approach relevant to climate change adaptation planning are (1) Becoming aware of problems, (2) Intention and commitment to act, (3) Conducting local climate change and impact assessments, (4) Listing impacts and options, (5) Prioritizing adaptation actions, (6) Incorporation of adaptation into other relevant plans, (7) Implementation and (8) Evaluation (derived from UN-Habitat (2011) and Bicknell et al. (2009)). From a strictly rational perspective the elements should progress from (1) to (8), so that actions are based on knowledge and overall prioritisation. From this perspective, as stated by Danish municipal planners in a recent study, uncertain knowledge of local effects of climate change impacts is a major barrier to the development of adaptation strategies, because it blocks the progressive stages and lessens the legitimacy of policies (Hellesen et al. 2011; Lund et al. 2012).

So, while the rational approach has strengths, it also has limitations as an approach to cope with a complex task, with many actors involved, and where immediate action is needed. In the Danish study, planners accepted the uncertainty related to climate change impacts, and simply went ahead with the creation of action plans using whatever knowledge available in an incremental manner working towards an overall strategy (Hellesen et al. 2011). This is an example of *the pragmatic approach* to planning, which stresses planning as an incremental process, based on collaboration and multiple knowledge perspectives (Allmendinger 2009). The Fig. 3.2 sums up the characteristics of respectively the rational and pragmatic approach according to the planning process, types of knowledge used, goals, and the kinds of participants taking part.

Adaptation in African cities is a very complex task where a pragmatic approach is necessary. Involving a wider set of participants, such as people living in the extensive informal settlements, and including their knowledge is crucial both for the process and the results. Adaptation in Africa must acknowledge informal settlements' right to planning and influence (Myers 2011) in order to facilitate communication and involve local knowledge and private resources in solutions, thus increasing the efficiency and quality of decisions. But this also poses challenges of how to integrate actions in a strategic planning at city level, in order to co-ordinate local initiatives and national policies (and funding) and to integrate crucial sectors (infrastructure, green areas, health, waste management, water supply etc.).

	Rational approach	Pragmatic (collaborative) approach
Planning process	Defined progressive stages	Incremental
Type of knowledge	Expert knowledge	Expert and local, experiential knowledge
Goals	Clear and pre-defined	May change as new knowledge is gained
Participants	Politicians and professional planners	Multiple stakeholders

Fig. 3.2 Ideal typologies of rational and pragmatic approach to planning based on Lund et al. (2012), Allmendinger (2009), Healey (2007), Myers (2011)

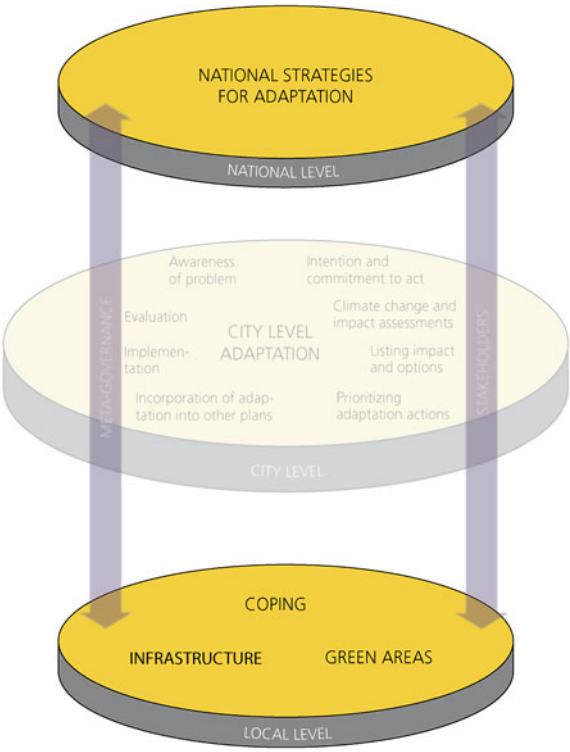

Fig. 3.3 The city level is relatively weak in climate change adaptation in the CLUVA cities as illustrated by Herslund et al. (2012)

3.5 Adaptation Measures: Findings from Cluva Cities

In the case cities, climate change adaptation is not yet specifically addressed at city level in coherent adaptation strategies, but a wide range of adaptation activities are nevertheless taking place. Here we only give an overview, for more detail see Jørgensen et al. (2012) and Herslund et al. (2012).

3.5.1 Rising Awareness and National Framework

The national level contributes to raising awareness leading to an emerging framework for local and city level action. In Tanzania and Ethiopia national policies have been launched which require local authorities to work on climate change adaptation. Both have involved stakeholders from various sectors in the preparations. This gives the local authorities a framework for action and gives climate change adaptation an 'owner', at least at national level (Jørgensen et al. 2012).

The city of St. Louis started a process of its own in 2010, utilising networks with a partner city, UNESCO (St. Louis is classified as world heritage), and UN Habitat to identify and develop projects in collaboration between French and Senegalese planners, resource persons and local actors. The projects both contained ideas for the overall development and functionality of the city and specific ideas for how to build and plan local areas in a more climate proof and sustainable manner.

3.5.2 City Level Plans

In the CLUVA cities, climate change adaptation has not yet been specifically addressed at city level in an adopted climate change adaptation strategy. Neither is climate change adaptation mentioned explicitly in master—or structural plans for the cities (Jørgensen et al. 2012; Kombe and Kweka 2012; Institutional Assessment of CLUVA cities 2012). However, some climate change elements are addressed, such as localisation of new city areas (St. Louis) and expansion of green structures in Addis Ababa (Institutional Assessment of CLUVA cities 2012) and Ouagadougou (Ouedraogo and Jean-Baptiste 2012).

But the cities also face challenges in order to include adaptation in their plans. As acknowledged by experts working in the Addis Ababa Environment Protection Authority; except data coming out of the national meteorological service agency, no detailed research has so far been undertaken on the city or any other city in Ethiopia for that matter showing the impact of climate change (Jørgensen et al. 2012). Also in Ouagadougou, the impacts and vulnerability risks caused by climate change have not yet been sufficiently evaluated yet, but national and international co-operation between practice and research is to remedy this and strengthen expertise through training (Ouedraogo and Jean-Baptiste 2012). This illustrates the problems of basing adaptation on a strictly 'rational approach' to planning as expressed also in the frustrations of Danish planners mentioned above.

In the CLUVA institutional assessment report (Institutional Assessment of CLUVA cities 2012), a common conclusion among the five cities identifies lack of coordination as a serious problem. Especially in the field of environment, coordination between actors and between the different levels of government, city, municipalities and local councils is totally lacking. Lack of awareness, expertise,

institutional responsibility and capacity also raised as problems in Tanzania (Kombe and Kweka 2012) as well as in St. Louis and Addis Ababa (Jørgensen et al. 2012), hindering a more coherent response. In St. Louis, however, setting up district councils has proven to be very important in the adaptation to climate change, especially in relation to flooding (Herslund et al. 2012). The lack of a broader framework means that the direction and coordination of the activities going on in all the cities become fragmented. The CLUVA 'institutional assessment' proposes a solution to the lack of coordination in the form of 'steering committees, climate change forums, or working groups' that can coordinate and also ensure multi-sectorial and multi-level involvement, thus advising a 'pragmatic approach' (Institutional Assessment of CLUVA cities 2012).

3.5.3 Adaptation by Individual Projects and Sectors

While coordinated city-level efforts are sparse, quite a lot of activity is taking place locally and in specific sectors. Addressing the challenges of climate change adaptation may not be the explicit or main purpose of these activities, but in practice they can assist in the process of adaptation. Furthermore, many communities and individual urban households are already involved in activities that will enhance the resilience of households and communities. Such coping strategies or autonomous adaptation activities—which local communities pursue without any sponsor or authority involved—also form an important part of adaptation to climate change.

These efforts include projects related to urban infrastructure, green area development, upgrading informal areas, resettlement of affected people, and enhancing local coping capacities. Two examples are given below.

Green area development may be used as an example of such activities. Urban green spaces have become recognised as important contributors to the quality of urban life and urban environments as they provide a number of essential ecosystem services such as biodiversity, recreational activities, reducing air pollution and heat islands, and preventing urban flooding through water infiltration, storage and evaporation within the local catchment areas (Andrade and Vieira 2007; Godefroid and Koedam 2003; Fryd et al. 2010). Urban green spaces in developing countries, however, are often under threat. Example in the CLUVA case cities of Dar es Salaam (Mng'ong'o 2005) and Addis Ababa (Belete 2011) green spaces are jeopardized by overuse, waste dumping, and urban construction. However, greening projects are also under way. In Addis Ababa, more than 40 % of the city area has been allocated for green development, including extending the number of public parks and urban forests, improving conditions for urban agriculture, public tree plantings and buffer zones along the 75 rivers in the city. It has been important to combine the protection of green areas with projects also aiming at improving the livelihoods of urban inhabitants, especially through urban agriculture (Herslund et al. 2012). In Ouagadougou, a project to improve the infrastructure of the urban

forest and national park "Bangr-weogo" put focus on the importance of green areas. This urban forest form, together with the green belt around the urban area of Ouagadougou and some sacred woods and green spaces, a green structure in Ouagadougou which helps adaptation to increasing risks of drought, desertification and flooding (Herslund et al. 2012).

Informal area rehabilitation is likewise a very important jigsaw piece in climate change adaptation. In Addis Ababa the only strong intervention related to climate change adaptation undertaken by the city government is the legalization of informal settlements built before 1996. Estimates by planners working in the city government put the current share of informal housing in Addis between 80,000 and 100,000 units. A considerable proportion of this amount is in the process of legalization. Due to this process, inhabitants in the informal sector have been able to improve their housing situation to withstand the direct impacts of climate change (intensive rainfall and flooding) (Jørgensen et al. 2012). In St. Louis, large areas suffer from lack of sanitation and drainage. Some of these areas are being upgraded with drainage and raised roads based on sponsoring from the EU or other development agencies (Information from study visit St. Louis April 2011). In Dar es Salaam, upgrading programs has been ongoing for the last decades. NGOs have been important in this work and now a 'Citywide Strategy for Upgrading Unplanned and Unserviced Settlements in Dar es Salaam' is in the process of being developed, including provision of new building plots, increased density, access to safe drinking water; access to adequate sanitation; roads, drainage, and solid waste collection (Dodman et al. 2011). In Ouagadougou, more than 60 % of the population live on undeveloped land. The City Council did not have means and methods to control the situation, but a way to legalise the informal areas has been to start to build houses. The completion by the state of a moderately priced housing area for the middle social strata has taken place outside the city (Ouedraogo and Jean-Baptiste 2012).

Sector—and local projects are very important in adaptation to climate change impacts, but they also have limitations if not integrated in a city-wide strategy. Example green area development has several benefits and is a low-cost solution. However, green areas are being encroached, so green efforts must be coordinated with overall spatial and social strategies.

3.6 Perspectives and Conclusions: Adaptation at City Level

No doubt, African cities—as exemplified in the CLUVA case cities—face a very difficult task in rising awareness, initiating, integrating, funding and implementing climate change adaptation plans. Even in developed countries, the task is new and overwhelming. Knowledge, methods and data are lacking, and the task comes on top of other important tasks for city politicians and planners (Hellesen et al. 2011).

3.6.1 Governance Deficiencies

A study within the CLUVA project on the governance framework for climate change adaptation lists a number of challenges based on Dar es Salaam: An unclear organisation at national level with overlapping authorities and lack of ownership to the task; lack of mechanisms to support vertical and horizontal coordination; lack of operational capacity; lack of knowledge among urban planners; and lack of public participation (Vedeld and Kombe 2012). Such deficiencies can probably not be remedied in the short term, but they can be seen as "systemic weaknesses" which must be taken into consideration in designing climate change adaptation at city level.

3.6.2 Much Activity: Weak City Level

When looking into specific initiatives which can be defined as relevant for climate change adaption (Jørgensen et al. 2012; Herslund et al. 2012) also positive aspects come to light. Many initiatives are taking place within various sectors, and although they lack coordination at city level, experiences are gathered. However, vertical coordination between state, city and local levels is missing, as well as horizontal coordination and integration of sector and local initiatives into a city-wide integrated and coordinated strategy. The city level seems to be weak; instead valuable, but uncoordinated, efforts take place at the local level. Herslund et al. (Herslund et al. 2012) illustrated this in Fig. 3.3.

Although this finding is specific for the CLUVA project, similar types of conclusions can also be drawn in developed countries. The Danish studies found that incorporation of climate change adaptation in the urban/municipal planning system is an obvious advantage, but that no best practice has been developed yet; municipal co-ordination (between sectors) is crucial, but difficult (Hellesen et al. 2011). Local politicians feel that adaptation is challenged first and foremost by lack of economic means because adaptation measures (which are expensive responses to uncertain long term impacts) will 'loose' to more immediate needs such as social services and schools. Also the lack of an adequate legal framework is a problem. Good contact between politicians and administration as well as public participation will help both awareness and implementation (Lund et al. 2012).

Despite the challenges, it could be safely said that in the Danish context the city level—or the municipalities—are the most important and strongest level both for initiating activities and for coordination cross sector as well as vertically. Mguni et al. compares responses to urban flooding in Copenhagen and Dar es Salaam. Copenhagen follows a top down approach, developing an overall strategy, making assessments, specifying action, and implementing the most urgent tasks first. Opposite in Dar es Salaam, there is no overall strategy or systematized assessment, but adaptation is going on in local, often informal settlements, e.g. where local

communities take measures to combat flooding. Such efforts form important elements to be included in a possible adaptation plan (Mguni and Herslund 2012). To make a difference, adaptation needs participation of the inhabitants in vulnerable areas.

In the context of African cities, it will probably be important to strengthen the city level in climate change adaptation, in order to coordinate, finance and prioritize efforts.

3.6.3 Combined Approaches

Although at stronger city level is needed, it might be a dangerous path to put all the marbles on a city level based rational planning approach. A pragmatic approach would rather take a starting point in existing activities. The planning elements of rational planning should be a part of adaptation planning, but they need not necessarily all be present and finished before any planning can occur. The listing of elements (in Fig. 3.2) can be used as a checklist to get an overview of activities that could form elements in a more comprehensive and coordinated strategy and plan for adaptation

In other words: to be effective, city-level adaptation plans need not to be all-encompassing holistic plans. They can also be put together by *coordinating* a variety of local community plans, projects and activities as well as sector plans and strategies using a pragmatic approach. While such a plan may not capture all conceivable contingencies which may result from climate variability in the long term, it is more likely to foster action faster than a rational planning approach. This in turn will generate experiences and learning that can be applied in other similar areas or sectors.

3.6.4 Need for Relevant Knowledge

Both in Africa and in Denmark, planners find that lack of knowledge is an important issue. Specific data and knowledge about future local impacts (downscaling) is severely needed both in order to raise awareness and put adaptation on the agenda, but also in order to launch effective policies and measures. An important question is how to use expert knowledge together with local knowledge in the processes and how to ensure that expert knowledge produced is relevant for the local stakeholders. The CLUVA project produces much data and knowledge to be used by the case cities. As part of the process of making data useful, an indicator system is prepared and discussed with stakeholders in the cities. Indicators encompass physical, institutional, and attitudinal indicators as well as indicators covering local assets, and have been developed in a qualitative (Jean-Baptiste et al. 2011) as well as a quantitative (GIS-based) (Nyed and Herslund 2012) set up. Such efforts may form an important link between research and practise.

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Chapter 4
"Resilience for All" and "Collective Resilience": Are These Planning Objectives Consistent with One Another?

Kalliopi Sapountzaki

Abstract Several cases of risk management ventures, predominantly post-disaster recovery experiences, have evidenced the individualized and liberal nature of Resilience to Risks and Hazards. This has been addressed by several authors some of whom have arrived at provocative suggestions regarding the role of Resilience, such as that "Resilient/adaptive systems actively try to turn whatever happens to their advantage" (Waldrop 1992), or that "Resilience refers to agents interacting locally according to their own principles or intentions in the absence of an overall blueprint of the system" (Stacey et al. 2000) or even that "Cities' transformation after disasters come in response to conflicting or multiple resiliences" (Vale and Campanella 2005). Above authors advocate the view that resilient to hazards can be any entity, agency or system from single individuals and businesses to Local Authority Organizations, National Governments or International Institutions. Each one of these actors should actor be faced with a single or multiple risks will opt solutions and actions matching own interests and own risk and vulnerability trade-offs. These self-centered solutions may exacerbate vulnerability and exposure of other actors, either collective entities or individual households. Besides, these solutions may trigger off new hazards currently or in the future. If this is the case indeed, i.e. individual comes in conflict with collective Resilience, one might wonder how could both objectives of "Urban Resilience" and "Resilience for all individual Citizens" be simultaneously accommodated. Also how these objectives impact one another. The present paper addresses these problems and suggests ways out of the impasse.

Keywords Social resilience · Institutional resilience · Resilient city · Personal resilience · Vulnerability · Vulnerability transference/transformation

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4.1 Introduction: Clarifying the Terms "Resilience", "Social Resilience" and "Resilient City"

The country I come from, Greece is currently running a serious fiscal and socio-economic crisis. Under the circumstances the state shrinks its social welfare functions, among them pensions and health care subsidies. As a result pensioners and people with chronic diseases in need of their periodically consumed medicines encounter difficulties in satisfying such basic necessities. Consequently, public health is put at risk.

What actually happens in this case is that the State in pursue of reduction of its vulnerability to debt-crisis cuts its expenses by jeopardizing health of the Greek citizens. The state employs its Resilience possibilities to avoid default by transferring its own financial vulnerability to the aged and the chronically sick and transforming it to social or health vulnerability. In this example, Resilience is beneficial to the agent employing it but may be harmful for other interconnected agents (in our case the groups of fragile health).

This dual working of Resilience should not surprise us if we took seriously the suggestion that self-organization, i.e. resilience refers to agents following their own principles and satisfying their own intentions (Stacey et al. 2000); or even the suggestion (Waldrop 1992) that systems try to turn whatever happens to their own advantage.

In Chap. 7 of the *World Disaster Report—Focus on Community Resilience* (International Federation of Red Cross and Red Crescent Societies (IFRCS) 2004a) one reads about a woman in the slums of Mumbai who lived by herself in a derelict plastic-sheet tent under a bridge. The woman has been interviewed by researchers who had approached her in search of a case study dweller exposing a poor mitigation strategy. Instead they discovered one of the most successful examples of vulnerability treatment by means of Resilience. According to the researchers' report among the woman's personal possessions was a TV powered by a clandestine electrical connection. The Report reads (International Federation of Red Cross and Red Crescent Societies (IFRCS) 2004a, p. 149):

> At first glance her living situation seemed highly exposed to risks of flooding fire and eviction….. The woman seemed either ignorant of the risks she faced or simply that she did not prioritize risk reduction… In fact however, the woman had a very conscious and coherent risk mitigation strategy. She was the owner of a simple, yet well-built flat in an established neighbourhood somewhere else in Mumbai. Having a school-aged daughter and relying on relatively few skills herself with which to compete for employment, she placed the greatest importance on protecting the one specific livelihood asset that could assure a better future for herself and her daughter. In order to afford sending her daughter away to school, she rented out her safe home and lived in a dwelling which, though precarious, would be easy to replace if damaged by a natural hazard….

In this illustrative example the interviewed woman-leader of her household would actually face not only the obvious hazards of flooding, fire and eviction but also the threat of poverty and further marginalization should her daughter was left

uneducated. With her limited resources the woman opted to target one hazard (long-term poverty and marginalization) and long-term socio-economic vulnerability only. The woman made maximum use of her minimal livelihood assets by being pro-active and mitigating what she opted as primary hazard and primary form of vulnerability and by deteriorating at the same time the hazards of her daily life (natural hazards and eviction) and immediate forms of vulnerability (health and physical vulnerability of her dwelling).

It should not escape that the resilient woman in the slums of Mumbai and other slum dwellers with similar attitudes perpetuate slum existence and expansion and increase vulnerability of their neighbourhoods and the city as a whole. Resilient citizens may become unwillingly accountable for vulnerable and non-resilient city structures. Hence, "Resilient Citizens" and "Social Resilience" cannot be identical with "Resilient Cities".

The first example about the Greek state transforming and transferring its own vulnerability to specific population groups is an evidence of resilience as a process of transformation and transference of vulnerability from certain actors (institutional in our case) to others (e.g. powerless population groups). The second example of the dweller in Mumbai slums is an evidence of resilience as a process of rebalancing own vulnerability facets (short and long term, also economic, physical, health etc.) and in relation to the various hazards encountered.

Indeed there are five options of resilience functions (Sapountzaki 2012):

(a) Internal (re)balancing of own vulnerability facets, meaning control and restriction of certain facets leaving others to deteriorate;
(b) Transformation and transference of vulnerability (specific facets) to other actors;
(c) Redistribution of vulnerability in time, i.e. in relation to the disaster cycle stages; also rebalancing between exposure and response capacity;
(d) Redistribution of vulnerability with regard to current and future hazards;
(e) Receiving vulnerability from other actors.

In the example of Mumbai slums we have seen how people's resilience or "social resilience" may undermine an urban structure's resilience and the whole city's vulnerability. One might wonder then: What is "Urban Resilience"? How sensible is the term "Resilient City"? May a "Resilient City" be the habitat of vulnerable citizens? If all citizens of a city are resilient, will they constitute then a resilient urban community and a "Resilient City Structure"?

In the exciting book *The Resilient City—How modern cities recover from disaster* (Vale and Campanella 2005) which explores the notion of resilience with regard to the post-disaster recovery phase, the editors are wondering in the final chapter (p. 335):

> …at least for the last centuries or so, nearly every traumatized city has been rebuilt in some form. This historical fact raises the question of whether it is possible for a city to be rebuilt without being resilient. What does the concept of Resilient City mean if every city appears to qualify?

The above text embodies the assumption that a city that has been reconstructed rapidly after devastation from a disaster has proved to be a resilient city. For instance, the city of Tangshan is considered by many as a highly resilient city (Chen 2005) because after having been turned into a vast ruin by the earthquake of July 28, 1976, was rebuilt then, within 10 years, into a modern earthquake resistant city with an improved quality of life, a source of pride for modern China. But has it been resilient for sure, considering that the old city lost more than 240,000 of its population, 97 % of its residential buildings and 78 % of its industrial facilities (Chen 2005)? Is it possible for a city which has been rebuilt from scratch to qualify a resilient city? Or in reality, recovery of Tangshan was due to the resilience of the then new state regime under Deng Xiaoping (after Mao's death and end of leadership) *who foresaw the potential of using a rationally reconstructed Tangshan to show the outside world China's ability to modernize and to affirm the superiority of Deng's socialist regime over Mao's outdated leftist ideology.*

Vale and Campanella (2005) recognize and admit that the process of rebuilding alone is not enough for a stricken city to qualify resilient in the recovery phase. What matters is who recovers, which aspects of the city and by what mechanisms. It is worth quoting a relevant extract (Vale and Campanella 2005, p. 341):

> In any traumatic societal event, some people will always be more resilient than others and so the notion of a resilient city is always inherently incomplete and unpredictable … There is never a single, monolithic vox populi that uniformly affirms the adopted resilience narrative in the wake of disaster. Instead key figures in the dominant culture claim authorship, while marginalized groups or peoples are generally ignored in the narrative construction process.

However, to the author's view the problem of the term "Resilient City" is not simply that it is an inherently disputable and contested term due to its political content. The problem rests basically with the inherent contradiction that the term embodies and conceals. Indeed, when one agent (e.g. an individual, household, institution etc.) is resilient and recovers or avoids risk in the city it is most probable that some other agent(s) experience increase/transformation of their vulnerability either simultaneously or in the future. This is because of the finiteness of resources usable to resilience and the modus operandi of resilience. In this sense a city is resilient and vulnerable at the same time while these two properties constantly interact and change. This is reasonable because as it has been explained already resilience means vulnerability transferences, transformations, redistributions and reallocations. No one can ever characterize a city (especially a mega-city) as totally resilient or totally vulnerable. In this sense the term "Resilient City" is a misleading term.

Resilience attitudes are actually performed by a wide variety of actors/agents in the city: Authorities and institutional organizations, individuals and households, social groups and business networks, techno-human systems and so on. What concerns us mostly in the context of this paper is what happens to the citizens if a city is qualified with resilient authorities/institutions (i.e. authorities capable of engaging and utilizing appropriate resources for the purpose of avoidance of or fast

recovery from risks/disasters). Reversely, if a city is qualified with resilient citizens what will happen then to the institutions and the urban community? Furthermore, what will be the repercussions on the physical structure of the city in each of the above cases? The two following sections are an attempt for answers to these tricky questions.

4.2 Resilient Governments/Institutions: Who Takes the Vulnerability?

Sakdapolrak et al. (2008, p. 14) examining the case of mega-cities suggests that *the central regulatory mechanism for the mega-city resilience sphere consists of two elements: institutions and people and their interaction…. People and institutions each have specific vulnerabilities and resiliences determining their ability to withstand to perturbation.* Current section is devoted to the vulnerabilities and resiliences of institutions, particularly authorities and their impact on vulnerability and resilience of cities and citizens.

Chen (2005, pp. 236–237) in his analysis of the reconstruction of Tangshan after the 1976 earthquake makes eloquent observations regarding the secrecy of the authorities and the denial of the then Mao regime to release information about the disaster to the outside world:

> …. If the earthquake had not been detected by a number of seismological centers around the globe the news of this great catastrophe would never have reached the outside world…. The authorities were so reluctant for the outside world to find out about the impact of the earthquake that they closed the city to foreigners for the next two years.

The regime in an effort to manage its own vulnerability of authority (i.e. propensity to do harm to the status of authority, political acceptance and competence of a government or institution in general) attempted to avoid exposure to international criticism regarding the size of losses. As a result it deprived the traumatized city from external aid thus increasing citizens' vulnerability in the emergency and recovery period.

Similar is the case of post-disaster Mexico city under De la Madrid's leadership. In the three years prior to the quake De la Madrid having worked closely with IMF toward liberalization of the economy of Mexico (for the purpose of recovery from the 1982 debt crisis), made the initial decision to reject foreign aid. Later, he changed his mind, but the delay stalled reconstruction and angered the citizens (Davis 2005). Once again, vulnerability shifts from the state to the most impotent social groups.

Governments and authorities in general are usually featured by three basic forms of vulnerability regardless of the hazard or risk to which they are exposed: economic vulnerability (i.e. limited accessibility to economic resources should a crisis arise), operational/functional vulnerability and vulnerability of authority (the probability of losing competence, political power and legitimacy). If the authorities

are resilient mitigation planning measures in advance are rarely an option as such measures are costly and usually unpopular, meaning that such measures tend to deteriorate both economic and vulnerability of authority.

To quote an example, the terrible disaster in Bam after the earthquake of 2003 revealed a number of problems regarding seismic legislation and its application in Iran. The inspectors who are sent to examine new public and commercial buildings are often paid off by developers to certify their construction as conforming to earthquake design standards, without carrying out a thorough inspection. Furthermore, despite the provisions that the engineer bears responsibility if the damaged building is constructed after the code of 1989, in practice prosecutions are almost non-existent. On top of that there are no laws against negligent municipalities which fail to protect municipal infrastructure through retro-fitting (International Federation of Red Cross and Red Crescent Societies (IFRCS) 2004b).

Pre-disaster risk mitigation can really be an option for elected governments if the respective urban communities are featured by high risk perception. In such cases governments are compelled to mitigation planning so as to keep their vulnerability of authority low. Indeed, high risk perception of communities is the "necessary" (but not "sufficient") condition for actual risk mitigation by these communities.

In recovery periods resilient authorities waver between targeting their vulnerability of authority on one hand and economic on the other. In the case of Mexico city post-earthquake recovery first priority for the governing party (PRI) was to rebuild and recover the major offices of the ruling party and the government. Davis (2005, p. 266) reports: *President de la Madrid made a great effort to visit building sites and assess physical damage. It did not go unnoticed that he did not visit any of the victims nor meet with displaced citizens… These stances further alienated citizens who felt that people should come before the party/state in any recovery plan.*

To refer to another example, after the landslide of Venezuela in 1999 which hit especially the Vargas state the government gave priority to large scale engineering works and underestimated social issues. As a result several months after disaster numerous families lived in houses with structural damage, many lacked potable water and adequate disposal of solid and human waste (Sapountzaki 2012).

In both above examples the authorities acting as resilient agents opted to reheat national and regional economies and spend their resources to this end while generating at the same time new exposures and transferring extra vulnerability to the already victimized groups (e.g. exposure to epidemics and problems of public health, vulnerability to future extreme events etc.). This is the essence of government's post-disaster resilience: to be knowledgeable of the diverse options of a nation's or a city's vulnerability, how these affect government's own vulnerability and consequently select to treat, relieve and recover those aspects that match better government's interests and principles (under conditions of specific resource availability).

At the initial stage of relief after the 1976 Tangshan earthquake with Mao being still the leader of China, Mao's dogma was that if the people alone (without external aid) could recover they would have achieved a great human triumph regardless of the human hardship. This would serve to confirm the superiority of Mao's leadership and the victory of his ideology within the Chinese communist party (Chen 2005).

Finally, in case of governments minding their economics and opting to avoid economic vulnerability, reconstruction/recovery is usually left to the private sector. More often than not however, the private investors speculate on the urgent needs of the homeless and the latter experience an extra burden of social and economic vulnerability. Hein (2005) describes eloquently how the neologism "yakeya" was brought about in Edo, Japan. In the past Edo has been suffering from repeated conflagrations and the reconstruction of affected districts was always left to the private sector. *Yakeya –based on the words for speculative rental row houses (nagaya) and burning (yake)- were so poorly built and rebuilt that they would bring profit to their investors even if easily and frequently vanished in flames.*

4.3 Resilient People: Do They Mitigate City's Vulnerability?

The examples and theoretical remarks of the previous section show clearly that more often than not citizens and individual households are left alone in their struggle to cure their several vulnerabilities (economic, human, pre-disaster, recovery period's, vulnerability to eviction, unemployment, displacement, natural hazards etc.). On top of that the poorest and mostly marginalized groups have often to deal with extra vulnerabilities transferred to them by formal institutions and authorities during post-crisis periods. Consequently, they have to rely on their own resilience resources and defend them with courageousness and self-sacrifice. Sapountzaki (2007) reminds us that those groups that do not take advantage of the expensive for them public offers in relief and recovery periods can alternatively capitalize on material or immaterial, routine or exceptional resources either under private or social control: private property, behavioural assets, personal knowledge, experience, formal and informal social and economic networks, social knowledge, memory and ethics, place focused cultural practices, parallel structures of illegality etc. Especially the land property rights and assets constitute for middle and lower classes the non-negotiable asset enabling some sort of resilience. It is for this reason that urban structures rarely change after reconstruction even in case of razed cities after disasters.

Indeed most of the ambitious comprehensive reconstruction plans have failed in practice due to the citizens themselves exhibiting resistance to change of land ownership/tenure patterns. Vale and Campanella (2005) argue that visionary new

city plans aimed at correcting long-lasting deficiencies or limiting current and future urban risks and vulnerabilities do not find their way to implementation even after substantial devastation of urban areas. To back their position they quote the example of the futile efforts of the architects after London's great fire of 1666, to put in practice bold new plans for the city's street network. Above authors invoke then Kevin Lynch's explanation (1972): *The most ambitious plans were thwarted by entrenched property interests and a complicated system of freeholds, leases and subleases with many intermixed ownerships.*

It becomes evident that individual citizens and the poorest rather, themselves combat and undermine collective or city level resilience just because they claim their rights on the means of personal resilience (basically their pre-disaster property rights). More specifically, the sum of claims of individual citizens for their pre-disaster entrenched rights on urban land perpetuate and increase a collective form of vulnerability, i.e. urban structure's physical vulnerability.

There are actually numerous examples of direct conflicts between individual and collective resilience (i.e. the resilience of the community as a whole), or to put it in another way causal relationships between individual resilience and collective vulnerability. In the previous section we have seen already why and how institutional (i.e. some form of collective) resilience produces numerous individual vulnerabilities. It has been revealed already that it is a myth that resilience is always good as an ever vulnerability abating factor. It does only good to the agent employing the property but it may harm others (collective or individual agents) by increasing their vulnerability.

People and individual households as if they are conscious of this dubious nature of resilience they usually opt individual resilience instead of collective. It is exactly for this reason that physical and other forms of the wider urban structure do not improve in reconstruction/recovery periods and not because of some kind of *inertia of urban resilience* as Vale and Campanella (2005, p. 346) suggest. The preference of people and households to personal resilience rather than collective has been confirmed in the Bam's reconstruction after the earthquake of December 2003. After pressures from the victimized groups, four months after the disaster, the International Red Crescent Society introduced a cash voucher system to replace the distribution of relief items (except for hygiene kits). This has enabled disaster affected people to recover part of their livelihoods and hence to acquire means for activating always more individual resilience.

According to theoretical assumptions resilience is centered virtually on self-priorities and self-capabilities (Sapountzaki 2007). Resilience is about selecting among risk targets, selecting among vulnerability facet targets, allocating these targets in time and striking the selected targets (by using available resources) according to own principles and survivability prospects. It is more than obvious that the range of above risk and vulnerability targets (and available resources to striking them) differ from agent to agent especially from individual to collective agents such as central and local authorities. Under the circumstances it is almost unlikely that the solutions of collective resilience as emanating from institutional organizations can meet the necessities of each individual for vulnerability curing

and risk confronting. Instead, knowledgeable private individuals struggle for their own opportunity to resilience by defending and expanding their livelihoods, especially durable income sources and land property assets.

4.4 Resilience in Mega Cities: Selecting Among Risk Mitigation Targets

Mega cities are incubators of risk. Hansjurgens et al. (2008, p. 20) argue that:

> Mega urbanization involves unprecedented growth, high population density and a concentration of economic and political power, turning the urban habitat into both a space of opportunity and a space of risk. What is more mega cities generate a highly complex variety of simultaneous and interacting processes that produce and reinforce risks and dangers.

The same authors suggest that mega cities' vulnerability is affected by three types of risk: (a) single hazardous events, (b) chronic long-term damaging processes and (c) events related to global change. Hansjurgens et al. (2008) suggest that three elements of mega cities shape each one's specific vulnerability: size/scale, speed of change and complexity. Mega city's increasing social polarization due to globalization causes and reproduces social exclusion with an always increasing in percentage marginalized population. According to Sakdapolrak et al. (2008, p. 11) these people *are vulnerable to the effects of economic, social and political insecurity, exploitation, environmental pollution, natural hazards, health crises, food insecurity.* Meikle (Meikle 2002) explains that their livelihoods are threatened by their informal/illegal status undermining their labour, tenure and political rights; their degraded living environment affects their health and their reliance on the cash economy makes them vulnerable to price rises and financial crises. As regards location of the marginalized informal neighbourhoods IFRCS (International Federation of Red Cross and Red Crescent Societies (IFRCS) 2004a, p. 145) reports that slum settlements in Mumbai *have sprung up wherever land could be found: on steep slopes, by open gutters and streams, on low-lying flood plains, under high voltage wires, beneath stone quarries, along railway lines and highways and inside industrial zones.* As a result natural hazards in the slums become more destructive; flood waters remain for long periods in these non-serviced districts; their residents are exposed to bacteria and communicable diseases due to garbage and sewage left in the open air and polluted land and water table; infant mortality rates become high; natural and technological hazards combine into Na-tech and residents' vulnerability deteriorates due to the high density of poorly built structures and the labyrinth like pattern of streets trapping inhabitants in case of emergency.

The example of the highly resilient female slum dweller quoted in the introduction is instructive as regards slum dwellers' resilience:

- Slum dwellers are gifted with high resilience owing to their high exposure and vulnerability, plight experiences/memories and hence their high risk perceptions.
- The predominant resilience functions of the slum dwellers are (a) re-arrangement of own vulnerability facets (economic-social, physical-housing, human etc.) and (b) selecting a hazard to target among the several being encountered.
- In selecting a hazard target slum dwellers show preference to chronic hazards rather than extreme events. After all chronic hazards cause harm daily while with some luck extreme events may be late comers to find them in a more robust position.
- In selecting a vulnerability facet to combat slum dwellers show preference to their economic or income vulnerability. This preference most probably deteriorates other forms of slum dwellers' vulnerability (health, housing, social, human etc.) as a result of a vulnerability rollover process.
- Slum dwellers are interested in boosting their own individual resilience rather than cooperate with others and the Municipality for collective resilience in the slum districts. This is partly because they feel that vulnerability in their slum neighbourhood is generated and reproduced by the authorities themselves, migration processes and even their neighbours or newcomers in the slums. Hence slum dwellers adopt usually a dual strategy: In the slums they treat only immediate crisis physical vulnerabilities and only through minor adjustments; but they appeal to distant places and spaces for durable resilience resources to pro-actively cure their long-term vulnerabilities.

It seems then that there are widespread myths and delusions about resilience and its universally welcomed effect. The next concluding section deals with these myths and reviews urban policy options under a renewed perspective.

4.5 Conclusions: Myths and Dilemmas on the "Resilient City"

The term "Resilient City" even as a long term vision is a misleading term/concept. It is a term denoting that all components of a city can become simultaneously resilient, i.e. capable to get rid of or cure their vulnerability. We have seen however, that resilient citizens do not identify with resilient city structures (physical and other). The Resilient City is utopia because resilience and vulnerability co-exist they constantly reproduce one another. The two properties co-habit in the urban system. An urban community of resilient citizens cannot ever become a non-vulnerable community. On the contrary, documentary evidence shows that resilient individuals may and most probably produce vulnerable communities, institutions and/or urban physical structures, i.e. collective vulnerability. Documentary evidence indicates that the reverse is also valid: resilient governments/authorities may burden with extra vulnerability impotent and marginalized social

groups, meaning that institutions may produce individual and social vulnerability. Hence, the best the concept "Resilient City" can offer as a policy objective is to boost resilience of some aspects/actors in the city by deteriorating the vulnerability of others. Besides, the slogan "Resilient City" equalizes the most and the least vulnerable in the city as regards their rights on resilience.

The symbiotic relationship between resilience and vulnerability in the city rests with the modus operandi of resilience. Its employment necessitates resources which are limited and for which numerous actors, individual and collective, struggle in the urban arena. It is evident that *the actors dispossessing others or collective entities from their own resilience resources restrict the latter's possibilities for vulnerability reduction* (Sapountzaki 2007). Besides, one of the basic resilience functions is vulnerability transference (in time and space) to other actors. Hence, boosting of resilience of some actors translates into increasing vulnerability of others.

Assessment of the resilience effect on vulnerability necessitates identification of resilience origin (i.e. where/whom it comes from), resilience function type and the levered vulnerability's "journey" and destination. Resilience as internal rebalancing of one's own vulnerability facets by an actor beneficial may be to this actor because it allows the actor to adjust effectively to changing circumstances of resource availability and the blend of hazards confronted. It does so without doing harm to other actors, individual or collective. Resilience as a mechanism of transference of vulnerability is generally beneficial for the actor taking the resilient action but may be harmful for others. If vulnerability shifts from the poor and vulnerable toward the well-off and safe or accountable institutions, resilience then may rehabilitate "vulnerability justice" in the city and/or trigger institutional reforms to this direction. If on the other hand vulnerability shifts from the well-off and the political elite to the already poor and vulnerable vulnerability inequalities are going to increase.

The slum districts and squatter/illegal settlement areas of mega-cities are incubators of risks, vulnerabilities and resilience. The residents of these marginalized districts exhibit preference to individual rather than community resilience. Their individual resilience strategies target chronic rather than extreme event risks and own economic or income vulnerability rather than physical, human, housing or health vulnerability. Should opportunities arise they develop dual strategies, for combating both immediate crisis vulnerability on the spot and long term vulnerability by appealing to distant safer places and spaces.

Resilient governments and authorities are those which mind for their economic and vulnerability of authority. Mitigation planning measures in advance of disasters are rarely an option for these authorities because mitigation measures are costly and unpopular. Only in case of communities with high risk perceptions predisaster risk mitigation can become a viable option for public authorities. It is not by chance that after seismic disasters seismic design building codes usually become stricter.

In post-disaster recovery periods authorities and state institutions waver between managing their vulnerability of authority on one hand and their economic

on the other. More often than not they prioritize national or regional level macro-economic objectives to the disadvantage of local level social issues and the mostly victimized groups. The latter finding their vulnerability worse and worse turn to their own material and intangible resilience resources. Among them land property rights are of paramount importance and those who feel dependent on these obstruct any change in the urban pattern even for urban structure vulnerability mitigation. In a sequence of events resembling a vicious circle institutions deteriorate social and individual vulnerabilities and numerous individuals resist collective resilience at least in the form of urban vulnerability mitigation planning. Improving risk perceptions is the only way to break these vicious circles of vulnerability transference.

4.6 Recommendations

- The slogan "Resilient City" should be replaced by "Resilience in the City" as it rests with the urban community to prioritize between resilient citizens and resilient institutions, or individual and collective resilience (i.e. the resilience of the urban, physical and other structures) through consensus-building or other democratic processes. This change rehabilitates the political content of the concept and may have a really activating impact on citizens so as to become effective vulnerability managers.
- Vulnerability and Resilience assessment studies in relation to single or only natural hazards do not make sense. In the real world vulnerability and resilience are always complex properties generated by and constituting reactions to multi-risk contexts. Hence, policies to boost resilience cannot refer exclusively to flood risk, earthquake, risk of poverty, social exclusion, epidemics etc. Policies for resilience can only refer to the whole spectrum of hazards each actor is confronted with and it is up to this actor to decide hazard targets, hazard prioritization etc.
- City residents and institutions should all become aware and knowledgeable of the threats and risks encountered in the different parts of the city and by the various individual and collective actors. Each city should assign or conduct a multi-risk identification study with reference to chronic risks, extreme event risks and local impact of globalized risks. Official reports accessible by the public should inform every citizen about where, by whom, what risk is encountered. Threats to institutions are important and should also be included in such reports. These multi-risk identification reports should be constantly updated by means of a risk observatory similar to the environmental monitoring systems.
- The resilience means of the poor and vulnerable should be enhanced during normal periods if vulnerability/resilience justice is to be pursued in the city. Among these resources land property rights (freeholds, leasing, sub-leasing, land allocation etc.) are very significant. If these rights are offered inside the

housing districts of the poor and vulnerable they can contribute to physical upgrading and mitigation of vulnerability of these districts by their dwellers themselves. At the same time these poor and vulnerable dwellers should be encouraged to maintain their social, property, family and other bonds with distant places (e.g. with countries of origin in case of external migrants etc.). These bonds will offer to the urban poor pools of resilience resources and the chance of vulnerability transference to distant places beyond the city, especially in emergency and recovery periods.

- Citizens and communities should be consulted (by means of referendums, polling processes or other governance methods) to select between individual and collective resilience. Do they trust institutions to conduct all relief and recovery aspects should a disaster/crisis occur or they do prefer individualized support with resilience resources for each one to find own housing and business recovery trajectory? Should the community opt individualized resilience, external aid in case of disaster will have to be allocated to individual households/firms. Otherwise, institutions become legitimized to use and spend financial aid for collective, national or regional level, recovery objectives (e.g. major infrastructure works, subsidizing reconstruction of the major industries and production sectors etc.).
- Political empowerment of the poor and vulnerable is very critical not only for the purpose of improving their accessibility to resources but mainly for increasing dependence of city institutions and their vulnerability of authority from these groups. To this end, grass-root organizations and NGOs are of paramount importance.
- Enforcement of risk taxes and introduction of penalties for those who demonstrably have transferred vulnerability to or generated exposure for others are policies and measures halting the unfair processes of vulnerability rollover from the powerful and resilient to the powerless and vulnerable. Such provisions might be paralleled to those of environmental taxing.
- Building high risk perceptions is the key policy toward resilience boosting. High risk perception is the key factor toward "Good Resilience", meaning (a) emphasis on pre-disaster vulnerability (pro-active resilience), (b) equal concern for chronic risks and natural or globalized ones, (c) equal concern for current and future vulnerability, (d) rebalancing of own vulnerability without transferring it to others, (e) learning to avoid extra vulnerability coming from others. Risk education, training, information and research are fundamental for high risk perceptions. Hence, risk learning should be embodied in the routine teaching programmes and courses at all levels of education; the respective curricula should address not only hazard and risk but vulnerability and resilience as well. Furthermore, risk and vulnerability mitigation visions and claims should take their position in the political agendas and those of civil society organizations. The mass media should undertake a part of responsibility for risk information release and dissemination.
- Outsiders should be banned from imposing their own resilience narrative on disaster stricken communities. This is particularly the case of private sector investors and developers who profit on disasters by taking advantage of the urgent needs of the homeless and stealing the exceptional resources produced by

the extraordinary crisis situation. This is indeed one fundamental responsibility for the competent institutions; success or failure in this sense will determine their term of authority.

All in all citizens and decision-making bodies should be aware of the fundamental truths about urban resilience politics: Resilience is a counteraction to vulnerability but not a panacea, vulnerability reduction depends on who can be resilient and who cannot; resilience and its fight against vulnerability can never be promoted with a view of one specific hazard because actors in the real world consider all sorts of confronted hazards and make trade-offs; resilience is a liberal path to vulnerability reduction but it entails vulnerability inequalities and does not substitute public mitigation policies. ….And take care: when somebody's vulnerability is reduced sometimes, somewhere, it is probable that others elsewhere are encumbered with some form of vulnerability, currently or in the future. Collective resilience and vulnerability mitigation does not always keep pace with promotion of individual resilience.

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Chapter 5
Linking Sustainability and Resilience of Future Cities

D. Asprone, A. Prota and G. Manfredi

Abstract Resilience and sustainability are now primary goals for future cities. On one hand, the extreme natural and man-made events that have recently hit urban systems (earthquakes, tsunamis, terroristic attacks) makes resilience a principal challenge of our society. On the other hand, the high environmental, social and economic burden that cities have today, combined with the high exposure of the world population in cities, makes sustainability as well a main objective for future development. However, how the two concepts are linked and how we should imagine future cities in terms of resilience and sustainability, represent an issue for scientific debate. An approach aimed at hinging the concept of resilience within a sustainability-based framework is being proposed here, where safety of city inhabitants is considered as a main requirement for sustainability of future cities. Here, the city is seen as a complex and dynamic organism for which sustainability should be ensured at each stage of the urban development. The proposed approach moves from the point that, for the city, an extreme event and the resulting changes moving the city to a new point of dynamic equilibrium, represent a stage in the life cycle, i.e. the Hazardous Event Occurrence phase; hence, it is stated that resilience represents the sustainability of this phase, from the economic, social and environmental point of view, for all the present and future actors, directly and indirectly involved in the recovery process. Furthermore, since urban systems are interconnected with each other by a complex network of relationships, it is also stated that city resilience must be sought on a "glocal" scale, as it also happens for sustainability; that is, the objective of city resilience must be pursued both on a local scale, referring to the physical and social systems within cities, and on the global scale, referring to the system of relationships which connects cities to each other.

Keywords Sustainability · Resilience · Future cities · Disasters

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5.1 Introduction

Nowadays, sustainability is recognized by many scholars and practitioners as one of the prerequisites for the successful development of contemporary society. The concept of sustainability is evoked to characterize and define the optimal relationship between man and nature, in whatever form it is realized. Nevertheless, the concept of sustainability is very complex and the correct implementation of "sustainable" processes and transformations can be extremely difficult. The objective of sustainable development, in fact, in its widest meaning, is to govern a complex system of actors and entities, represented by man and society on one hand and environment and natural resources on the other hand, linked by complex relationships and conflicting dynamics.

The greatest expressions of the conflict between development and conservation is most present in the city. In fact, the fast development of contemporary society of recent decades is leading urban environments to be ever more crucial nodes of the network of contemporary society itself. Human processes and transformations are concentrated in cities, where, since 2007, the majority of the world's population resides, where the natural environment is completely cleared to make way for the built environment and where the challenge of sustainability becomes more difficult, but essential. The "sustainable" city is the challenge of today, both in terms of local development, related to communities and local resources, and of global development related to society, energy resources, and the health of the planet.

Cities are connected by a dense and complex web of relationships and represent the heart and engine of the global development of contemporary society. But at the same time, cities are increasing their vulnerability. Catastrophic natural events can bring down cities and the network of relationships that take place in them. Natural events as extreme weather events (recently more frequent and intense as a result of the ongoing climate changes), earthquakes, tsunamis or man-induced events such as terrorist attacks or accidents, can have extreme effects on cities and communities. Hence, the resilience of cities against catastrophic events is a further challenge of today. City transformation processes must be rethought, to mitigate the effects of extreme events on the vital functions of cities and communities. Redundancy and robustness of the components of the urban fabric are essential to restore the full efficiency of the city vital functions after an extreme event has occurred. Hence, sustainability and resilience are the keywords for future cities.

It is widely discussed in scientific literature that sustainability and resilience are strongly connected. Numerous efforts have been made to theorize about the link between these two concepts applied to urban systems, to territories, or more generally to communities and thus to society. The UN Summit on Sustainable Development, in 2002, stressed the importance of including, within the framework of sustainability, the capacity of society to manage natural hazards and mitigate their impacts: "Can sustainable development along with the international instruments aiming at poverty reduction and environmental protection, be successful without taking into account the risk of natural hazards and their impacts? Can the

planet afford to take the increasing costs and losses due to natural disasters? The short answer is, no." (World Commission on Environment and Development (WCED) 1987).

Callaghan and Colton (2008) stressed the need to build resilient and sustainable communities through the management of the community capital and its environmental, social, cultural and economic aspects. The community capital is the real engine of both sustainable development and resilience to extreme events. The concepts of sustainable development and resilience were also joined by Rose (2011) who theorized that the absence of economic resilience to violent changes induced by extreme events threaten sustainable development.

However the complexity in defining the relationship between the sustainable development of cities and the resilience of urban systems and communities against extreme events arises from the difficulty in defining singularly the concepts of sustainability and resilience. In fact, given their multidisciplinary nature, neither sustainability nor resilience present an univocal definition, but are open to different interpretations, depending on the point of view from which the problems are treated. In the following sections the different approaches available in literature to the definition of resilience and sustainability of cities are analyzed. Then a definition of city resilience against extreme events is proposed, strictly related to the concept of sustainability of contemporary cities.

5.2 Different Approaches to City Resilience

Today, extreme events, both natural and man-made, threaten cities more than ever, due to the high exposure of contemporary society in cities. Hence, city governments, anywhere in the world, need to implement risk mitigation and risk management actions, aiming at resilient cities against extreme events.

Historically, the concept of resilience was introduced first in the nineteenth century in physics, where it was used to indicate the ability of materials to withstand shock loads without suffering damages. Numerous definitions of resilience applied to urban systems are also available in literature and an excellent review is presented by Zhou et al. (2010). In fact, a contemporary city can be interpreted as a complex system, composed of dynamic relationships between its physical environment, i.e. infrastructures, space, networks and lifelines, the natural environment and its social environment, consisting of communities and their internal relationships. Hence, according to a general definition, cities can be considered resilient if able to cope with extreme events without suffering devastating losses and damages to their physical systems or reduced quality of life for the inhabitants (Godschalk 2003). However, a comprehensive definition is still not available, given the complexity in defining the properties of urban systems and the response of cities to extreme events.

What are the real operations taking place in urban systems? What about the dynamic equilibrium at the basis of the urban system operations? What is meant by

limited damages and preservation of functionality for urban systems after extreme events? Does the optimal response of urban systems to extreme events, i.e. the "resilient" response, depend on the type of extreme event? These are just some of the questions that make the resilience concept exploding with different and multidisciplinary meanings, as proposed in literature.

Furthermore, the complexity of urban systems introduces a further distinction to the definition of resilience, depending on the point of view from which the problem is dealt. In applying the concept of resilience to complex systems, such as cities, two approaches can be followed: (a) the resilience of ecosystems, and (b) the engineering resilience. In the first, proposed and developed by Holling (1973, 1986, 2001), resilience can be defined as the ability of a system in dynamic equilibrium, subject to external shocks, to move to a different dynamic equilibrium stage. On the contrary, engineering resilience, developed by Pimm (1984), Bruneau et al. (2003) can be defined as the ability of a system to absorb an external shock and quickly return to the initial stage.

Apparently the first definition may be more complete and suitable for urban systems; in fact, moving from the fact that a complex system in dynamic equilibrium (as the urban system, which consists of physical and social subsystems linked by a dynamic network of relationships) can present different equilibrium stages (i.e. can "work") in various configurations, it can be concluded that a positive response to a malicious external shock can also be represented by a new equilibrium stage, different than the previous one. For example, looking at the terrorist attack on the World Trade Center in New York on 11 September 2001, it can be said that the city of New York had a "resilient" response. New York quickly recovered from the social and economic damages, even if the equilibrium was reached in a different configuration of the physical system, i.e. without rebuilding the World Trade Center towers and relocating the activities elsewhere. Furthermore, the social value of the towers, which had represented a crucial symbol for the collective identity of New York, has been preserved by reconfiguring the city in a different dynamic equilibrium; that place was re-though (i.e. Ground Zero). The towers' values still exist and their physical absence was recovered from the social and cultural point of view.

Nevertheless, engineering resilience is also extremely meaningful. In fact, one could argue that a complex and dynamic system, as the city, is always able to reach a state of equilibrium after a shock, because the ability of cities to adapt to changes is extremely high. But the new post-event dynamic equilibrium could be "worse" than the previous equilibrium stage; in this case only with an engineering resilience approach a "negative" response can be appreciated. Quality and performance indicators of the urban system can be used for this scope.

Thus, in order to merge the different approaches, it can be concluded that the urban system is resilient if, after the shock, it can reach a dynamic equilibrium stage, even if different from the previous one, but, at the same time, certain indicators of quality and performance of the system return to (or become higher than) pre-shock values. This concept was also introduced by Dalziell and

McManus (2004), which affirmed the need to introduce metrics of resilience. This approach can be strictly interrelated with the concept of sustainability metrics, discussed in the following section. Hence, given the need to introduce metrics of resilience, which indicators should be used? Are the indicators typically used to assess city sustainability suitable for the scope? Which quality and performance indices can describe the "effectiveness" of the response to external shocks?

The centrality of communities in urban systems presents an alternative conception of resilience. Rather than focusing on the strength and flexibility of built infrastructure, the social resilience of communities provides a buffer between the external shock and the individual citizen of an urban system (Adger 2000). Social resilience, according to Adger, can be measured by three characteristics: resistance to external shocks (a) the ability to recover from external shocks (b) and creativity (c), that is the ability to adapt to new circumstances. Hence, the approach to social resilience affirms the centrality of communities, able to manage the other physical elements and determine resilient urban systems.

In all the approaches so far analyzed, however, resilience is perceived as the ability of the city to have a "positive" response, when exposed to an external shock, as an extreme event. The main issue is the need to specify what a "positive" response is: the return to the previous equilibrium configuration or even a different reconfigured equilibrium stage? And, in a complex and dynamic system, as cities are, what is an equilibrium stage? Furthermore, is resilience to be reached separately both in the social and the physical system, or social system resilience entails physical system resilience? Thus, is the physical system resilience condensed in the community resilience? Hence, is community, representing the only decision maker for urban management, the only master of a city's destiny, the key to a resilient city?

5.3 Sustainability of Urban Systems

The concept of sustainability is used to define the optimal relationship between humankind and nature, in whatever form it may be realized. In fact, sustainability is required in all human processes involving the use of natural resources, the development of technologies and the development of cities and territories. However, the concept of sustainability is extremely complex and a successful deployment of sustainable processes can be extremely difficult. In fact, the sustainability of development aims to manage a complex system of individuals and entities, represented by citizens and society on one hand and by environment and natural resources on other, and linked through complex relationships and conflicts. Thus, a process or a transformation providing advantages to a group of individuals, can damage the environment or another group of individuals, near or far, in space and time, by interacting with the environment and natural resources (Gunderson and Holling 2002; Kates et al. 2001). Hence, only understanding and managing the

relationships between individuals, society and nature a sustainable development can be pursued and implemented. The concept of sustainability can be divided into a set of concepts, representing the rules for sustainable development, as currently acknowledged:

- Sustainable development pursues both the present and future economic development of society, the welfare of individuals and the preservation of environment.
- Sustainable development meets the needs of present generations without compromising the ability of future generations to meet their needs.
- The rate of utilization of any resource must not exceed the rate of regeneration of the resource itself (Jansson 1984).

The concept of sustainability as here presented was outlined and defined in the eighties, as a result of a dialectical process initiated by a group of economists, led by Herman Daly and Robert Costanza. The first step was given in a symposium held in Stockholm in 1984, entitled "Integrating Ecology and Economics" (Jansson 1984). Tiezzi gave an original definition of the sustainable development issue, in his main work "tempi storici, tempi biologici" ("historical time, biological time") (Tiezzi 1984). He theorized that one of the main characteristics of contemporary society is the contrast between the fast pace of society and human transformations and the slow pace of biological cycles and nature transformations. According to Tiezzi, the reason for the environmental crisis is this conflict, which humankind has never faced in its history. Thus, according to Tiezzi, we need to reconsider the "biological time", pursuing the sustainability of any social and environmental transformation.

Using Tiezzi's approach, the onset of the conflict between society and nature times is highlighted in cities. Cities are the places where human transformations are condensed, where the natural environment is substituted for the built environment and the sustainability challenge becomes even more difficult to win, but essential. The "sustainable city" is the challenge of today.

Given these considerations, city sustainability should be pursued by analyzing and managing the effects of built environment transformations, in terms of economic, social and environmental impacts. In other words, city sustainability must represent a balance between the satisfaction, at different moments, of economic, environmental and social requirements, moved by different "city stakeholders", often conflicting with each other.

Hence, a generic city transformation is sustainable if it is:

- Equitable: satisfies social and economic requirements,
- Feasible: satisfies environmental and economic requirements,
- Bearable: satisfies environmental and social requirements.
- For a generic city transformation, the assessment of the satisfaction of these requirements provides an assessment of the sustainability.

5.4 Linking Resilience and Sustainability

In previous sections the concepts of resilience and sustainability applied to urban systems have been separately addressed. The link between sustainability and resilience of contemporary cities is evident and has been introduced by several authors, with different approaches but with a common objective. The UN Summit on Sustainable Development, in 2002, already mentioned above, emphasized that contemporary cities, in order to be sustainable, need to be resilient to disasters. In particular, Tobin (1999) tried to model the optimal city policy to be implemented in order to achieve sustainable and resilient communities. The proposed approach involves the use of 3 different models:

- mitigation models (a), i.e. the implementation of decision support systems aimed at engaging concrete actions to mitigate the risks;
- recovery models (b), i.e. systems of recovery operations from the post-event damaged configuration, to close the disaster-damage-repair-disaster loop; however the recovery operation system should not increase social inequalities and should take into account the complexity of the communities affected by disasters;
- structural and cognitive models (c), i.e. systems to make communities aware of the risks which they are prone to and to encourage them to implement even ordinary actions, to mitigate the effects of disasters.

By using this approach, Tobin defined the properties that resilient and sustainable communities should have. Moving from Tobin's approach the connection between the concepts of city resilience and city sustainability stays in the approach to the complexity of sustainability, in which resilience plays a fundamental role. In fact, as mentioned in previous sections, the complexity of sustainability can be summarized in the following rules:

- sustainability of a system involves a dynamic equilibrium between several factors related to economics, society and environment, often governed by different forces, contrasting each other;
- sustainability of transformations and processes must be pursued and ensured for all the time in which their effects propagate;
- sustainability must be pursued with reference to all the actors involved, both those directly participating to the processes and those affected by their indirect effects; furthermore, sustainability must be ensured for both the present actors and those belonging to future generations.

This approach to the complexity of sustainability is implemented in different scientific fields; for example, in engineering, a wide literature has been developed in recent years on indices, methods and procedures, for assessing the sustainability of products and industrial processes. According to these approaches, a sustainability assessment is composed by the following steps:

- For each man-made process and transformation, the social, environmental and economic impacts need to be evaluated.
- Furthermore, these impacts should be evaluated for the various actors involved in the process, that is, for example, in the case of an industrial product, workers, manufacturers, users, etc.

Therefore, these impacts should be quantified for the entire period in which the transformation process has effects, analyzing the impacts induced during the phase of production (a), use (b), maintenance (c) and disposal (d) phase, that is for the entire life cycle.

It is important to underline, since it will be useful hereafter, that some critical issues exist in the implementation of this approach:

- sustainability assessment can be conducted only once the boundary conditions, i.e. the unit to be analyzed, have been defined;
- sustainability assessment can only be comparative, between different options. In fact, each human transformation determines an environmental, economic and social burden; hence, sustainability assessment can only be aimed at assessing the "best" option, that is the less impacting one.

These recent approaches are also applied to the transformations of the built environment, where high environmental, economic and social burdens are induced. Hence, in these cases, since it is necessary to analyze the entire lifecycle of the urban transformations, all the potential extreme events that could hit the city structures and infrastructures during their life-time are to be taken into account. Hence, it is necessary to implement a probabilistic approach, as commonly used in risk engineering (e.g. multi-hazard loss estimation procedures), to deal with the possibility that different extreme events may occur on the physical elements of the city during their life-time. Thus, sustainability assessment should include the assessment of the resilience against the hazardous events, that is the sustainability of the post-event recovery processes. This phase can be named as hazardous event occurrence (HEO) phase.

5.5 Conclusions

Resilience and sustainability are now primary goals for future cities. On one hand, the extreme natural and man-made events that have recently hit urban systems, and on the other hand, the high environmental, social and economic burden that cities have today, combined with the high exposure of the world population in cities, make resilience and sustainability the main objectives for future development.

However, how the two concepts are linked and how we should imagine future cities in terms of resilience and sustainability, represent an issue for scientific debate. This work is part of this process and proposes an approach aimed at

hinging the concept of resilience within the sustainability framework. The city is seen as a complex and dynamic organism, for which, as for any human process or transformation, sustainability should be ensured at each stage of the life cycle. The proposed approach moves from the point that, for the city, an extreme event and the resulting changes moving the city to a new point of dynamic equilibrium, represent a stage in the life cycle; hence, it is stated that resilience represents the sustainability of this phase, from the economic, social and environmental point of view, for all the present and future actors, directly and indirectly involved in the recovery process.

5.6 Recommendations

It can be stated that the sustainability assessment of any urban transformation must include a further phase within the life cycle, in addition to the construction, operation, maintenance and disposal phases; this phase is defined as that, whose impact are due to hazardous events that can take place in the life time and that can only be probabilistically treated. According to the current approach to sustainability, the effects to be considered for this phase are those due to the event occurrence itself (i.e. the direct damages and losses), together with the effects of the post-event recovery operations; furthermore all the effects must be evaluated in terms of economic, environmental and social burden, for all the actors involved.

Thus, the link between resilience and sustainability can be now clearly defined: in fact, a structure will be sustainable if, among other things, it is able to minimize the negative impacts of potential disasters, both during and after the events, in terms of social, environmental and economic burden, for all the actors involved; in other words, it will be sustainable if its HEO phase is sustainable, that is if it is resilient. In these terms, resilience becomes one of the characteristics that contribute to the sustainability. Raising the scale and looking at the entire city, the approach to sustainability assessment can be similarly defined; however, the concept of lifecycle must be redefined. Evidently, the city lifecycle, for our purposes, has no beginning and no end. Hence, the phases to be considered are:

- the phase of "use" of the city, or the city metabolism, which includes the system of activities and relationships that occur day by day between the different actors of the city and the day by day transformation of the physical system;
- the phase of "maintenance" of the city, or the city growing, which includes the activities for a continuous reconfiguration of the city, in particular of its physical system;
- the HEO phase, i.e. which includes the changes taking place when the city suffers an extreme event and tries to reconfigure both its physical and social system to reach a new equilibrium stage.

A city, or rather a configuration of the city, that is a configuration of its physical and social systems, will be more sustainable if it can guarantee economic, social and environmental benefits, for all its communities and for the future community, also during the HEO phase; hence, it will be more sustainable if it is more resilient. At this point it can be argued what is the correct approach to generally define the resilience of the city. Is it the engineering resilience, where it is expected that after an extreme event the city should return to the previous stage, or the ecosystem resilience, where it is allowed that the city can reach a dynamic equilibrium in a different stage?, the correct approach should overcome both ideas.

In fact, as a result of extreme events, cities undergo a system of transformations, which can be small or large and can affect its physical system and/or social system, leading to different possible equilibrium stages. Then, it is not helpful to debate whether resilience means the ability to return to the previous stage or reach a different stage of equilibrium. What is really important is to determine if the system of transformations, occurring during and after the event, is sustainable, regardless of the initial pre-event and final post-event equilibrium stages.

Specifically, since sustainability cannot assume an absolute value, it only makes sense to assess whether the system of transformations occurring after an extreme event is more or less sustainable than other options.

This approach clarifies how city resilience is a requisite for city sustainability and how the dichotomy between the ecosystem resilience of Holling (1973) and the engineering resilience of Pimm (1984) can be solved, when applied to urban system. In fact, the two contrasting principles that:

- a resilient response consists of a rapid reconfiguration in an equilibrium stage, even different from the previous one (ecosystem resilience), and
- a resilient response consists of a rapid recovery of the previous stage (engineering resilience),

are overcome by the principle that a resilient response consists of a sustainable response to external shocks; this implies that a different equilibrium stage can also be achieved (in terms of social and physical systems), but certain properties must be recovered, as the quality of life, the health of the environment or the robustness of the economic system.

A further crucial issue is represented by the definition of the geographical scale, used to evaluate the resilience of urban systems, i.e. to assess the sustainability of the HEO phase. Indeed, the complexity of contemporary cities stays in the network of relationships taking place within them, but also in the interlaced relationships that cities have with each other. The response of a city to an extreme event could be judged as not resilient, if referred to the single city resources and to transformations that its physical and social systems undergo. However, a resilient response, that is a sustainable HEO phase, may be based on the system of

relationships that the city has with other cities; thus, the whole system of cities may have a resilient and sustainable response.

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Chapter 6
Natural Hazards Impacting on Future Cities

Paolo Gasparini, Angela Di Ruocco and Raffaella Russo

Abstract Natural hazards will have a growing impact on future cities because the climate change dependent hazards will increase in intensity and because of the increasing vulnerability of cities. The global impact of each hazard in any city can be conveniently described through a probabilistic quantified approach to risk and a quantification of resilience. The supply chain must be included in the estimate. Real time methods of risk reduction must be implemented to manage emergencies in future city. It is essential the participation of citizens nudging them to proper behaviors and using also social networks and low cost networked sensors to get the needed information. Several advanced technological methods are available for effective real time risk mitigation as shown in Japan. The application in other countries is hindered by the lack of proper laws and people information programs.

Keywords Natural hazards · Future cities · Megacities · Black swans

6.1 The Urban Development Scenario

Since the first decade of the twenty-first Century most of the world population live in urban areas. The trend toward a growing urbanization accelerated a few decades ago. It is probably an irreversible process. According to the United Nations Population Division (UNPD) data, the urban population grew up from 600 million (30 % of the global population) in 1950 to 3.3 billions (51 % of the global

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population) at present time. The percentage of population living in urban areas is expected to grow to 60 % in 2030 (UNPD 2005).

A consequence of this process is the growth of mega-cities. This term indicates cities or large mega-urban regions encompassing several individual cities, such as the Ruhr area in Germany or the Randstad conurbation in the Netherlands (The Hague, Amsterdam, Utrecht and Rotterdam) with more than 10 millions inhabitants, high concentrations of values and infrastructures, high level of global interlinking, close interconnection among flows of goods, finance and information. At present days there are 50 mega-cities, most of them in developing countries. Some of the megacities in Asia, South America and Africa are rapidly becoming meta-cities (i.e. urban concentrations of more than 20 millions of inhabitants). Many of the megacities are located in areas with significant hydro-geologic, seismic, volcanic or meteorological hazard. All of them are threatened by some sort of natural hazard.

In industrialized countries also smaller cities are becoming "risk-attractors" because of the development of lifelines, inter-connected systems and highly vulnerable infrastructures. Cities amplify natural risk also for the increased probability of the cascade phenomena, i.e. a damaging primary event triggers a sequence of dangerous events originating in structures and systems created by man (such as failure of dams, urban floods due to extensive underground structures, industrial accidents, etc.). Typical examples in the last centuries have been the fire devastating San Francisco after the 1906 earthquake, the flood due to dams collapse after the Katrina Hurricane in the New Orleans neighborhood, the industrial accident due to the earthquake in Izmit, Turkey, in 1999 and Kobe, Japan, in 1995, until the more recent severe damage of the Fukuoka nuclear power plant, in Japan, after the M9 offshore earthquake and consequent tsunami in February 2011 (Wenzel et al. 2007; Trice 2006).

6.2 Natural Hazards Impacting on Future Cities

Natural hazards can be divided in two broad categories: geological and meteorological hazards. The main difference is that geological hazards can be assumed to not undergo inherent changes with time over periods of 10s or 100s of years, as long as human actions do not disturb the source system (as in the case of seismicity induced by massive fluid injections). Meteorological hazards may undergo significant changes, because of climate changes.

Figure 6.1 (based on data retrieved in Munich Re 2004) indicates that more than 50 % of the megacities are characterized by a high level of some natural hazard. Sixteen of them are threatened by more than one hazard source with high probability of occurrence. Further 21 are threatened by more than one hazard with medium to low probability. A high hazard level means that a catastrophic event can occur every few tens of years or so.

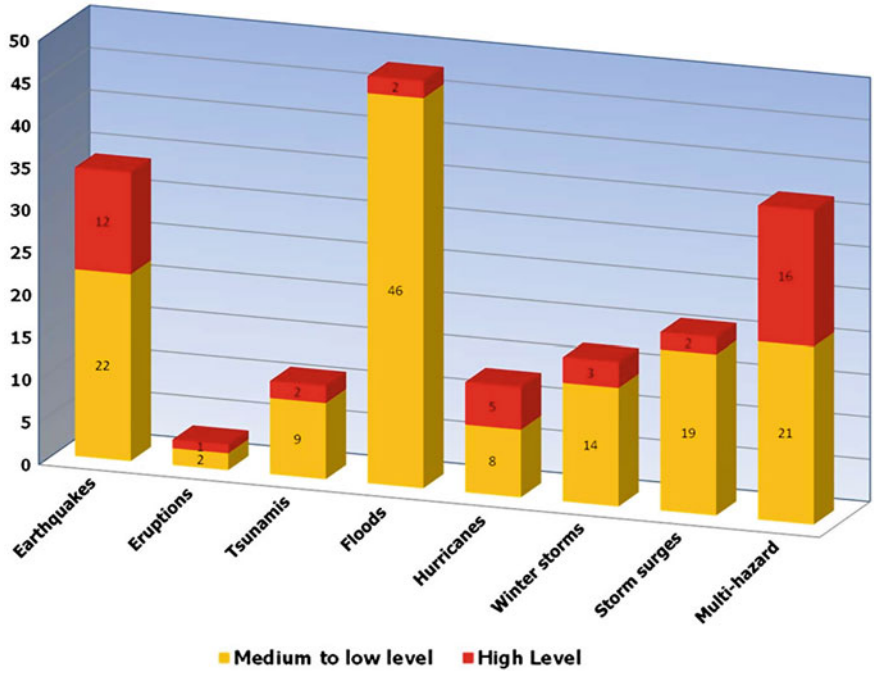

Fig. 6.1 Level of natural hazards impact on the 50 Megacities

Cities and megacities contribute to increase hazards as well, creating its own characteristic climate. Megacities are pronounced heat islands. The mean temperature in its interior can be several degrees Celsius (up to 10 °C) higher than in the surrounding countryside. In the warm season, the weather extremes are often significantly intensified: this causes heat waves, thunderstorms, hail. As urban areas are mostly paved with concrete and asphalt, a large proportion of rainwater runs away on the surface. The sewerage systems are often not designed for this, with the result that torrential rainfall in big cities regularly leads to local flash flooding (Munich Re 2004).

The percentage of the Earth surface covered by urban areas is 2.8 %. It almost doubled from 1992 to 2005. This increases the probability that a natural damaging event can occur within the limits of each city and not many km away. The important consequence of this is that a smaller magnitude event, having a high probability of occurrence, can have an impact comparable to that of a distant more rare larger magnitude event. This is particularly true for earthquakes, two recent examples being the April 6, 2009 M6.3 earthquake occurred about 10 km below the city of L'Aquila, Italy, and the February 22, 2011 event occurred just below the city of Christchurch in New Zealand.

6.3 A Better Way to Estimate Damages

The traditional way to estimate damages from a natural event is through the evaluation of Risk (R), defined as:

$$R = H * V * E$$

where H is the hazard, the probability that a certain adverse event generating a phenomenon of a given intensity will occur in a given area in a given time interval (1 y or 50 y or 1,000 y…), E is the total potential loss due to an adverse event in a given area, V is the Vulnerability, i.e. the fraction of E that could be lost after a specific adverse event (Marzocchi et al. 2012). Urban vulnerability usually includes structures, infrastructures, lifeline systems, transport networks, information and communication systems, financial and social assets. This approach is still used by insurance companies.

In recent years the consciousness that a complete estimate must also consider an additional quantifiable parameter, called *resilience*, has been reinforced.

Basically resilience was defined as the capability of a system to preserve or restore its state. It has been gradually broadened to the vision of a proactive resilience paradigm (cope with and adapt to change) where resilience is seen as the ability of a system to self-organise and build the capacity for learning and adaptation in addition to its capability to preserve or restore its functionality (Kleina et al. 2003). Robustness, adaptability and transformability as major elements of resilience provide a wider perspective for creating stakeholder interactions and go far beyond the traditional hazard and vulnerability reduction methodologies. The level of a society's resilience is influenced not only by its capacity of disaster management, but also by other social and administrative services, public infrastructure and a multitude of socio-economic and political linkages with the wider world.

Resilience can be measured as a function of the time needed to restore an assigned functionality to the system, which not necessarily coincide with the starting state (Cimellaro et al. 2010) (Fig. 6.2).

Delocalization of productive processes all over the world exacerbates the **supply chain risk**, above all in cases of **black swans**. Black swans are events occurring outside the real of regular expectations, because nothing in the past can convincingly point to its possibility. They have an extreme impact, producing a very large loss. They are characterized by the triplet: rarity, extreme events, retrospective (though not prospective) predictability (Taleb and Nassim Nicholas 2007).

Natural disasters effects can generate global consequences: a catastrophic event in China, for example, *would have far-reaching and long-lasting negative economic impact. It would slow down the global economy because China is not only a major exporter of goods, but also a major importer of goods* (Global 2011).

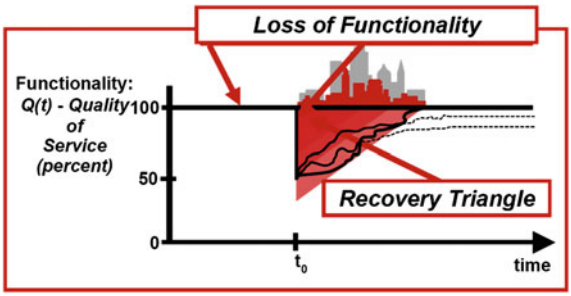

Fig. 6.2 Resilience can be quantified through the area of the *recovery triangle*. Different stages of functionality can be reached (Reinhorn and Cimellaro 2011)

On March 17, 2000 a fire in Albuquerque (New Mexico) destroyed thousands of cell phones in the Philips plant; Philips was the major supplier of semiconductors to Nokia and Ericsson.

Nokia found quick solutions to the emergency, minimizing the impact. Ericsson responded to the shock many weeks later, suffering a $2.34 billion loss in its mobile phone division and market share loss (Sheffi 2007).

In Thailand the share of parts and components in total exports of automotive products approximately doubled from 17 % in 1998 to almost 35 % in 2011 and the country became a significant part of the global supply chain of car production.

The flood hitting Thailand in July 2011 affected many industrial estates, causing a slump in the production with remarkable effects. The area is an important source of intermediate input supply through which some components are delivered just-in-time to final assembly plants. Therefore, the disruptions of components deliveries in this region inevitably compelled other stages of production in the non-flooded areas, in both Thailand and other countries, to cease their operations. For example, due to the shutdown of its plant in Ayutthaya, Honda experienced immediate shortages of auto parts which "forced Honda to cut production around the world, from the Philippines to Swindon in the United Kingdom" (Chongvilaivan 2012).

In December 2011 the Japanese Ministry of Economy, Trade and Industry (METI) conducted an emergency survey of 67 major Japanese industries to inquire on the effects of the Thai floods on their production. According to the survey, 81 % of the major Japanese companies production bases in Thailand are still producing less than they did before the heavy flooding broke out in July 2011 (Ministry of Economy 2011).

Moreover, Toyota stopped production in the Toyota Motor Thailand (TMT), causing Toyota in Japan to cut output by 6,000 units in 5 days (The Nation and Bangkok's Independent Newspaper 2011a).

The effects on some factories are shown in the following table (Table 6.1).

These examples of global consequences from catastrophic events raise the issue of the need of risk mitigation strategies to be implemented by companies. Indeed, supply chain is an essential component of a disaster chain where resilient measures must be applied to reduce losses on a global scale.

Table 6.1 Effect of Thai floods on Japanese companies

	Status	*Effects*
Automobiles		
Honda	Factory submerged	No prospect of recovery
Toyota	Parts not supplied by flood-damaged manufacturer	Production suspended for several days. Considering air shipment of parts and other measures
Nissan	Parts not supplied by flood-damaged manufacturer	Production suspended for several days
Isuzu	Parts not supplied by flood-damaged manufacturer	Production suspended for several days
Electronics		
Nikon	Digital camera factory submerged	No prospect of recovery
Sony	Digital camera factory submerged	No prospect of recovery
Canon	Printer-related factory submerged	Considering production at a different factory in Thailand and other areas
Nidec	Two electronic parts factories submerged and employees at four factories evacuated	Considering production in China and other countries
TDK	Electronic parts factory submerged	Considering production at a different factory in Thailand
Food		
Ajinomotol Calpis	Jointly established beverage plant submerged	Considering production at a different factory in Thailand

Source The Nation, October 18, 2011—www.nationmultimedia.com (The Nation and Bangkok's Independent Newspaper 2011b)

Therefore, companies should be flexible enough to quickly switch their operation scenarios to adjust for disruptions. A scenario-based strategy will not only minimize damage but can be helpful to eventually overcome debilitated competitors.

The mitigation efforts can be classified into three phases:

- proactive, building a resilient supply chain, investing in early warning systems;
- reactive, working for an expedite recovery (Agility);
- post-recovery, reporting, revaluating the supply chain, and recovering losses through insurance claims.

To demonstrate that risk awareness can lower failures, Plenert and coauthors (Plenert et al. 2012) analyzed the case of two companies undertaking different approaches in facing global effects from a catastrophic event: company A does not undertake risk mitigation measures, whereas company B implements a Business Continuity Plan. Once the adverse event occurs at time T, company B is able to discover more quickly (at point B1) than company A the disruptive effect of the event on the Supply Chain, recovering more rapidly and so minimizing the impact. Company A detects the disruption only at point A1 and takes a longer time for recovery, facing a stronger disruption impact (Fig. 6.3).

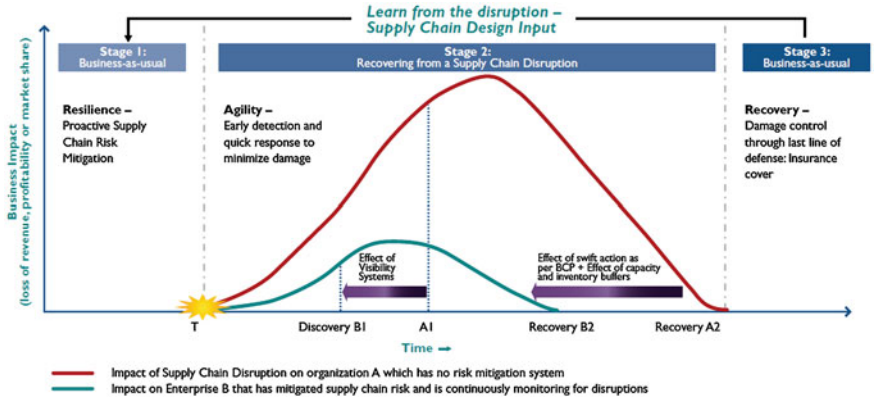

Fig. 6.3 Supply chain risk mitigation effects (Plenert et al. 2012)

6.4 How to Manage Urban Catastrophic Events

Megacities are Natural Risk attractors: how can we prevent them to become Risk Traps?

Sustainable Risk Mitigation actions must approach the complexity of city systems and include:

- A systemic and global approach (multi-risk) to risk evaluation aimed at actions planning based on a rank of possible risks;
- Mitigation action to be selected on the basis of consequence analysis, including evaluation of the effects on the supply chain;
- Definition of the acceptable level of risk;
- Urban planning conscious of natural risks;
- Adoption of real time risk reduction methods, such as early warning.

Early warning and methods of real time risk mitigation are becoming crucial for managing disasters in urban areas. In these methods the role of citizens is essential. Several EU projects are investigating these issues. Two of them, both dealing with earthquake risk, are the FP6 SAFER (Seismic Early Warning for Europe) Project and the FP7 REAKT (Strategies and tools for Real Time EArthquake RisK ReducTion) Project.

As most operational earthquake forecasts are associated with a significant degree of uncertainty, it will be desirable for the public response to be self-organized to such a degree. There are many safety decisions which an individual risk-informed citizen might make, affecting all aspects of daily life, from work to travel and recreational activities. Each individual should be 'nudged' to doing what is in his or her best safety interest, being given an informative hazard advisory by civil protection officials (Woo 2011).

It is customary for hazard advisories to be given to the public, which suggest changes in public behaviour, but do not force the public to take any specific course of action. For example, people are advised to wash their hands more frequently during a pandemic crisis, but they are not coerced to improve their personal hygiene. Similarly, travellers might be advised of a higher terrorist threat in some countries, without being forbidden to visit them.

Citizens can be also involved giving them the possibility to get or access information directly. For example, SAFER proposes a completely new generation of early warning systems, based on low-cost sensors (taken from the air-bag system of the car industry) that are connected and wireless communicating with each other in a decentralized people-centred and self-organizing observation- and warning network. "Decentralized" means that the total information available in the network will not only be transmitted to a warning centre but will also be available at every node of the network. "People centred" means that people can afford to buy their own sensor and by installing it in their home may not only gain from, but also contribute to the warning network. This would ensure the dense coverage of an urban area with early warning sensors, not tens or hundreds, but thousands or ten thousands, which is necessary to gather accurate warning information. The system has to be "self-organizing" in order to automatically adapt to changes in the network configuration if, for instance, the number of users will increase, or some of the network sensors will fail as a consequence of a strong earthquake.

The prototype of such a low-cost and self-organizing system has been successfully tested in the city of Istanbul. It has also been applied to monitoring the health state of critical infrastructures such as the Fatih Sultan Mehmet Suspension bridge across the Bospouros or certain buildings in L'Aquila (Italy) after the strong earthquake of April 6th, 2009. Although the number of nodes for which the network has been configured at present is still conventional, SOSEWIN (Self-Organizing Seismic Early Warning Information Network) as the system is called, has opened a novel avenue for seismic early warning that is extremely promising. The REAKT project aims at establishing the best practice on how to use jointly all the information coming from earthquake forecast, early warning and real time vulnerability assessment. All this information needs to be combined in a fully probabilistic framework, including realistic uncertainties estimations, to be used for decision making in real time.

REAKT will follow also an innovative strategy considering each citizen as an individual decision maker. A way to set up citizen operated networks is given by the existence of accelerometric sensor on some laptops. They can provide numerous additional ground motion measurements especially in large urban areas where the density of such laptops is high. The development of such networks goes in line with a presence on social networks. This is a way to engage with citizens as well as with the online communities which rapidly emerge after damaging earthquakes. We propose a feasibility study and network/system design for citizen-operated networks of embedded laptop motion sensors, which can contribute to the damage estimation with additional local measurements of ground motions in

populated areas, as well as providing means to engage the community for feedback, eyewitness reports, and educational purposes. The activity will be mainly focussed on the city of Istanbul.

These considerations apply also to EEW. With online news and social networking, and communication systems (like reverse 911 in the USA) which automatically send emergency messages to cell phones, the informed and risk-aware individual is in a position to react much more swiftly and sensibly to an event than if he or she relied on any central directive. In the application of early warning methods to infrastructure such as transportation and critical industrial installations, civil protection organizations have a joint role with the infrastructure managers in deciding on an appropriate real-time algorithm for system closure and shut-down. REAKT will develop such an algorithm balancing the benefits of reducing casualties in the event of a major earthquake with the economic cost, aggravation and disruption of false alarms.

6.5 The Future

Natural hazards will have a growing impact on future cities both because the climate change dependent hazards will increase in intensity and because of increasing vulnerability of cities. The global impact of each hazard in each city can be conveniently described through a probabilistic quantified approach to risk and a quantification of resilience. All the supply chain must be included in the estimate. To manage emergencies in city real time reduction methods must be implemented. For its implementation it is essential the participation of citizens nudging them to probable behaviors and using also social networks and low cost networked sensors for them to get the needed information. Several advanced technological methods are available for effective real time risk mitigation as shown in Japan. The application in other countries is hindered by the lack of proper laws and people information programs.

The crucial technical issues to be pursued are:

- Protection of strategic structures and infrastructures in European high risk areas
- Specialized decision support modules
- Low cost very dense sensor nets in urban environment
- Citizen's involvement in the protection actions
- Co-existence of centralized and de-centralized decision making.

They require the implementation of social and legal issues, such as:

- Education and training
- End-to-end diffusion of information
- Solution of legal problems.

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Chapter 7
Resilience and Sustainability in Relation to Disasters: A Challenge for Future Cities: Common Vision and Recommendations

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Urban areas, especially the growing number of mega-cities, are connected by a dense and complex web of relationships and represent the heart and engine of the global development of contemporary society. But at the same time, cities are increasingly vulnerable. Catastrophic natural events can bring down cities and the network of relationships that take place in them. Natural events as extreme weather events (recently more frequent and intense as a result of the ongoing climate

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changes), earthquakes, tsunamis or human-induced events such as terrorist attacks or accidents, can have extreme effects on cities and communities.

City transformation processes must be rethought, to mitigate the effects of adverse events on the vital functions of cities and communities. Redundancy and robustness of the components of the urban fabric are essential to restore the full efficiency of the city vital functions after an adverse event has taken place. Hence, resilience in the short-run is necessary to ensure sustainability in the long-run.

Disaster resilience is the process by which *communities effectively*, *efficiently*, and *equitably* implement their *capacity* to *absorb* negative impacts through *mitigation*, including *real time warning*, and to *respond* and *adapt* afterward so as to *maintain function* and *hasten recovery*, as well as to be in a better position to reduce losses from *future disasters.*

The participants to the networking event offer the following recommendations:

- To promote resilience it is necessary to consider vulnerability of complex interconnected systems, including institutions, individuals and physical systems.
- Resilience should be continuously re-evaluated because vulnerability and risk have dynamic properties.
- To promote resilience it is necessary to consider all hazards encountered including extreme events, local impact of global hazards, and chronic damaging processes.
- Resilience must be integrated into sectoral policies and governance systems, including the removal of legal and regulatory obstacles.
- Resilience should be pursued through an integrated multi-scale approach both for communities and physical systems.
- Resilience should be pursued taking into account local culture, resources, built and natural environment and socioeconomic conditions.
- Disaster risk knowledge should be increased, as should the awareness and responsibility of how individuals and communities can contribute to resilience.
- For effective risk management it is necessary to have community and individual participation.
- Resilience should be designed to be consistent with principles of social and environmental justice.
- Develop and implement improved quantitative and qualitative methods to measure and assess resilience for decision making, including consideration of uncertainties.
- Take advantage of all available technologies including social network systems and other low cost individual-based technologies.
- Take advantage of low-cost resilience tactics, at the individual business and household level, such as conservation of critical inputs, stockpiles, back-up equipment.

- Take advantage of formal and informal markets as potential sources of inherent resilience because they can provide signals of the value of remaining resources for efficient reallocation.
- Resilience can be strengthened by diversifying the supply chain.
- Successful local resilience experiences should be transformed into long-run adaptive practices.