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Defining the Resilient City

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Foreword

This note serves to inform the United Nations University project on Resilience and the Fragile City. This is an accompanying note to 'Conceptualizing City Fragility and Resilience' (de Boer, Muggah, Patel 2016) which formally presents the resilience framework and indicators for fragile cities. As resilience has become a more prominent and pervasive concept, several past and current endeavors aim to specifically operationalize it for policy and programmatic intervention by delineating frameworks, dimensions and indicators of resilience generally, urban resilience more specifically. This paper explores how resilience can be conceptualized and delineated for urban environments that are characterized by fragility as defined by this project (those that combine high levels of violence and extreme poverty affected by a disaster) (see de Boer 2015). Though frameworks exist to describe urban resilience using a variety of dimensions and indicators, these component parts have yet to be weighted or tested empirically. As this note lays out, most formally developed frameworks and indicators for resilience rest heavily within the natural disaster and risk reduction literature while various reports, programs and tools have added political, social and economic elements to the this debate to supplement these existing frameworks. A theory of change, rather than evidence, underlies how the vast majority of frameworks and indicators have been developed and justified. They are decidedly inductive rather than independently derived. Empirical data is overwhelmingly concentrated in the vulnerability and risk literature rather than resilience literature. The obvious gaps lie in the lack of specific frameworks applicable to this definition of fragile cities and empirically sound indicators independently developed for resilience against fragility in cities. This concept note reviews the literature base and these resilience frameworks as well as current debates to present a working definition of resilience for fragile cities and guidance towards specific dimensions and indicators.

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1. Introduction

From its early use in engineering and material sciences to later adoption in the fields of psychology, economics, and ecology, the concept of resilience has become increasingly prominent in the field of international development. More recently, academics and practitioners alike have also presented several frameworks to bridge resilience with disaster risk reduction and peace-building initiatives in urban environments. Resilience in cities is acknowledged both explicitly and implicitly in a number of the United Nations' 2030 Agenda for Sustainable Development (SDGs). Target 1.5 aims, by 2030, "to build the resilience of the poor and those in vulnerable situations, and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters" (United Nations 2015). Target 9.1 emphasizes building resilient infrastructure while target 11 aims "to make cities and human settlements inclusive, safe, resilient, and sustainable", and target 13.1 aims "to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters" (United Nations 2015). Most recently, the Urban Crisis Charter of the Global Alliance for Urban Crises, presented at the World Humanitarian Summit, directly identifies resilience as a core goal for the UN's New Urban Agenda (UN-Habitat, 2016). In addition to these explicit references to resilience, a complex systems approach for urban resilience suggests that every other sustainable development goal - e.g. improving poverty, hunger, and health outcomes - improves urban resilience as well, whether independently or through their interaction with more specific goals and targets. Building resilience in rapidly urbanizing environments afflicted by chronic violence, disaster and extreme poverty remains a challenging yet vital endeavor towards meeting the Sustainable Development Goals. This paper reviews important literature and frameworks relevant to understanding resilience in the context of fragile cities.

The following concept note begins by describing resilience as it pertains to different academic disciplines (**Section 2**) before examining its treatment in different disaster frameworks (**Section 3**). The following section offers a working definition of resilience for the purposes of the fragile cities project (**Section 4**). Next this paper reviews how resilience can be broken down into its composite parts based on common dimensions in the literature (**Section 5**) before reviewing literature on indicators for these dimensions and guidance notes on their selection (**Section 6**). This concept note concludes with a discussion of an approach for operationalizing the concept of resilience in the Resilience and the Fragile City project moving forward (**Section 7**).

2. Resilience in Various Bodies of Literature

Manyena et al. (2011) notes that "resilience originates from the Latin resilio, resilire or reseller, meaning to bounce back or bounce-forward." Broadly speaking, different academic disciplines invoke resilience to describe the response of a given system to a disturbance of some kind (Vale 2014). Most fields also recognize the distinction between positive resilience and negative resilience. While both types enhance the ability of the subject to cope with stress, negative resilience does so with undesirable externalities and long

term consequences that add vulnerability, risk and ultimately undermine resilience. Efforts to bolster resilience across different disciplines therefore emphasize positive adaptation despite adversity (Fleming & Ledogar 2008). Beyond these underlying themes, however, most academic disciplines employ a unique understanding of the concept. Given that cities are multi-dimensional entities and fragility is also multifaceted, defining resilience in an urban context must include insights from multiple professions and disciplines.

Definitions of resilience from different fields vary on two key spectrums, the first of which is the entity being described as resilient. In disciplines such as engineering and other material sciences, **resilience is used to describe the reaction of a material object or entity to stress**. In other fields it is applied instead to describe people, communities, or systems (both manmade and natural). Originally, the concept of resilience emerged in the field engineering and other material sciences to describe the capacity of materials and other physical structures to withstand stress and shocks without structural change or collapse. Resilience in this sense is an output or state of being based o**n how a material can withstand stress given "something inherent in the composition of the object"** (Vale 2014). In this conceptualization then, **resilience is used to describe the maintenance of a pre-crisis status quo for entities**. As such, resilience is an outcome measure with an end goal of limiting change or damage **most similar to robustness** (Cutter et al. 2010).

From engineering and material sciences, the notion of resilience was adopted by the field of psychology to describe the capacity of individuals - and children in particular - to withstand psychological stresses or traumas. In this field, early resilience studies tried to identify what qualities inherent to the individual allowed them to cope and function effectively following a given trauma. However, following this initial focus on individual attributes, psychologists began to recognize the importance of contextual factors in determining individual resilience. It is therefore from psychology that the notion of resilience was first extended to apply a wider lens to family units and communities (Fleming & Ledogar 2008). Whereas material sciences frames resilience as a direct consequence of a material itself, psychologists recognized **resilience as a process of how multiple factors interact**.

As the notion of resilience branched out from focusing on the individual to looking at families and communities, anthropologists also employed a resilience lens to examine groups of people in different spatial constructs. The application of resilience to people as opposed to materials requires a departure from the idea that resilience is inherent to its subject. Like psychologists examining the individual, anthropologists paid attention to contextual factors and relationships in determining the resilience of a community to stress (McCandless & Simpson 2015). This body of literature pays particular attention to the transformation that an external stress or shock will prompt in a community. More specifically, anthropologists argue that **by virtue of having experienced a stress or shock, a given community is fundamentally altered post-crisis. Resilience in this field is focused on a process of ongoing change and transformation**. Barrios (2014) emphasizes the dynamic between communities and government or nonprofit actors following a disaster in shaping the new community.

Resilience has also been adopted as a concept to describe systems, both manmade and natural. For example, economists employ resilience to describe how markets might recover following the loss of a key sector or employer - resilience in this sense describes the capacity of the market to function or return to pre-crisis functionality following the disruption (Vale 2014). Management professionals may employ a similar understanding of resilience with respect to business operations and supply networks. It is clear that **applying resilience to systems involves identifying how processes are interrelated and can therefore create cascading chains of disruption (fragility) and recovery (resilience)**. From resilience in this context we can also take the idea that communities or **cities are most resilient when redundancy exists** - that is, when multiple actors or systems(?) are able to assume a critical function (Milliken 2013).

In addition to the manmade systems referenced above, resilience was adopted by ecology to describe natural systems. In the field of ecology, resilience emphasizes the transformation of a given system into a fundamentally new one following a certain degree of stress (Vale 2013). Ecological theories of resilience provide a useful lens for the Fragile Cities project by suggesting the idea of multiple states of equilibrium. This is an important distinction between various academic disciplines in their treatment of resilience: where fields like engineering or material sciences employ resilience to describe the maintenance of or return to a sort of pre-crisis status quo (or pre-crisis functionality), fields like anthropology and ecology use resilience to describe how a system may transform in response to stress, and help to build a post-crisis reality that is more able to mitigate future shocks. **These approaches recognize the new equilibrium that any shock presents to a system and the process of resilience that can lead to a new and even improved status**.

Notably, ecologists also contributed to the conceptual development of resilience insofar as they employed a broader understanding of shock or stress to a given system. Whereas some fields prioritize the resilience of their subject to a sudden-onset crisis, ecologists also study long-term stress factors and slow degradations (Milliken 2013). **Resilience can thus be against a chronic or slow onset stress or compounding long-term stressors**. This holds true for resilience in cities when considering sudden crises (natural or man-made) as well as interacting long-term

trends (e.g. rapid urbanization, declining public services, increasing violence and growing social exclusion).

From its widespread application in ecological sciences, resilience emerged as a useful tool in climate change and natural hazards literature as well. In this body of literature, resilience is used to describe systems and measures that mitigate the potentially damaging effects of a natural hazard. Natural disasters are understood as the result of a physical event or natural hazard and human exposure or vulnerability. In this context, resilience is improved by measures that reduce exposure and vulnerability. This resilience paradigm thus shifts disaster causation from environmental determinism to social constructionism (Middleton & O'Keefe 1997), whereby human agency can mitigate the economic and human costs of a natural shock or stress. From this perspective then, **resilience seeks to not only restore functionality but also correct existing social, political, and economic structures that may have increased exposure and constrained capacity to cope with the crisis**.

More recently, frameworks designed to understand community resilience to natural hazards have motivated others to question how resilience might also help mitigate the effects of non-natural or manmade disasters (e.g. armed conflict). In the same way that resilience emphasizes the agency of communities in mitigating the damaging potential of natural hazards, resilience as applied to peace-building also emphasizes self-help mechanisms and local capacities. Whereas peace-building literature has traditionally emphasized root causes or determinants of violence and obstacles to peace, resilience focuses the conversation on positive adaptation by communities exposed to violence. In this context, Milliken (2013) suggests that resilience may help to explain why communities or cities that appear to have all the determinants of violent conflict do not, in fact, devolve into one. Drawing from ecology, resilience in peace-building also uses the notion of complex adaptive systems, whereby the resilience of a community is determined by a variety of interacting systems and their interrelationships (Bujones et al. 2013).

3. Resilience in Natural Disaster Frameworks

Just as the concept of resilience has evolved dramatically over time and across, disciplines, so too have the frameworks available for understanding it. The following section reviews key frameworks that contribute to an understanding of urban resilience, their specific added value, and their limitations. These frameworks for natural hazards have each sought to integrate or address resilience in a different way.

To begin, literature in the 1990s acknowledged resilience as part of a post-crisis recovery phase in a disaster cycle or continuum (Cuny 1983). In this kind of framework, disaster phases are represented as a succession of events (**Appendix 1, Figure 1**). One important weakness in this model is its commitment to restoring the pre-crisis status quo. Given that risk reduction efforts follow relief, rehabilitation, reconstruction and development, many of the physical and socioeconomic structures that contributed to the crisis would be reproduced by this model. Second, resilience in this model is treated as a discrete step - implying some sort of outcome - rather than an ongoing reform process. Finally, the disaster continuum also fails to address the issue of chronic or multiple crises - in this case, the model would indefinitely prioritize relief and rehabilitation efforts without considering how to improve the community's absorptive or adaptive capacities.

Norris et al. (2008) made a significant contribution to the literature in proposing a new model of stress resistance and resilience over time (**Appendix 1, Figure 2**). This model improves upon the disaster continuum approach by distinguishing between pre-event and post-event environments, thereby recognizing that a crisis leaves a community fundamentally altered. In this model, if community resources are sufficiently robust, redundant, or rapid, no dysfunction occurs following a crisis. However, in the event of extreme natural or manmade crises, resilience implies that dysfunction is only temporary, and resources in place can counteract the worst effects of the stressor such that pre-crisis functionality is maintained in a post-crisis environment. Yet, this model remains incomplete insofar as it treats resilience as a quality: a resilient community in this model will function fully in an altered environment, but the mechanisms by which this community became resilient are still unclear.

Bearing this need in mind, Cutter et al.'s 2008 Disaster Resilience of Place (DROP) model (**Appendix 1, Figure 3**) frames resilience as both a pre-crisis quality as well as an ongoing process. While this model was developed to address natural hazards, it could be adapted for slow onset natural disasters (e.g., drought) or other rapid onset events such as terrorism. This model presents the total hazard or disaster impact as the sum of 1) antecedent conditions, 2) event characteristics, and 3) coping responses. The degree of recovery with these coping responses motivates new mitigation and preparedness efforts such that the community is better prepared for the next crisis. The strength of this model therefore lies in its broader treatment of resilience as an ongoing process as opposed to a discrete step or quality. In recognizing resilience as a process, the DROP model (like Norris et al.) also distinguishes a pre- and post-crisis status quo.

While Norris et al. and Cutter et al. improved upon the disaster continuum approach by distinguishing between pre- and post-crisis communities and also presenting resilience as a process, these models do not acknowledge the possibility or even likelihood of multiple crises - they

assume that preparation or mitigation measures can be taken and implemented such that the community is more resilient when the next crisis occurs. In contrast, Renschler et al. (2010) consider resilience in light of a more prolonged or multi-dimensional crisis (**Appendix 1, Figure 4**). In this model, resilience determines the number of days it takes for a community to return to pre-crisis *functionality*, which does not imply the duplication of less resilient structures or processes. The stepwise decline of functionality starting from t0E1 represents multiple shocks. The return to pre-crisis functionality in this model seems limiting given the forward-looking nature of resilience espoused by various other definitions. In many cases an acute shock may represent the ideal opportunity to overcome various political roadblocks to reform that engender fragility and reduce resilience in a city. The post-crisis environment can be used to reduce the underlying risks that allowed such a crisis to unfold but this model seems to limit the goal of resilience to the classic return to pre-crisis standard. More applicable for fragile cities, however, is the prolonged multidimensional nature of the crisis represented by this model. The model and its illustration show that at various points after an initial shock, multiple stages or levels of functionality can be attained. The initial shock leads to an immediate post-crisis stage from which there can be an improvement or a further degradation and so on until a new equilibrium develops. This model shows that multiple interacting risks (fragility) can compound the initial shock into a cascade of shocks or chains of disruption into a downward trend of stages. Resilience can prevent this cascade into deeper crisis, mitigate its depth and/or allow faster recovery, also through multiple stages.

4. Defining Resilience in Fragile Cities

While developing a conclusive definition of urban resilience in fragile cities may be challenging, several defining characteristics can be drawn and synthesized from the literature above to propose a working definition.

The Fragile Cities project should be particularly interested in how cities already predisposed to chronic violence, disaster and inequalities exacerbated by rapid urban growth *interact with shocks and stresses, both natural and human-made*. Fostering urban resilience in fragile cities means, then, identifying ways in which individuals and communities *can function and indeed prosper* despite the challenges of poverty/inequity and violence as well as when facing a shock. Urban resilience in fragile cities should aim to complement poverty and violence reduction efforts as a means to the same end, to reduce the accumulated risks that undermine resilience.

This perspective values risk reduction and preparedness strategies. Although enhancing resilience does not necessarily drive down fragility in all cases, *reducing many of the underlying risks that define fragility can in fact enhance resilience*. Also, given the chronic nature of the risks that drive fragility, resilience in fragile cities is ever present. Resilience is both *an active process*, used to function despite the day-to-day risks and stresses that define a fragile city and *a collection of latent properties* that can be called upon during an acute shock. In addition, resilience as applied to urban environments and fragile cities in particular should consider *individual outputs and processes* (eg. flood barriers, police availability or evacuation protocols) as well as *adaptive and interacting systems* (eg. early warning and telecommunication systems, extra-judicial forms of justice and social networks).

Diane Davis (sponsored by USAID and the MIT Center for International Studies) describes urban resilience in fragile cities as "those acts intended to restore or create effectively functioning community-level activities, institutions, and spaces in which the perpetrators of violence are marginalized and perhaps even eliminated" (Davis 2012). The tools available to municipal authorities and their capacity to exert influence may be particularly limited in fragile environments. Policy recommendations to bolster resilience in urban environments may assume state capacities, authority, legitimacy and even positive intentions that may not exist in fragile cities. This USAID/MIT definition alone seems to lead away from the municipal authority as the agent of change or action to foster resilience and aims to *strengthen those community level/social institutions that can compensate for reduced state capacities*. While this may often be the case, the very dismissal of the government and its institutions as agents of resilience could in fact frame this definition as one of fragility rather than resilience or at least a secondary form of negative resilience. Rather, the *cooperative interaction between community/society and government* in its varied forms (eg. the role of community based organizations in urban planning or the integration of community based disaster response into wider government led efforts) and the strength of these relationships are key to resilience in fragile cities.

Another important point of distinction that resilience in fragile cities must address is the determination of resilience as leading to a desired outcome. Definitions that describe resilience in terms of "coping", "withstanding" or "absorbing" negative stresses before "bouncing back" tend to view resilience with a specific outcome in mind - that is, a return to a "normal" pre-crisis state or functional capacity. For more complex systems and with respect to fragile cities in particular, outcome-oriented resilience programs *focusing on the pre-existing state, risk reinforcing the processes that contributed to a crisis in the first place*. Ideally, urban resilience in fragile contexts also involves using situations of uncertainty or stress to realize improvements.

Working Definition

The challenge at hand is to define resilience in an urban context, such that it encompasses the various qualities above

while remaining analytically useful in different fragile cities and also applicable in policy-making. A working definition for resilience in fragile cities can be stated as follows:

The ability to activate protective qualities and processes at the individual, community, institutional and systems level to engage with hazards or stressors and cooperate with each other in order to maintain or recover functionality and prosper while adapting to a new equilibrium and minimizing the accumulation of pre-existing or additional risks and vulnerabilities.

Within this definition the actors or units of agency range from the individual to institutions to entire systems (both at the government or community level). The idea of *activating protective factors* refers to mitigating the impact of acute shocks these actors face through latent protective abilities. *Engaging* with the hazards or stressors encompasses the various modes by which actors and protective qualities i*nteract with these risks and stressors* and each other rather than simply resisting or absorbing their impact. This engagement includes risk awareness and communication as well as reduction and preparedness efforts. The definition also stresses the importance of *cooperative relationships* in the process. While resilience relies on latent factors in the face of a shock or acute stressor that requires a new action or process, the definition emphasizes the active nature of resilience in fragile cities that presently allows maintenance of daily function despite the ever-present combination of risks (fragility) they face. Finally, this definition recognizes the *new equilibrium* that can be developed by stressing a complex interacting system and the *aspirational nature of resilience* as a forward looking and positive process that minimizes further risks and addresses pre-existing risks, therefore avoiding negative forms of resilience. The following sections now delve into how various frameworks, models and resilience projects feed into identifying dimensions and indicators of resilience.

5. Resilience Dimensions

There is a large body of work that has sought to frame urban resilience in terms of composite dimensions. This body of literature is skewed significantly towards resilience vis-a-vis natural hazards. One of the earliest attempts to break down resilience into its composite parts was presented in 2006 by the Multidisciplinary Center for Earthquake Engineering Research (MCEER 2006). The MCEER identified four dimensions of resilience: 1) Technical; 2) Organizational; 3) Social, and 4) Economic. Building on this first attempt, the same research team released a new set of seven dimensions four years later (Renschler et al. 2010), defined by the acronym PEOPLES: Population and Demographics, Environmental/ Ecosystem, Organized Governmental Services, Physical Infrastructure, Lifestyle and Community Competence, Economic Development, and Social-Cultural Capital. This new framework also applied a new understanding of community resilience. Whereas the original MCEER framework emphasized reactive policy-making in response to a disaster, the PEOPLES framework lends greater attention to mitigation and preparation for future hazards.

Efforts by other researchers and institutions to elucidate resilience in an urban environment align closely with work by the MCEER. Most attempts recognize "Social" (including social capital), "Economic", and "Institutional" resilience as distinct dimensions. Most models also recognize "Infrastructure" as an important dimension, though some models focus on a particular type of infrastructure such as information and communications (Norris et al. 2008). The notion of "Community Infrastructure" (Cutter et al. 2008), "Community Capital" (Cutter et al. 2010) and "Community Competence" (Norris et al. 2008) recognize the importance of community capacities in determining urban resilience as well. Cutter et al.'s 2008 DROP model is one of few models that recognizes ecological resilience (Cutter et al. 2008), likely because most frameworks for resilience are designed to be useful for communities regardless of the ecological hazards they may or may not face.

These trends of consensus are validated by Ostadtaghizadeh et al. (2015) in a systematic review of assessment models for community disaster resilience. The authors summarize ten models that attempt to measure community resilience and suggest that the concept be understood using five dimensions: 1) social, 2) economic, 3) institutional, 4) physical, and 5) natural (Table 1). Given that "physical" resilience might include infrastructure and "natural" resilience can include ecological resilience, findings by Ostadtaghizadeh et al. align with the findings above. As Table 1 indicates, a given dimension is frequently referred or alluded to across models with slightly different jargon. An important component of operationalizing resilience in fragile cities will be converging on standardized terminology.

A few models delineate dimensions of resilience for manmade hazards alone, but some are designed to address natural hazards as well, such as the Rockefeller Foundation and Arup Group's "City Resilience Framework" (Rockefeller & Arup 2014, Appendix 2), the OECD's "Guidelines for Resilient Systems Analysis" (OECD 2014) and USAID's "Framework for Analyzing Resilience in Fragile and Conflict-Affected Situations" (Bujones et al. 2013, Appendix 3). These models also include Economic (including financial), Political, and Social (including social capital) dimensions. As in natural hazards frameworks, infrastructure is recognized in these models as well, (for example, as part of "Physical" resilience by USAID (Bujones et al. 2013)). Ecological resilience is recognized as "Environmental" by USAID (Bujones et al. 2013), "Environment" (Rockefeller & Arup 2014), and "Natural" resilience (OECD 2014). As opposed to strictly natural hazards models, there appears to be more attention to human security in this work, with dimensions such as "Human" resilience (OECD 2014) and "Health and Wellbeing" (Rockefeller & Arup 2014) included. The

Table 1. Dimensions and their synonyms or sub-categories of community disaster resilience

Dimension	Synonyms or Sub-Categories Across Models
Social	Human Capital, Lifestyle and Community Competence, Society and Economy, Community Capital, Social and Cultural Capital, Population and Demographics Environmental, Risk Knowledge
Economic	Economic Development, Society and Economy
Institutional	Governance, Governmental Services, Coastal Resource Management, Warning and Evacuation, Emergency Response, Disaster Recovery
Physical	Physical Infrastructure, Infrastructural, Land Use and Structural Design
Natural	Ecosystem

Source: Ostadtaghizadeh et al. 2015

USAID model is unique in that it identifies "Security" as an important dimension in and of itself (Bujones et al. 2013). Rockefeller & Arup (2014) also identify "Leadership and Strategy" as an important dimension. While fewer frameworks exist to address resilience in response to non-natural hazards, **this body of literature lends considerable attention to the strength of institutions, capacity for institutional reform, strength of social networks, and the mechanisms that exist to bridge government institutions and informal social groups**.

Qualities vs. Dimensions

Of note, resilience in urban environments has also been described in terms of certain recurring qualities. For example, MCEER (2006) suggests resilience in response to natural hazards and seismic shocks in particular requires "the 4 Rs," robustness, redundancy, resourcefulness and rapidity. Norris et al. (2008) describe resilience as when resources are sufficiently 1) robust, 2) redundant or 3) rapid so as to mitigate the damaging potential of a given hazard. The Rockefeller Foundation and Arup Group (2014) in turn list seven qualities to describe resilience in urban environments: reflective, robust, redundant, flexible, resourceful, inclusive, and integrated. Finally, the World Bank Group's City-Strength Diagnostic Tool (World Bank 2015) uses five qualities to describe resilient cities, including robust, coordinated, inclusive, redundant, and reflective. Others describe a gradation of qualities from absorptive to adaptive to transformative. These properties apply just as well for resilience in fragile cities and, while not required in the definition and not representative of dimensions, they exert their influence on the qualities of resilience.

Any set of the dimensions above could be applied to fragile cities given their significant similarities and subjective semantics/categorization. No legitimate case can be made for one over another to enhance or constrain the construct of resilience in fragile cities based on evidence. Moving forward, however, using the five common dimensions (Social, Physical, Economic, Institutional, and Natural) is easy to accept.

The Rockefeller/Arup framework's explicit mention of Leadership and Strategy dimension is important given that municipal authorities are key stakeholders. It also recognizes that effective leadership to orient government capacities toward resilience is an essential first step. Without engaged leadership, resilience is relegated to community institutions as agents of activity alone as described in the 2012 USAID/MIT definition of resilience (or fragility as explained above) in cities with chronic violence (Davis 2012). In essence, though, this leadership dimension can be integrated as part of the formal "Institutions" dimension, perhaps with a new name to highlight leadership.

Finally, the 2013 Bujones/USAID model's recognition of security as an independent dimension seems particularly useful for fragile cities given the major focus on violence (Bujones et al. 2013). This dimension encompasses the various influences, both risks and protective contributors, upon security ranging from police and judicial systems to community policing and the "security" imposed by organized crime. A framework for fragile cities may be served well by this specific dimension to isolate and highlight opportunities for intervention. While the Bujones/USAID framework was not developed specifically for urban fragility, adopting its dimensions - and focus on institutions/resources and adaptive capacities within each - may be equally valuable.

6. Urban Resilience Indicators

Aside from delineating dimensions of resilience, operationalizing an approach requires identifying more specific indicators that impact resilience and can serve as measures of their categorical dimension. Once again, overlap in indicators used across different models speaks to some consensus as to what indicators are most important within the dimensions above. However, **the relative importance of these indicators and their respective impact on resilience have yet to be empirically determined**. There is no current rigorous evidence base for universal selection, measurement, quantification or weighting. Given this fact, community level data from rapidly growing urban spaces and specifically fragile cities carries even greater importance and needs to be incorporated into existing models.

Appendix 4 displays the indicators used across four important models of resilience: the Community Disaster Resilience Index (Mayunga 2009), the Climate Disaster

Resilience Index (Shaw & IEDM 2009), Baseline Resilience Index for Communities (BRIC) (Cutter et al. 2010), and the PEOPLES framework (Renschler et al. 2010). These indicators flow from the same theory of change justification that their models employ. Selecting any based on their inherent strengths or weaknesses is futile as they are not independently derived. Instead, choosing applicable indicators among them based on specific context is a more viable and fruitful approach.

The following indicators are drawn based on similarities among multiple other specific toolkits/approaches to building resilience in urban areas. Again, these indicators have value given their recurring use as they show convergence through various approaches:

- **Ongoing evaluation of urban hazards and likely vulnerabilities to inform land use and urban planning** (ICLEI 2010, UNISDR 2012, UN-Habitat 2013, World Bank 2015). The City Strength Diagnostic tool emphasizes the importance of urban data management systems to support this objective (World Bank 2015). Some sources also include indicators that focus on addressing informal settlements explicitly in urban planning and identifying the unique vulnerabilities and coping mechanisms that they have (UNISDR 2012, World Bank 2015).

- **Licensing and regulatory frameworks in conjunction with land use and urban planning** (e.g., building codes) (IFRC 2006, ICLEI 2010, UNISDR 2012).

- **Robust built environments to ensure safety in private and public domains** (IFRC 2006, Pasteur 2011, World Bank 2015). Most sources evaluate the resilience of private housing and some identify financial incentives for upgrades to these built structures (UNISDR 2012). The resilience of public facilities (e.g., for education and health) and public infrastructure (especially transport infrastructure) is also a point of interest across multiple models (UNISDR 2012, UN-Habitat 2013).

- **Explicit and cross-sectoral Disaster Risk Reduction (DRR) initiatives**, including the existence of a single office to organize and coordinate DRR activities (UNISDR 2012, World Bank 2015), the design and implementation of a disaster management/response plan, and the design and use of early warning systems (UNISDR 2012). Models identify different responsibilities for the DRR agency, such as public education and training programs (UNISDR 2012).

- **Capacity of local government institutions**, measured in different ways. Some indicators focus on capacity building for municipal staff and elected officials (ICLEI 2010, World Bank 2015). Others focus on revenue systems and what kind of budget is allocated to disaster management work (UN-Habitat 2013). Other sources focus on particular institutions, such as the justice system (World Bank 2011). Multiple sources focus on public service provision and public works (ICLEI 2010, World Bank 2011, UN-Habitat 2013, World Bank 2015).

- **Strong local government linkages**, both upwards and downwards. Pasteur (2011) emphasizes links to higher levels of government, whereas the World Bank (2011) looks at local links to regional and international actors in reducing external determinants of local conflict. Other models look at downward linkages and civic engagement (ICLEI 2010), including contact with community organizations, businesses and residents (ICLEI 2010, World Bank 2015) and the presence of decentralized and participatory decision-making (Pasteur 2011).

- **Strong civil society and community networks**, including the presence of local NGOs and other civil society groups and community organizations (IFRC 2006, Pasteur 2011, World Bank 2015).

- **Ensured human security**, measured in different models by looking at incomes (IFRC 2006), income equality (World Bank 2015), poverty rates (IFRC 2006), and access to markets and employment (Pastuer 2011). Some models also monitor health and nutrition (IFRC 2006) and occupational health and safety (ICLEI 2010).

The Global City Indicators Facility (GCIF) has developed the first set of international standardized indicators and relevant metrics through the International Organization for Standardization (ISO), Sustainable Development of Communities - Indicators for City Services (ISO 37120:2014). These indicators group along the familiar dimension domains identified above. GCIF is leading the development of new indicators specific to sustainable development and resilience. These current and forthcoming indicators, however, come with the expected caveat: they remain unvalidated and their meaning for individual and combined impact on urban resilience remain unknown. They do, however, present a potential starting point to test indicators and metrics that can be universalized across cities. **In addition to standardization, important criteria for metric selection include validity, sensitivity, robustness, reproducibility, scope, availability, affordability, simplicity, and relevance**.

The literature on identifying factors for urban resilience also comes from case-based qualitative investigations in specific cities. Following a literature review and examination of other case studies, the Rockefeller Foundation and

Arup Group conducted research in six cities[1] to build their City Resilience Framework (**Appendix 3**). Of note, the Arup case studies were limited to a few cities, which were not specifically fragile and inadequately incorporated the opinions of community based organizations and marginalized citizens. The findings do, however, provide value in their reinforcing nature and contextual validation. This framework identifies 12 different goals, whereby a resilient city has:

- Minimal human vulnerability
- Diverse livelihoods and employment
- Diverse livelihoods and employment
- Collective identity and mutual support
- Social security
- Finance and contingency funds
- Reduced physical exposure
- Continuity of critical services
- Reliable communications and mobility
- Effective leadership and management
- Empowered stakeholders
- Integrated development planning

The recently released City Resilience Index from ARUP/ Rockefeller Foundation also delineates 52 indicators that follow from their original framework (Rockefeller and ARUP 2016). These indicators were selected after an extensive review of literature, expert consultation and piloting in cities to test credibility and usability for universal application. They are formulated into a self-assessment for resilience.

Finally, the literature on violence reduction and crime prevention in urban areas to build urban resilience (Davis 2012) identified six important components: 1) crime prevention education; 2) social capital; 3) improved social welfare and livelihoods; 4) urban design interventions and infrastructure provision; 5) good governance; and 6) security sector reform. This endeavor later modified these dimensions based on case studies in eight cities marked by chronic violence.[2] Davis (MIT 2012) found that cities in situations of chronic violence could build resilience by: 1) Empowering social relations; 2) Utilizing common purpose; 3) Fostering cooperative autonomy; 4) Reimagining state-community relations; 5) Making police a part of positive resilience; 6) Transforming spaces of violence; 7) Promoting private investment; 8) Investing in infrastructure. This investigation suggests heavily weighting social factors and the relationships between communities and citizens and their municipal authorities. **This community-government cooperation, as it relates to a wide variety of issues, represents a valuable area of leverage for enhancing resilience in fragile cities through this project**.

As with the dimensions of resilience, identifying indicators can and has taken multiple approaches with some overlap and consensus on specific indicators but the field is still evolving (see Box 1).

BOX 1. Summary of methods to justify indicators/factors of urban resilience

1. Theory of Change

- Indicators selected based on how and why resilience is built through expected outcomes.

  i. No empirical evidence of true impact on resilience.

2. Case Based

- Largely qualitative but highly contextual identification of indicators based on specific case studies.

  i. Does not allow for comparison across cities.
  ii. Value is relegated to self-assessments over time to assess relative change in the same community OR
  iii. Can be validated by multiple investigations in different contexts.

3. Empirical Associative Data

- Quantitative data associating an indicator with resilience.

  i. Data only proves association and not causality.
  ii. Compromised by confounding factors that may have a more direct relationship to resilience.

4. Empirical Causal Data

- Data to prove that one change in a specific factor leads to a specific change in resilience.

  i. Difficult to prove retrospectively or trial prospectively due to multiple interacting factors.
  ii. Challenge in defining the specific measure of resilience and the factor under study - Forces narrow definitions.
  iii. Strongest data for causal influence comes from randomized controlled trials that are often unfeasible in studying urban resilience.

7. Adopting an Approach

Identifying universal factors that promote resilience is difficult. Because factors that enable resilience can be so context specific, pulling out universal ones may lead down the wrong path by ignoring important context specific factors. The subjective construction of resilience can also complicate this process as the perception of one's ability to overcome risk may have as much impact as objective factors including income and social protection programs (Bene et al., 2016). This makes identifying a standard definition and universal metrics challenging.

Measurement, however, is critical to make the concept of resilience relevant and useful for humanitarian and development actors. Without measurement, determining which resilience intervention are most effective to inform program and policy will be impossible. Efforts must continue to identify important characteristics that can also be measured and compared across time and between cities.

In addition to the frameworks and efforts mentioned above, multiple other resilience frameworks in the development

[1] Cali, Concepción, New Orleans, Cape Town, Surat, Semarang

[2] Johannesburg, Karachi, Kigali, Managua, Medellin, Mexico City, Nairobi, and Sao Paolo

and humanitarian literature have been presented that are not specific to cities but add to the growing array of measurement approaches. Some of these frameworks have been used to address vulnerability around specific issues such as climate change (BRACED by DFID, Bahdur et al. 2015), food security (RIMA-II by FAO 2016) or livelihoods (Vaitla et al., 2012) while others remain more broad in scope (Hughes and Bushell 2013). They each adopt different methods of measurement from quantitative to qualitative data, from context specific indicators to more universal metrics. Measurement is clearly fraught with challenges and limitations no matter the underlying framework or approach taken, as discussed very well in a recent guidance document supported by DFID (Sturgess, 2016).

The various efforts underway to conceptualize and measure urban resilience are currently complimentary. They each employ evidence and adopt an understanding of resilience and data collection relevant for each specific context and goal. Each of these approaches has advantages and disadvantages. Some incorporate qualitative approaches, others do not weight indicators, whilesome require readily accessible data, complex equations or extensive self-assessments. Individual frameworks may be best for specific scenarios such as natural hazards but be less relevant for very fragile cities. In reality, multiple approaches will be required until the evidence-base and data availability can fulfill the aspirational nature of these efforts to guide the selection of more universal indicators on one hand and more context specific indicators on the other.

Understanding how each of these factors, on their own and together, interact with risks to impact resilience will be critical moving forward. The growing array of data along with evaluations of efforts to build resilience should help identify essential factors for resilience and build consensus around a collection of metrics that allow measurement of these characteristics and thus, resilience.

Resilience Factors in Fragile Cities

The accompanying paper 'Conceptualizing City Fragility and Resilience' (de Boer, Muggah, Patel, 2016) identifies resilience factors by taking the approach of **selecting resilience indicators specific to fragile cities that had a) some empiric evidence base and b) metrics available in existing datasets across many cities**. While the empiric data on resilience in fragile cities and complementary datasets remains weak, a few key resilience factors can be gleaned with this approach:

- Income and social equality
- Effective and entrusted police and judicial systems
- Microeconomic security, and social protection mechanisms
- Minimum provision of basic services

Three additional factors are strongly implicated in resilience for fragile cities but have very limited data availability:

- Social cohesion
- Social networks/social support
- Strong government-community cooperation.

This approach presents a way forward, albeit limited by sometimes associative rather than causative data, and by metrics and proxies from available datasets that may not accurately or perfectly represent the selected indicator. These will need to be refined as new evidence on indicators is made available and new metrics or proxies for their measurement are collected across fragile cities.

A reasonable strategy to measure resilience in fragile cities could adopt a mixed method approach whereby 1) standardized quantitative indicators with some degree of empirical evidence and 2) those with a significant theory of change are combined with or modified by 3) locally derived contextual factors and insights. Investigations for locally derived factors can identify novel outputs or processes or support the selection of existing factors from among those delineated in the frameworks, models and toolkits above. In either case, this approach will add context and relevance to the specific city addressed. The exact method of local tool application whether as a self-assessment module, guided assessment with municipal authorities and communities, or externally applied evaluation, would need to be determined and dictate the exact strategy taken.

All of these indicators and their metrics can be quantified by assigning qualitative measures a specific numerical value. Some qualitative factors such as social cohesion have instruments available that can be utilized to score and derive a numerical value. Others will have to be assigned a Likert scale (eg 0-5) to translate them into a numerical value. This process of quantification and the very selection of indicators will at some point be subjective. This subjectivity cannot be avoided but should not prevent us from starting the process. Similarly, creating an aggregate score for resilience may require subjective weighting out of necessity due to the lack of rigorous regressions to guide such weighting. *The need for subjectivity in choosing indicators, assigning metrics and selecting imperfect proxies, should not paralyze investigators from developing a pilot tool.*

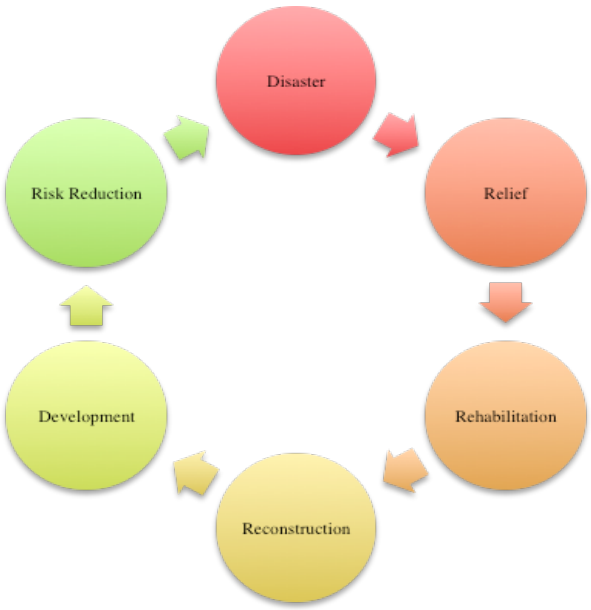
Measurement is critical to making the concept of urban resilience useful for decision makers addressing city fragility, and a wide variety of work exists to guide selection of indicators and metrics. Decisions about these selections, cognizant of their respective strengths and limitations, must be made in order to move forward.

8. Conclusion

The concept of resilience continues to evolve with additional disciplines and actors adopting the concept, adding to its understanding and nuance. The definitions of resilience also now include qualities that imbue it with more than simply withstanding a shock or recovering function but incorporate the complexity of new equilibriums, reducing vulnerability and thriving beyond the pre-existing states. The definition proposed in this paper brings together these qualities for a working definition of urban resilience. The growing collection of frameworks is rooted in their disciplinary and conceptual starting points but resilience has been advanced by each treatment. The frameworks and indicators of resilience, however, are often built on a theory of change rather than rigorous empirical evidence. This is changing. Qualitative evidence to guide the selection of indicators and metrics is growing but there remains a striking paucity of quantitative research. The conceptual framework for resilience to fragility in cities put forward here rests on empirical associations and available data and takes an approach that aims to leverage the growing availability of structured and unstructured data and evidence. **Finally, identifying factors for resilience and their respective measures must also be supplemented by understanding how these various factors interact with one another and fragility factors**. Some protective factors may work individually or together against certain collections of risks but not others and how they play out in various contexts must be further researched. Clearly, more research along with application of frameworks will be critical to help refine and update our understanding of resilience and allow better decision making for a growing urban world.

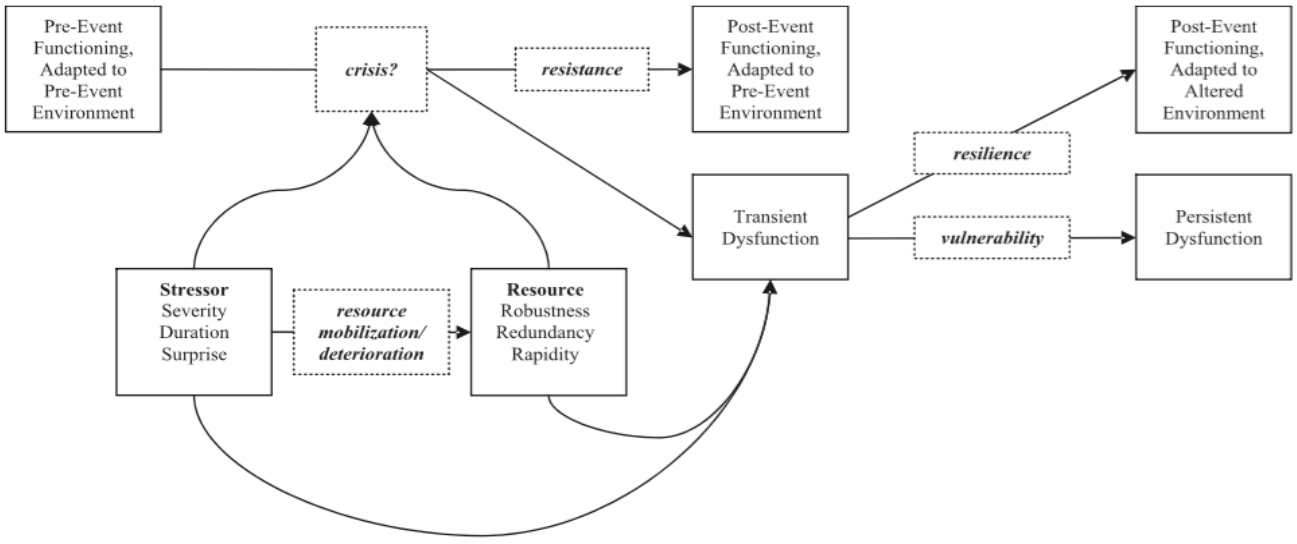
Appendix 1. Resilience in Disaster Frameworks

Figure 1. Sample Disaster Phases Model



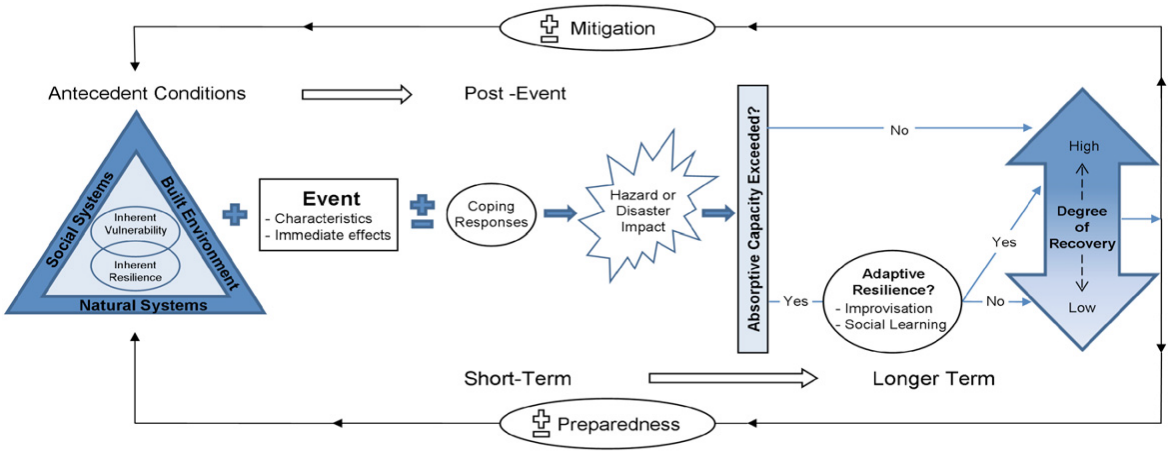
Source: Manyena 2009

Figure 2. Model of Stress Resistance and Resilience Over Time



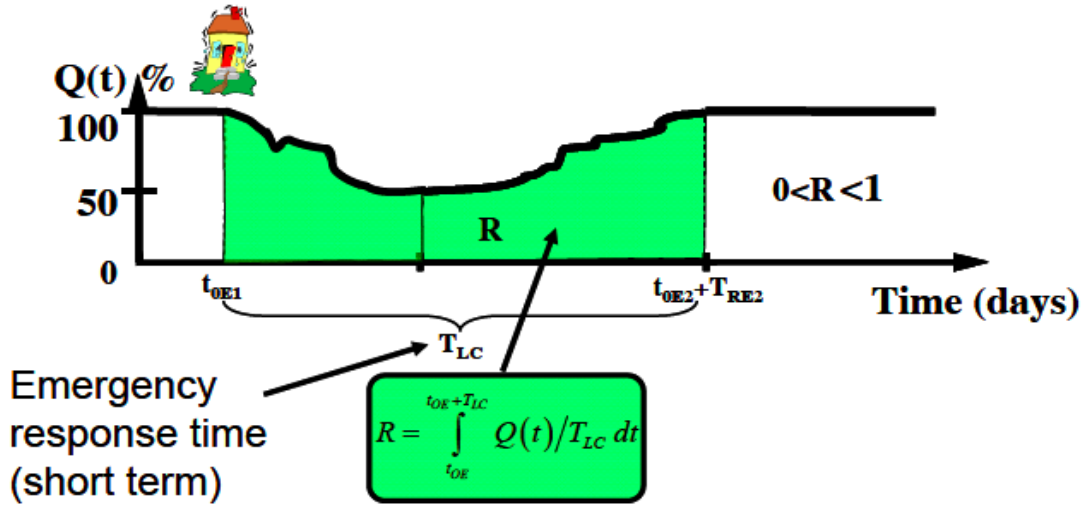
Source: Norris et al. 2008

Figure 3. Disaster Resilience of Place Model



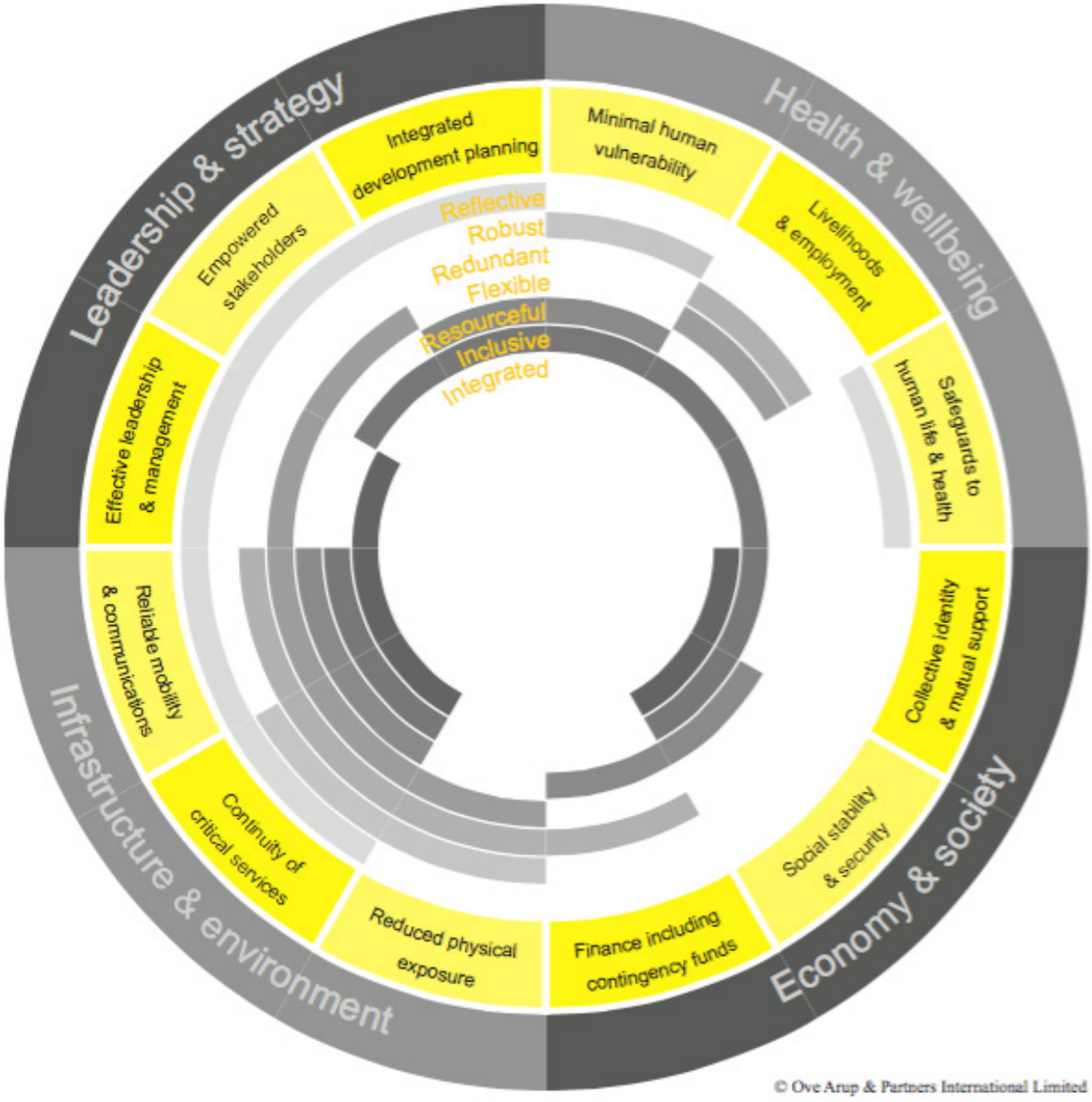
Source: Cutter et al. 2008

Figure 4. Functionality Curve and Resilience



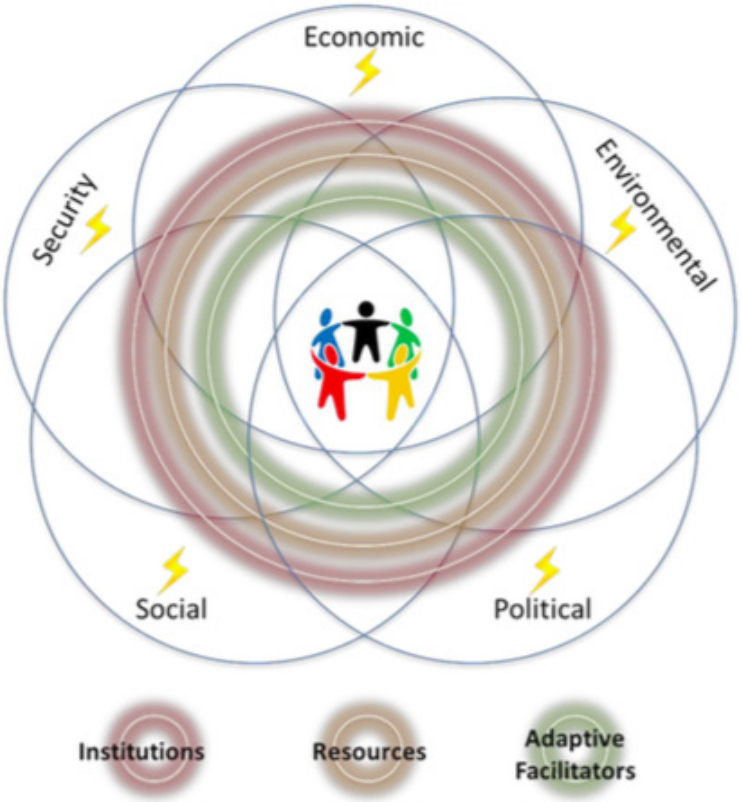
Source: Renschler et al. 2010

Appendix 2. City Resilience Framework



Source: Rockefeller & Arup 2014

Appendix 3. Framework for Analyzing Resilience in Fragile and Conflict-Affected Situations



Source: Bujones et al. 2013

Appendix 4: Indicators of Resilience

Table 1. Dimensions, measures and metrics used for assessment of community disaster resilience in the Community Disaster Resilience Index

Dimension / Domain	Indicators
Social	Nonprofit organizations registered; recreational and sport centers; registered voters; civic and political organizations; census response rates; religious organizations; owner-occupied housing units; professional organizations; business organizations
Economic	Per capita income; household income; employed civilian population; owner-occupied housing units; business establishments; population with health insurance
Human	Population with more than high school education; physicians; health care support workers; building construction workers; heavy and civil engineering construction workers; architecture and engineering workers; environmental and conservation workers; land subdivision workers; building inspectors; landscape architects and planners; property and casualty insurance workers; highway, street, and bridge construction workers' population employed in legal services; percentage of population covered by comprehensive plan; percentage of population covered by zoning regulations; percentage of population covered by building codes; percentage of population covered by FEMA approved mitigation plan; community rating system; fire fighters, prevention, and law enforcement workers; population employed in scientific research and development services; colleges, universities and professional schools employees; population that speaks English language very well; population employed in special needs transportation services; community and social workers
Physical	Building construction establishments; heavy and civil engineering construction establishments; highway, street, and bridge construction establishments; architecture and engineering establishments; land subdivision establishments; legal services establishments; property and casualty insurance establishments; building inspection establishments; landscape architecture and planning establishments; environmental consulting establishments; environmental and conservation establishments; scientific research and development establishments; colleges, universities, and professional schools; housing units; vacant housing units; hospitals; hospital beds; ambulances; fire stations; nursing homes; hotels and motels; occupied housing units with vehicle available; special needs transportation services; school and employee buses; owner-occupied housing units with telephone service; newspaper publishers; radio stations; television broadcasting; internet service providers; temporary shelters; community housing; community food service facilities; schools; licensed child care facilities; utility systems construction establishments

Source: Mayunga 2009

Table 2. Dimensions, measures and metrics used for assessment of community disaster resilience in the Climate Disaster Resilience Index

Dimension / Domain	Indicators
Social	Population; health; education and awareness; social capital; community preparedness
Economic	Employment; finance and savings; budget and subsidy; income; household assets
Institutional	Mainstreaming of disaster risk reduction; effectiveness of zone's crisis management framework; knowledge dissemination and management; institutional collaboration; good governance
Physical	Electricity; water; sanitation and solid waste; accessibility of roads; housing and land use
Natural	Ecosystem services; land-use in natural terms; environmental policies; intensity/severity of natural hazards; frequency of natural hazards

Source: Shaw 2009

Table 3. Dimensions, measures and metrics used for assessment of community disaster resilience in the Baseline Resilience Index for Communities

Dimension / Domain	Indicators
Social	Educational equity; age; transportation access; communication capacity; language competency; special needs for disabilities; health coverage
Economic	Housing capital; employment; income and equity; single sector employment dependence; female employment, business size, health access
Institutional	Mitigation plan; flood coverage; municipal services; political fragmentation; previous disaster experience; mitigation (social connectivity), mitigation (participation), mitigation (storm ready)
Physical	Housing type; shelter capacity; medical capacity; access/evacuation potential; housing age; sheltering needs; recovery
Natural	Migration; place residency; political engagement; social capital (religion); social capital (civic involvement); social capital (advocacy); innovation

Source: Cutter et al. 2010

Table 4. Dimensions, measures and metrics used for assessment of community disaster resilience in the PEOPLES Framework

Dimension / Domain	Indicators
Population and Demographics	Distribution/Density (Urban, Suburban, Rural Wildland); Composition (Age, Gender, Immigrant Status, Race/Ethnicity); Socioeconomic Status (Educational Attainment, Income, Poverty, Home Ownership, Housing Vacancies, Occupation)
Environmental/ Ecosystem	Water Quality/Quantity; Air Quality; Soil Quality; Biodiversity; Biomass (Vegetation); Other Natural Resources
Organized Governmental Services	Executive/Administrative (Emergency Response and Rescue, Health and Hygiene); Judicial; Legal/Security
Physical Infrastructure	Facilities (Residential, Commercial, Cultural); Lifelines (Communications, Health Care, Food Supply, Utilities, Transportation)
Lifestyle and Community Competence	Collective Action and Decision Making (Conflict Resolution, Self-Organization); Collective Efficacy and Empowerment; Quality of Life
Economic Development	Financial Services; Employment by Industry; Production by Industry
Social/Cultural Capital	Child and Elderly Services; Commercial Centers; Community Participation; Cultural and Heritage Services; Non-Profit Organizations; Place Attachment

Source: Renschler et al. 2010

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