

Beyond Resilience





The Institute for Social and Environmental Transition-International catalyzes transformative changes toward a more resilient and equitable future. Through research, training, and implementation activities, we improve understanding and elevate the level of dialogue and practice as society responds to natural resource, environmental, and social challenges. We serve as a framework for equal collaboration among individuals and organizations in the North and South.

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Beyond Resilience

By Michelle F. Fox, Dr. Marcus Moench, and Rachel Norton

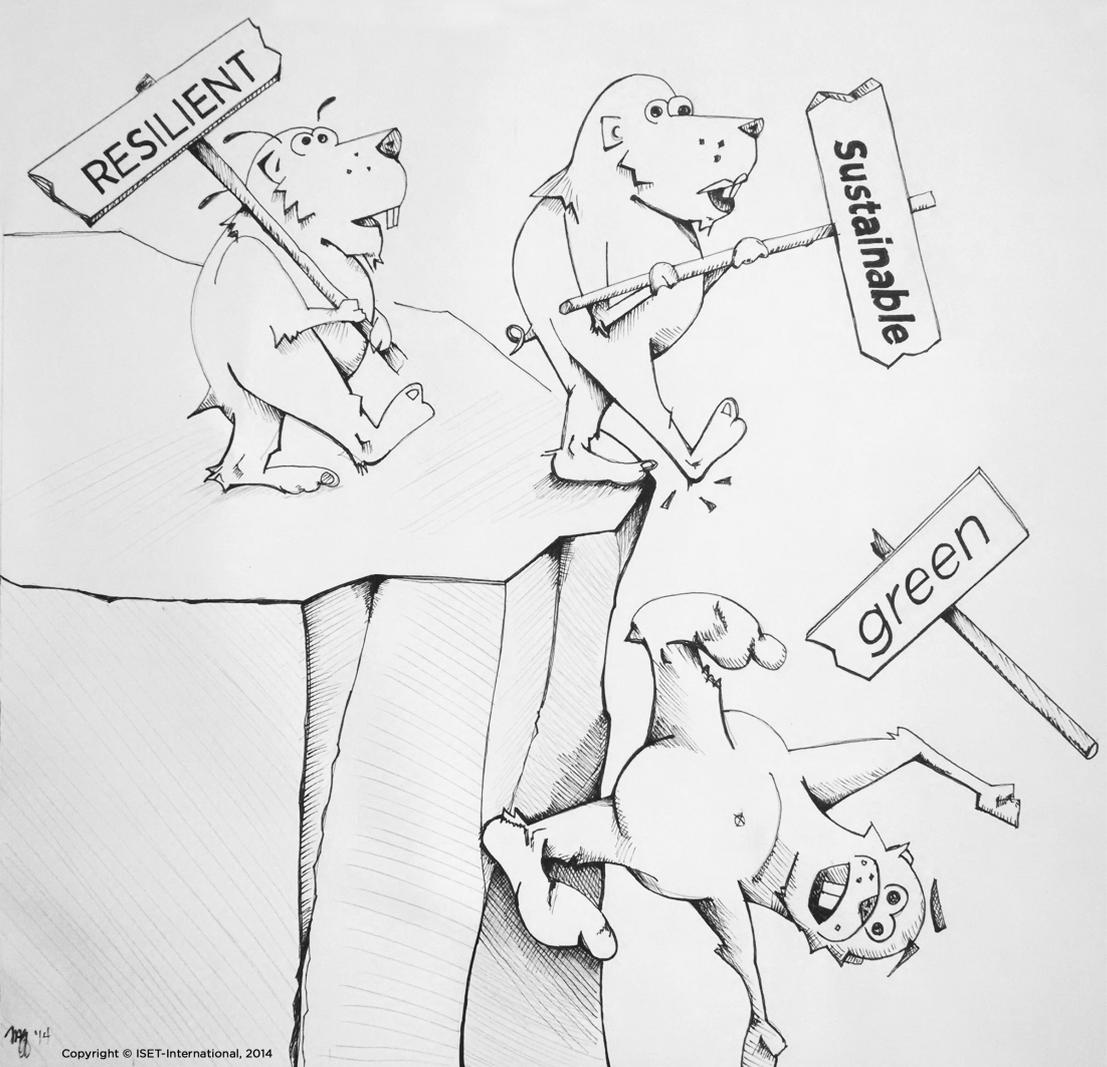
Contents

Preface	1
Resilience is...	3
The Resilience Narratives series	4
Introduction	13
Lenses for examining resilience	17
Characteristics of resilience	18
Interconnectivity	22
Spatial scales	26
Temporal scales	30
Systems-of-systems	34
Complexity and emergent behavior	38
Putting it all together	43
Synchrony in adaptive cycles	44
Vision, values, and voice	47
Resilience is just one approach of many	47
Resilience versus transformation	49
The limits of resilience	50
Conclusions	51
References	53
Acknowledgments	55

Preface

The Resilience Narratives team has set out to increase understanding of the basic characteristics of resilience through creative communications that complement traditional research and analytical writing. This publication introduces the materials that will be released in later installments of this series.

Beyond Resilience presents a foundational at-a-glance introduction to the concept of resilience—how resilience manifests in cities around the world and what some of the limits of resilience are.



Answer: E) all of the above

Resilience is...

- A) a buzzword
- B) a concept of profound importance
- C) a commonly used word
- D) a word with multiple meanings
- E) all of the above

The use of the word resilience has proliferated, with the word popping up in everything from national and development policy debates to discussions of personal and community identity. At the same time, the concept of resilience has been actively explored by the scientific and academic communities as an attribute of the complex ecological, social, behavioral, and psychological systems of which all humans are a part. Understanding the factors that contribute to resilience in systems has profound importance for everything from society's ability to respond to climate change to post-disaster and trauma recovery. Resilience is also a word commonly used to refer to the inherent ability of people or things to withstand and/or recover from disruption. As with many words in the English language, the meaning of resilience depends on the context in which it is used.

The purpose of the Resilience Narratives project is to explore the concept of resilience, particularly in its dual application as a commonly used word and an attribute of complex systems. The Resilience Narratives focus on urbanization and climate change—two of the most significant processes shaping our common future. Our first goal is to generate a discussion that explores both the common meanings of *resilience* and the manner in which resilience terms can contribute to a much more profound understanding of complex system dynamics. Our second but equally important goal is to prevent resilience from becoming a buzzword lemming that unwittingly follows sustainability (and a host of other terms) off the proverbial cliff into an abyss of meaninglessness.

In this venture, the Resilience Narratives observe the definition of *resilience* as provided by the Resilience Alliance (see page 15).

Source: Modified from a blog post by Marcus Moench (2014, June 9). Retrieved from <http://blog.i-s-e-t.org/introduction-to-the-resilience-narratives-blog-buzzword-lemmings/>

Beyond Resilience

Below

Gorakhpur, India
Children gathered around as their teacher shared the story of their flood resistant school. Over the course of this project, the team traveled to locations around the world meeting with people who are incorporating resilience planning concepts into their communities.



The Resilience Narratives series

Many of our products are either ephemeral or experiential. They all contribute substantively to the understanding of what resilience is and is not. The narratives are told through shadow puppet shows, ceramic prayer wheels, photography, videography, blogging, and analytical writing, among other media. Pursuing this creative communications project has provided an opportunity for us to explore new methods of communicating science while honoring the nuances and complexity of the subject matter.

Beyond Resilience is the first product of the Resilience Narratives series. The full suite of materials is designed to offer a powerful, in-depth presentation on the concept of resilience; illustrate issues and capture the current discourse; and investigate resilience in the urban context and the positive and negative social and environmental consequences that these characterizations can generate. While each product has been developed as part of the Resilience Narratives series, each is also intended to stand alone and speak to a range of audiences from diverse disciplinary and cultural backgrounds.

Below

Da Nang, Vietnam

The woman below prepared a meal as her daughter gave us a tour of their storm resistant house in Da Nang, Vietnam. The women were able to make improvements to their home with a micro-finance loan. This program kept them safe during Typhoon Nari in October 2013.



Shadow puppet vignettes

Working with people from diverse cultures is integral to Andrea Caspari's teaching, as are her personal background and experience as an anthropologist. Andrea is an educator, artist, and co-founder of the Firefly Shadow Theater. Andrea uses a simple light projector, a screen, and intricate puppets made of paper and found materials. The craft of shadow puppets brings to life processes and ideas that are otherwise difficult to capture through the spoken word or writing.

Andrea has produced a series of vignettes that explore issues of climate, shelter, water, energy, and food, as well as visioning for a more positive, resilient future. Her shadow techniques illustrate the complex relationships between society and the environment in a direct but sophisticated manner, and her scenes engage people while communicating across cultures and age groups.

Prayer wheels

Chris Moench has been making prayer wheels since 2000. The wheels are an ancient art form that invites interaction. With a gentle push, the viewer can set the wheel into motion and watch as the narrative illustrations "come to life." These narratives invite the viewer to ponder the web of life, and people are encouraged to write a note and place it inside the vessel.

The prayer wheels tell two stories with contrasting realities. The first story is a tale of ignorance, resource extraction, pollution, and the neglect of entire populations who suffer under avoidable circumstances and fates. The reality represented here is one where global economic disruptions, armed conflict, disease, and disasters plague the world. The second story presents a future where harmony has been found between people and the environment. Despite overwhelming complexity in the world, society is empowered. The global risks and threats are clear, but society's tremendous ability to design, collaborate, and adapt through millions of small actions across scales aggregates. There may never be one grand solution to all of the world's problems, but a thousand 1% actions can lead to great change and also generate the momentum we need to guide our own course toward a more desirable future.

Top

A mother and child stand in their village, which is situated next to a berm. The distant city evokes the idea of industry and opportunity. The berm holds back water, but should it fail, the houses nearby will become inundated by floodwaters, and the people who seek shelter in these undesirable locations would have few resources available to help them rebuild.

Bottom

Community members mobilize to raise their houses and dig ditches along the roadway to promote flood resilience. A boat is stored under the house on the left. In some parts of the world, floods are frequent and unpredictable. While some cities are looking for ways to hold back the floodwaters, others are learning to live with floods. More of Andrea's work is featured on <http://www.FireflyShadowTheater.blogspot.com>



Beyond Resilience

Top

Chris Moench's prayer wheels explore themes of hope and renewal. Through the illustrated surfaces, he seeks to narrate stories about the natural and timeless cycles of life, death, and rebirth. More of his work can be seen at <http://axisofhope.net/>
Photo by Chris Moench

Bottom

Detail of Threat Prayer Wheel
Photo by Chris Moench



Below
Resilience Prayer Wheel
Photo by Chris Moench



Analytical writing

Marcus Moench & the Resilience Narratives team
ISET-International

Analytical writing to explore resilience concepts in depth and document experiences in their application represents a core element of the Resilience Narratives project. This writing draws on an extensive array of applied work by ISET-International and many of our partners on resilience planning and implementation undertaken as part of the Asian Cities Climate Change Resilience Network and other programs. Most of this work has been in urban and rural areas across South and Southeast Asia. Products include peer-reviewed journal articles, brief analytical blogs, and much more extensive working papers. The goal is to refine the emerging sets of narratives and discourse regarding complex systems, resilience, and transformation in relation to the growing challenges associated with the processes of urbanization and climate change. Particular attention in this is given to the tensions that arise between concepts of resilience in relation to more scientific understanding of complex urban system dynamics and the manner in which resilience terminology is used in public and policy debates.

Below

Udon Thani, Thailand

Visioning tools are being used to help cities like Udon Thani develop plans that account for increasing populations and the uncertainty of climate change. The city is frequented by flooding, and waterbodies like the one pictured below act as a buffer for critical infrastructure, particularly shelter.





Photographer: Alexis Wagnon, 2014

Introduction

The concept of resilience can be applied to anything—people, ecosystems, cities—and there is a growing trend to use the word *resilient* to describe a desirable state of the world. On pages 14-15, we call upon the subtle differences in the description of *resilience* in a variety of sectors as a starting point for this publication. Each definition varies slightly based on the type of system the practitioner studies or engages in.

The methods that a psychologist might use to understand resilience in a person will vary significantly from those used by an engineer trying to design a resilient bridge. While both individuals are experts on the subject of resilience, they use different tools to understand how the dynamics of resilience play out in their respective field and to design and implement effective change processes. Although these experts work in disparate fields, there may come a time when the psychologist and engineer must collaborate to solve a complex problem.

Systems-level problems are almost always too complex and complicated for one person or discipline to effectively address on its own. To effectively catalyze change at a systems level, interdisciplinary teams and diverse groups must collaborate to bring multifaceted, innovative solutions to the fore. However, there are gaps in understanding, motivations, and interests across these diverse groups (Moran & Carroll, 1994). The way people see and understand the same problem can be entirely different. These gaps can create challenges, misunderstandings, or blind spots when interdisciplinary and intercultural teams attempt to design a solution collaboratively. This was our motivation in producing this writing—to introduce and invite a diverse set of actors into this discussion to encourage collaboration.

In *Beyond Resilience*, we seek to clarify what resilience is and how resilience concepts can be used in the context of rapid urbanization and climate change. The focus of the writing, however, is on resilience and resilience concepts in an urban context, not on the climate science *per se*. Many of the examples we use concern flooding and other extreme weather events. Such events are likely to increase as a consequence of climate change.

The intersection of urbanization, climate change, and the socio-ecological systems that they affect spawns a myriad of complex problems that are difficult, if not seemingly impossible, to solve. Nonetheless, there are a number of contexts where an understanding of resilience can be employed to identify and clarify solutions.

Before investigating the nuances of the word *resilience*, we assume the following general descriptions of the words *urban* and *climate*. *Urban* refers to the area that encompasses a town or city and its suburbs, all of which have some degree of population density and infrastructure. *Climate*—not to be confused with weather—refers to the statistical average of atmospheric and meteorological conditions (i.e., temperature, humidity, wind, and atmospheric particle count) in an area over an extended period of time.

Various descriptions of resilience

“Resilience is the capability of a system with specific characteristics before, during and after disruption to absorb the disruption, recover to an acceptable level of performance, and sustain that level for an acceptable period of time.”

—Resilient Systems Working Group

“Resilience is the process of adapting well in the face of adversity, trauma, tragedy, threats or significant sources of stress—such as family and relationship problems, serious health problems or workplace and financial stressors. It means ‘bouncing back’ from difficult experiences.”

—American Psychological Association

“Resilience is the ability to absorb disturbances, to be changed and then to reorganize and still have the same identity (retain the same basic structure and ways of functioning).”

—Resilience Alliance

“City resilience describes the capacity of cities to function, so that the people living and working in cities—particularly the poor and vulnerable—survive and thrive no matter what stresses or shocks they encounter.”

— Arup International & Rockefeller Foundation

“Urban climate resilience is the ability to survive, recover from, and even thrive in changing climatic conditions. It includes the ability to understand potential impacts and to take appropriate action before, during, and after a particular event, such as a typhoon, major flooding or prolonged drought, to minimize negative effects and maintain the ability to respond to changing conditions, even unpredictable conditions.”

—Asian Cities Climate Change Resilience Network

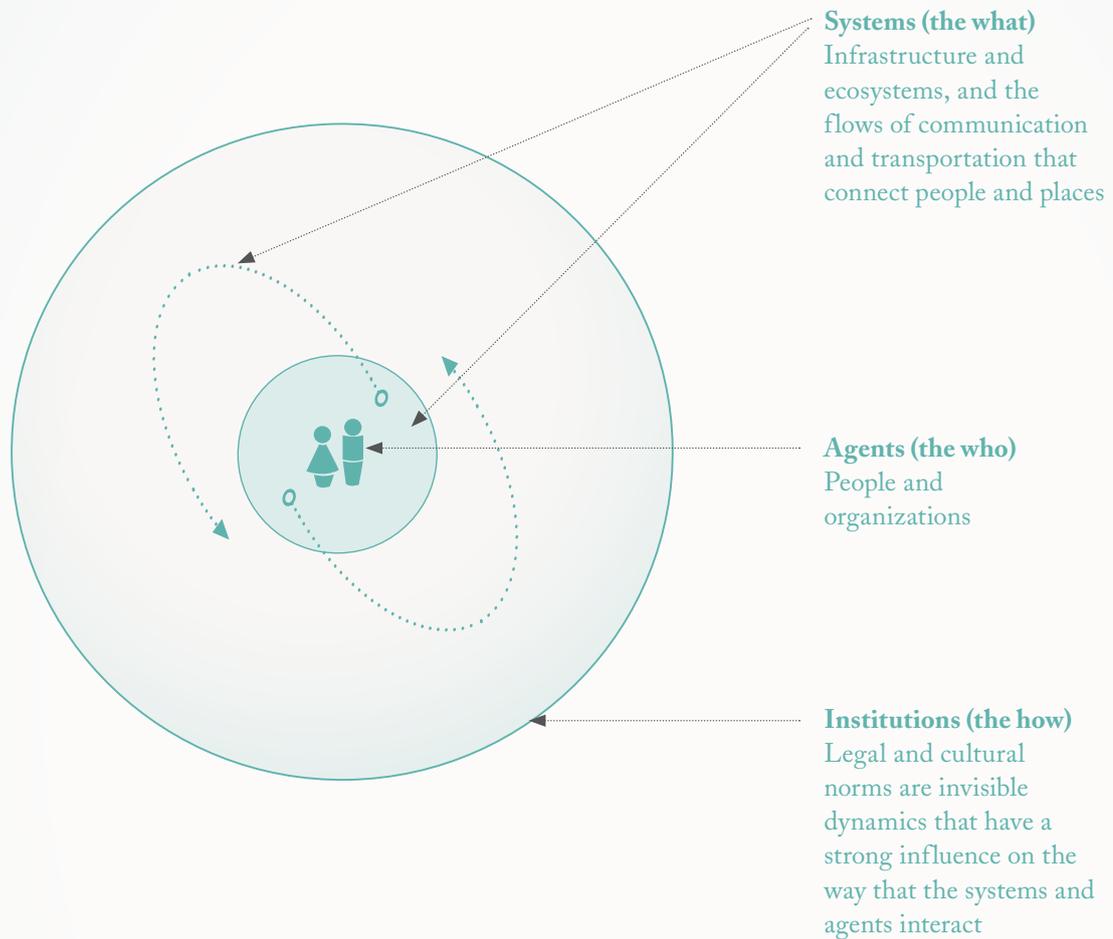


Lenses for examining resilience

The means by which resilience is achieved within the context of a city or community can be examined through different lenses, including characteristics of resilience, interconnectivity, spatial scales, temporal scales, systems-of-systems, and complexity and emergent behavior. We explore each of these in the following pages.

Characteristics of resilience

The resilience of an urban system can be evaluated via the characteristics of its systems, agents, and institutions (Tyler & Moench, 2012). These elements of a city provide a framework for understanding resilience, and initiating action and iterative learning. Approaching the understanding of complex urban systems via the analysis of the fundamental drivers of human behavior, the dynamics of complex infrastructure and ecological systems, and the institutional “rules-in-use” enables forms of understanding that assist in tackling seemingly unsolvable problems.



Components of urban systems

Systems, agents, and institutions

While most cities have similar infrastructure systems and urban service needs (i.e., potable water, health services, sanitation, food, etc.), the institutions that define them and the social and cultural organizations that influence the city's population vary widely. These institutions affect the behavior of people and organizations (agents)—introducing a variable unique to each place for how an urban scale system functions.

Characteristics of resilience in focus

Below are listings of characteristics that help to illustrate the resilience or fragility of a city. Under each characteristic are an idiom (or a variation on one) and a description. The idiom is intended to illuminate meaning, while the description reveals the nuance behind each term.

Characteristics of systems (infrastructure and ecosystems)

Redundancy & modularity

“don’t put all your eggs in one basket”

Redundancy and modularity allow a system to accommodate disruptions by providing multiple, distinct pathways to deal with demand or replace failed components.

Flexibility & diversity

“bend with the wind”
“go with the flow”

Flexibility and diversity refer to the ability of a system to carry out essential functions in a variety of circumstances. Both spatial diversity (spreading out essential services) and functional diversity (the ability to accomplish tasks through various means) are key aspects.

Safe failure

“nothing is too big to fail”
“hope for the best, plan for the worst”

Safe failure pertains to the interconnections between systems, where failure in one part of a system does not create a cascade or domino effect throughout the system.

Characteristics of institutions (legal and cultural norms)

Rights & entitlements

“get up, stand up, stand up for your rights”

Rights and entitlements determine access to services, information, and capacities. They can enable or constrain responses to disruption and the ability to recover.

Decision-making

“the buck stops...where?”

Transparent, representative, and fair decision-making processes can help to enhance resilience in systems by recognizing the rights of diverse groups to engage in the decision-making process.

Information flows

“what you don’t know may hurt you”

Resilience is enhanced when people and organizations (agents) have key information for planning and decision-making processes.

Characteristics of agents (people and organizations)

Responsiveness

“don’t fiddle while Rome burns”

Responsiveness emphasizes the capacity of agents to organize, reorganize, and act in preparation for, and in response to, a shock or stressor. It refers to quick action as well as foresight and awareness of potential future scenarios.

Capacity to learn

“fool me once, shame on you; fool me twice, shame on me!”

Capacity to learn attests to agents’ ability to learn from experience and improve performance.

Relationships & social networks

“I get by with a little help from my friends”

When it comes down to it, this characteristic underlines the need to simply know who to call when trouble strikes and having relationships so that you know that people will pick up when the phone rings. This also applies to organizations.

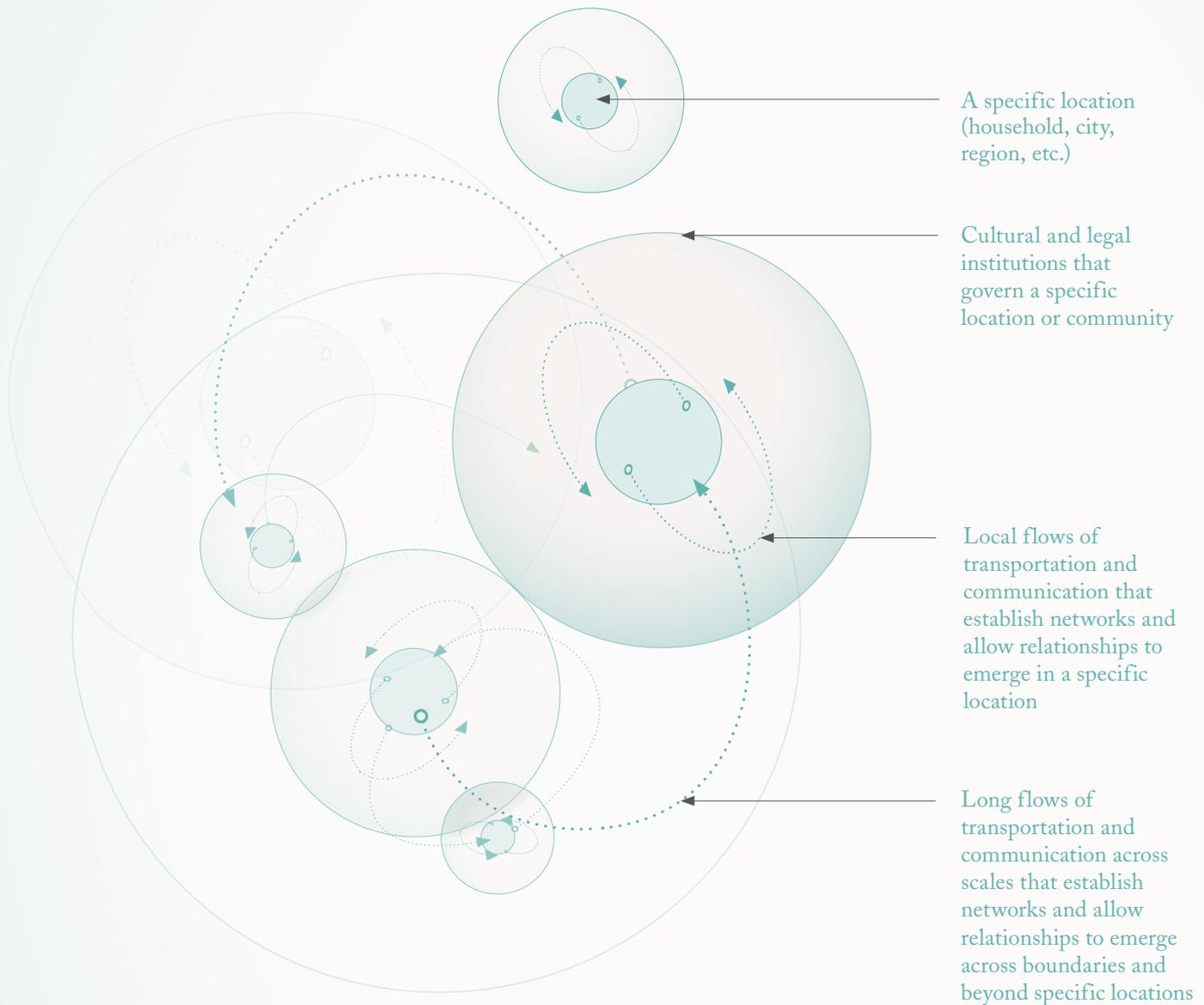
Resourcefulness

“think on your feet”
“save for a rainy day”

Resourcefulness refers to the ability of agents to mobilize resources, innovate, and anticipate problems before they arise. It also refers to the resources available and an agent’s ability to access resources such as money quickly.

Interconnectivity

Places—households, cities, regions—are connected through flows of transportation and communication. These flows enable services to be delivered and relationships between people and organizations to establish themselves. These often invisible connections are the channels that enable our world to function.



Long and short networks

Cities are not isolated entities

Cities are interconnected nodes within short- and long-distance networks. Short local networks generate the local socioeconomic fabric, and the long global networks connect a location or scale to the rest of the world (Manzini, 2015).

Interconnectivity in focus

With our current global economies and emerging technologies, our world has never been so connected. Information can circle the world in a second, social movements can mobilize overnight, and diseases can spread around the world as fast as a plane can fly.

Interconnectivity amplifies the potential for new information or changes at a specific location to impact a system across scales of time and space. For example, the potential of a flood to impact the lives of local citizens is obvious, but with connected systems, the impact of that flood can continue outward and disrupt global supply chains for months or even years. This was seen with the Thailand flood of 2011, when multiple industrial estates found themselves inundated by floodwaters for months. As a result, markets around the world watched as the price of external hard drives soared (Fuller, 2011).

Flows

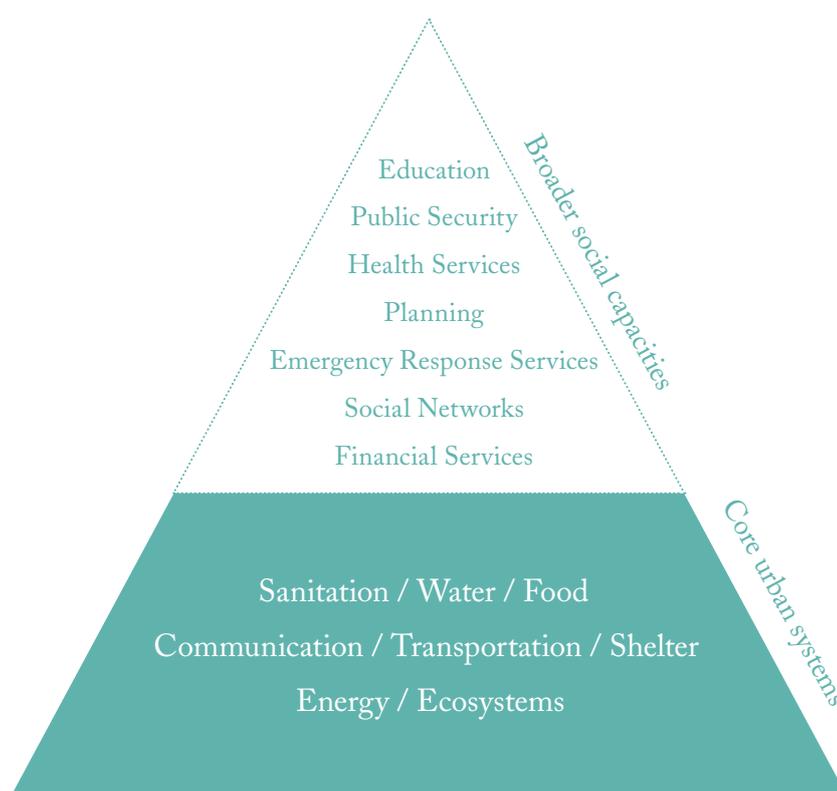
Cities have distinct identities based on their specific location and the idiosyncratic cultural and legal institutions that govern them. By virtue of shared ecosystems and the flows of transportation and communication across scales, cities are also part of a much larger fabric that extends beyond their own boundaries and carrying capacity—that is, the city's capacity to solely provide the population with the resources that it needs to survive.

Cities are interconnected and dependent on resources from other parts of the world. Individuals are also connected through global social networks, economies, communications, transportation, politics, and a shared natural environment. This is perpetuated by the increasing occurrence of networked communication, transport, and economic systems and the patterns of power, finance, business, and industry they support. There are, of course, advantages and disadvantages to this. On the one hand, connectivity to other parts of the world enables a city to access a greater supply and more diverse set of resources and new ideas. On the other hand, vulnerability can arise if a city becomes too dependent on the inflow of resources such as food, industry, or energy.

Core urban services

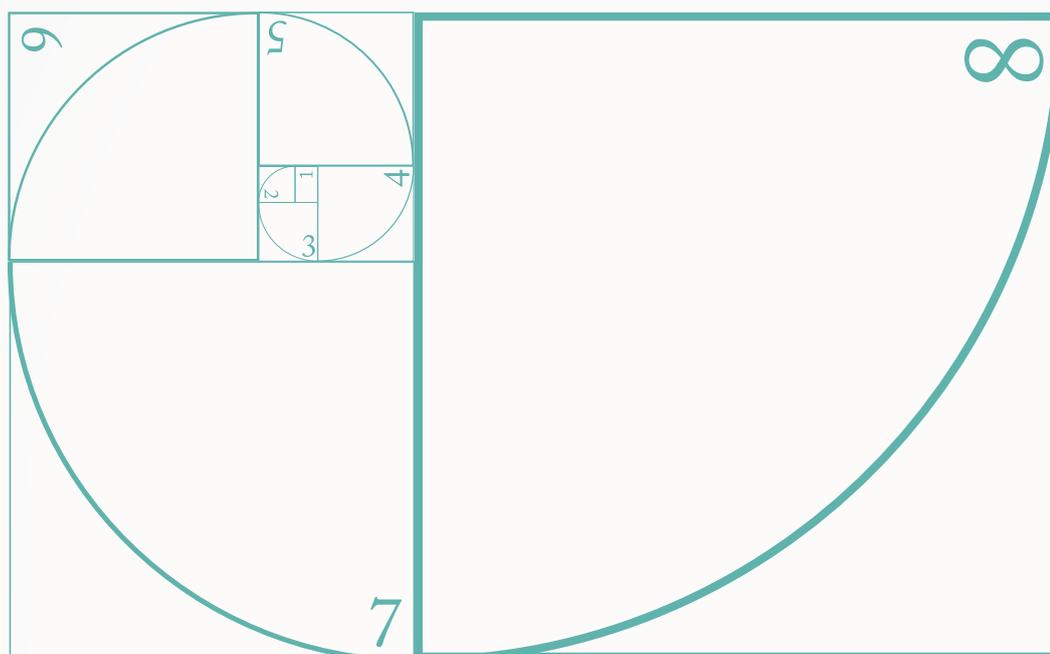
The information graphic below presents a hierarchy of core urban services. If a service at the base of the triangle fails, then all the other services become vulnerable. To draw a metaphor from ecology, these core urban services provide the core environment, which then enables other systems to emerge and thrive.

Their interconnections and dependencies are what enable cascading impacts to occur, particularly with regard to core urban services. For example, if a failure or disruption occurs at the energy system level (a core urban service), ripple effects will be felt through all urban systems—from food systems to health services to financial services—because there is very little on an urban systems level that can operate without reliable energy. Similar effects can be seen if access to potable water, communication, or transportation is lost.



Spatial scales

The smallest unit of a city—the household—is connected to the grandest scale—the world. The golden ratio is presented as a metaphor for the growth of a city and illustrates how the smallest scale is connected to the largest. Attributes of cities, however, scale at varying rates in relation to population (Bettencourt, 2013).



City scaling

The information graphic above is an illustration of the golden ratio. The exact origins are unknown but date back to Phidias, a Greek philosopher (500–432 B.C.E.).

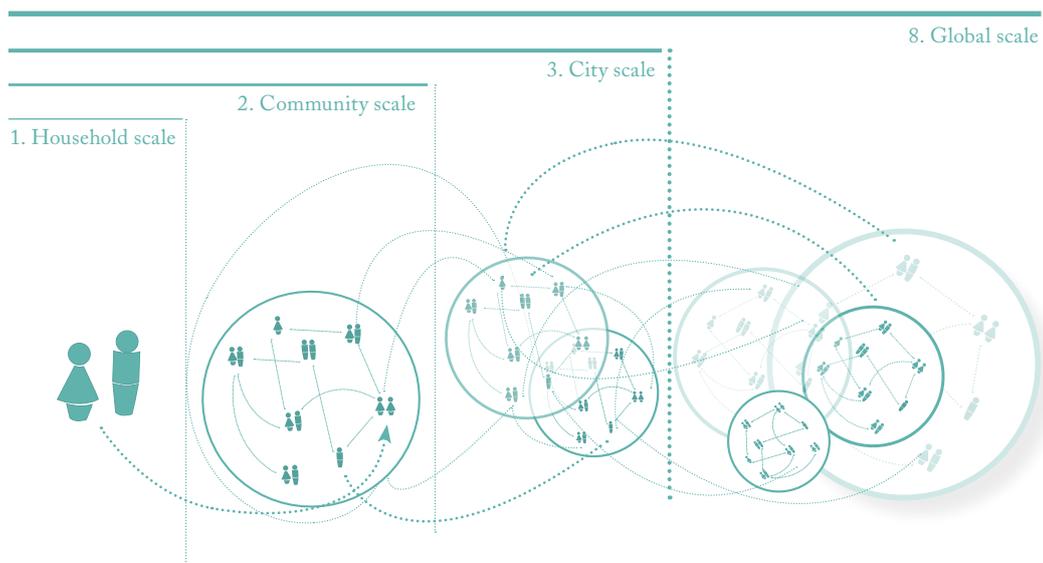
0, 1, 1, 2, 3, 5...

The golden ratio is a simple mathematical relationship that is found in nature. Mathematically, it is known as 1: 1.618 and is related to the Fibonacci sequence, where each number is the sum of the two preceding numbers (0, 1, 1, 2, 3, 5, 8, 13, 21, and so on)—offering a formula for scaling. Everything from the way a nautilus grows to the way the human body proportions develop can be linked back to this ratio, as it predicts the natural growth pattern of almost all living things on Earth.

A similar growth pattern can be seen in the way we describe and understand spatial scales of cities. Moving from big to small: a region encompasses multiple cities, cities are comprised of multiple communities, and communities are made up of multiple households or individuals. Because of these scaling patterns, each unit is therefore connected or at least associated with the scales that it builds upon or sits within.

Spatial scales in focus

The same dynamics that exist at the household level can be seen at the global level. Sudden changes at the household level can send rippling effects throughout the entire system, influencing change at the global level—and vice versa. Though each scale can be isolated, the lines between them are often blurry. Each scale builds on the other, and they all aggregate upwards to define a shared identity. On page 29 we describe scaling from the household to the global. To understand a systems-level problem, it's often necessary to look beyond, above, and below the location where change is hoped for—that is, to look across multiple scales for solutions.



Attributes of cities grow at varying rates

As cities evolve, different elements of the city demonstrate varying rates of growth—either sub-linear, linear, or super-linear (Bettencourt, 2013). Critical infrastructure, such as roads, demonstrate economies of scale, as they tend to expand less rapidly, or sub-linearly, as compared to the city as a whole. Resource demands, such as food supplies, have a direct correlation to the population, or a linear growth pattern. Other aspects, such as wealth, creativity, and crime, arise from increasing opportunities for interaction, demonstrating super-linear properties, with large urban areas displaying more of such features per capita than small urban areas (Bettencourt, Lobo, & Strumsky, 2007).

1. Household scale¹

The household consists of an individual or a group of individuals who share housing or who use shared systems to access resources.

2. Community scale

A community is a set of individuals, households, or organizations that share elements of identity or activity.

3. City scale

A metropolitan or urbanized area comprises many communities and scales of geography that need to coordinate around shared systems, such as potable water, transportation, communication, food systems, and so on.

4. City, peri-urban, rural scale²

A city's boundaries are often blurred by areas that may not lie within the city proper. This includes peri-urban land that is often included in a regional plan but often does not yet receive all of the services that the city offers the fully urbanized areas (e.g., potable water, drainage, solid waste management, etc.).

5. Regional scale

Cities within a region share a common geographical boundary and are sometimes influenced by the same legal and cultural institutions.

6. National scale

Nations are fixed by political and geographical boundaries, and can encompass multiple regions, cities, and communities.

7. International scale

The international scale involves the relationship between two or more nations.

8. Global scale

The global scale includes all scales that are bound together by a shared environment and the interconnections that are established through flows of transportation and communication between locations.

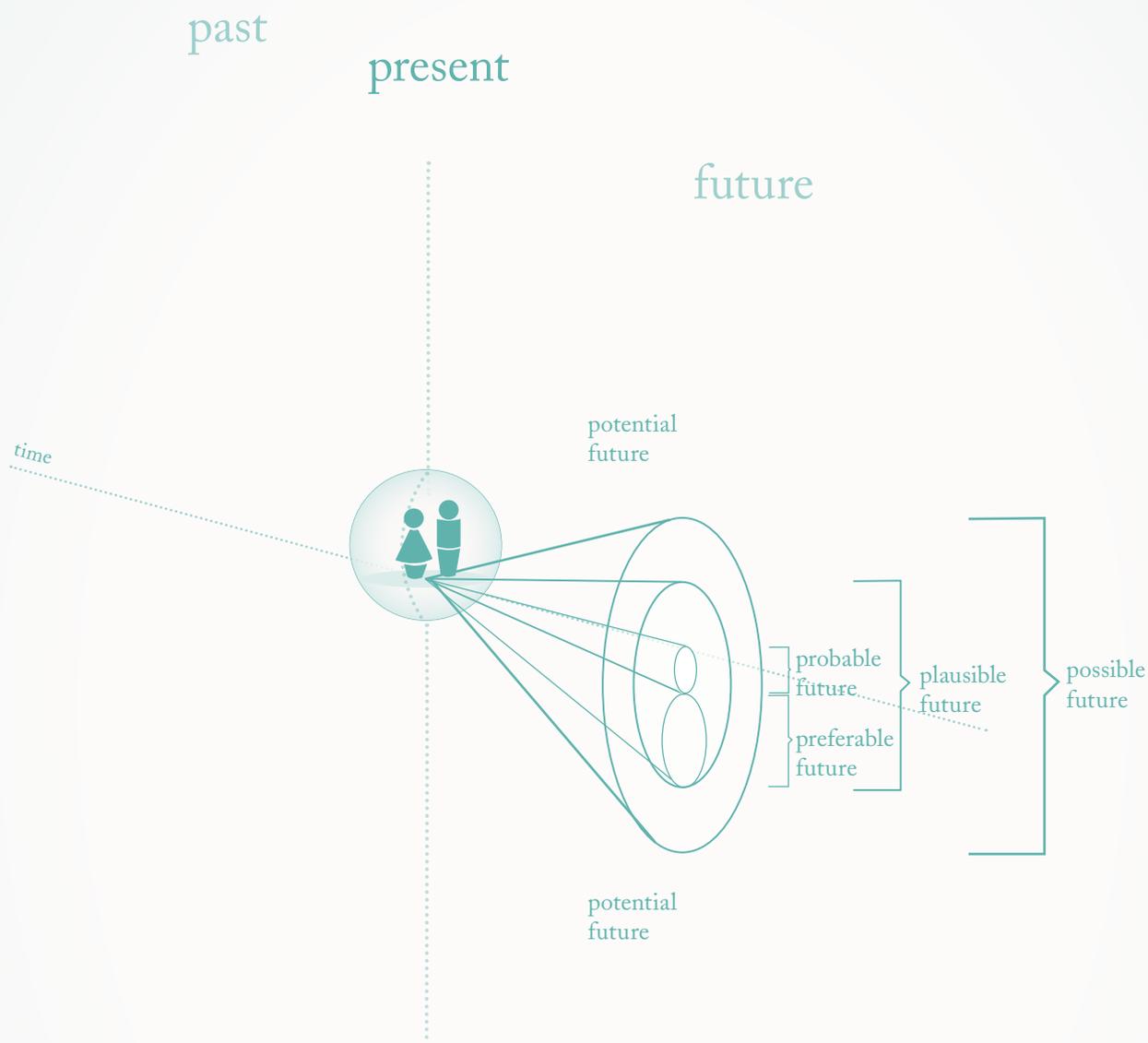
¹ Our starting point is the household and not the individual because urban and community resilience relies on systems and dynamics that may not exist at the level of a single individual. It is worth mentioning, however, that the individual has the lowest level of agency and the capacity to intentionally act on his or her environment.

² In contrast to peri-urban areas, rural areas outside the city are relatively easy to distinguish from the city proper. Rural land is critical because it provides open space and natural resources that the city relies upon for a healthy ecosystem.

Temporal scales

By observing the historical patterns, evidence, and artifacts of a place, we are able to better understand the dynamics that are present in current situations and identify the tools and materials available for designing interventions.

Through the use of modeling, visioning, and scenario planning, we can anticipate probable, preferable, plausible, and possible scenarios for the future.



Futures cone

The information graphic above has been modified from Voros's (2003) information graphic on "futures cone."

Lasting impressions

Two cars are moving toward each other at high speed. Time is of the essence to avoid a head-on collision. When two continents are drifting across the ocean, over millenia, the crash may be inevitable as well, but that does not really affect us on a human timescale. The decisions we make in urban development affect our lives and our children's lives. We need to think on timescales that reflect not just our own lifetimes, but those of future generations. Many cities in England still reflect design elements introduced by the Romans. Recognizing this, the challenge for us is to create a vision, pass on lessons and learning, and lay the groundwork that will enable and inform future generations.

Temporal scales in focus

Some systems are resilient on timescales that, for people, are too long to be of value. A system's resilience, in other words, is only as good as the temporal scale that matches human need. Take the example of planning. Any attempt to plan must consider the appropriate timescale to assess needs, by considering the past and looking to the future. If projects are designed using inappropriate timescales, they may produce ineffective solutions or generate more problems (Ziemer, 1997, Chapter 6). Similar to the manner in which cities scale physically, the dynamics that affect specific locations occur at different timescales. For example, the lifespan of critical infrastructure such as shelter or bridges and the average lifespan of people all differ.

Planning at an urban scale, particularly considering climate change, requires planning horizons of 50 years or more. Models and projections can be produced to visualize possible scenarios for the future and helps us to better understand the dynamics shaping our world. Through this, we are able to predict landuse, resource management, and population growth patterns decades out with some degree of certainty.

Uncertainty is unavoidable. The future is not predefined, predetermined, or predictable because the fundamental dynamics that play out across time and space, which shape our world, are inherently unknown (Voros, 2001). The graphic on the previous page illustrates the concept of the "futures cone," which acts like the headlights of a car, illuminating the probable, preferable, plausible, and possible futures that lie ahead (Voros, 2003).

Practitioners around the world use visioning to improve planning and contrast business-as-usual scenarios with resilient pathway scenarios. The Building Urban Climate Resilience: The Economics of Alternative Development Pathways team of ISET-International did just this in Da Nang, Vietnam and Gorakhpur, India. Scenario development helped assist with the development of alternative future visions for city development (Singh, Khan, Tran, & Hawley, 2015). This strategy informed decision-making processes by

Below

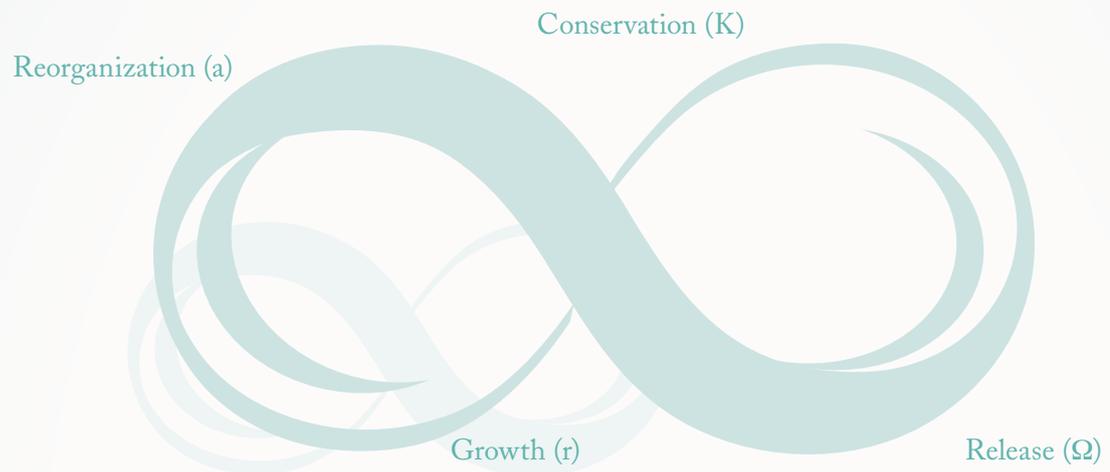
Da Nang, Vietnam, is undergoing rapid urbanization, and construction is transforming the nature of the environment and the risk of flood and typhoon. Planning and visioning are being coupled to better understand the dynamics and potential futures for the city (Tran & Tran, 2014).



identifying the costs and benefits of different interventions and development pathways over varying time horizons. Though we cannot predict the future, looking at temporal scales helps us to identify wise decisions that can put us on a more direct path toward a preferable future.

Systems-of-systems

No discussion of resilience would be complete without reference to panarchy, the relationship of subsystems to larger “systems of systems” and adaptive cycles (Gunderson & Holling, 2002). The resilience of a city reflects complex adaptive cycles at multiple scales of time and space. Maintaining the dynamic adaptive nature of many socio-ecological systems—a process by which society and natural systems respond to constant change—requires cyclical phases of collapse, release, reorganization, and structuration (Gunderson & Holling, 2002). The smaller adaptive cycles at the household or business scale release accumulated tension, preventing shocks from being felt at the larger city or regional scale that could lead to collapse of the whole system.



Adaptive cycles

Information graphic source: Gunderson & Holling (2002).

The fallen giant

In 2008, the world's economy fell into a recession. Detroit, Michigan, was hit particularly hard when the city's lifeline, the automobile industry, collapsed; the "release" came when thousands of people lost their jobs and left the city in search of new opportunities and livelihoods. "Reorganization" can be seen in the urban revitalization efforts that are currently underway; however, the success of those efforts has yet to be determined. Had Detroit had a diversified economy and smaller businesses, none too big to fail, the city might have had the adaptive capacity to absorb the shock of the recession and rebound rather than collapsing. But instead, almost the entire economy relied in some way on the automobile industry, which led to a weak and fragile urban system.

Systems-of-systems in focus

Adaptive cycles include both a slow growth phase and a rapid reorganization phase that help to maintain the adaptive nature of the system. These slow and fast cycles occur within different time frames and at different scales. Cycles at the household, community, and city levels, and beyond, are nested within each other and are intimately interconnected; what happens at the level of the household has the potential to cascade up to the level of the city and vice versa. The emergence and growth of businesses illustrate this in a practical way; the businesses start small and grow, but most ultimately collapse, releasing people to engage in new industries and activities. The skills and businesses of sword makers in the Middle Ages, steam engineers in the industrial era, and automobile manufacturers in Detroit contributed to the growth of many urban areas that still exist today. These industries and the businesses they supported have now changed, freeing resources for the new information economy and the burgeoning urban areas where a host of new businesses exist. The fast cycles of individual industries and businesses contribute to the resilience of the longer, slower cycles that characterize larger urban systems. At the same time, these fast cycles can have real costs, as the many unemployed and unemployable people who were displaced when the auto industry failed can attest.

The phrase “think globally, act locally” is commonly heard in urban planning contexts and reflects an understanding of the stable, slow-moving forces present in the world. The interventions we design and emergent behaviors we observe at the local level have a relatively fast-moving and disruptive energy that can stabilize over time and develop into a conservation phase (e.g., new industries, systems, social and political institutions, etc.). Contrarily, these fast-moving, disruptive cycles can also destabilize larger, slow-moving cycles. Therefore, it is important for designers who are working at the systems level to have a global-level consciousness and a local-level footing across scales of geography and time.

The point to be made here is that interventions at the local level must be agile, especially in consideration of emergent behaviors and opportunities or challenges that may arise over time. Uncertainty is inherent, so a commitment to long-term engagement and monitoring where learning can evolve and be

applied is critical to achieving resilience. Maintaining a long-horizon view and goals will allow more lasting solutions to emerge.

By contrast, the initiation of robust, isolated, and linear solutions commits to a level of effort that can be unsustainable and sometimes wastefully ineffective. For example, in Kathmandu, Nepal, the government is pursuing a large and costly infrastructure project that is intended to deliver fresh potable water from a water source that is 26.5 km away. The Melamchi Water Supply Project has been delayed for almost 2 decades and the citizens of Kathmandu continue to lack access to clean water through the municipal system. This situation has, however, supported the growth of extensive water markets. Because of lackluster support from Kathmandu's urban services, citizens and businesses responded autonomously to the need and demand—an emergent behavior that was catalyzed by the constraining affect of larger institutional limitations.

Soft eyes, quick hands, can't lose

Imagine you are driving down a long stretch of highway. You don't (or shouldn't) stare with hard eyes down the center of the road at all times, or only at the bumper of the car in front of you. Instead, you allow your eyes to rest softly, shifting between the cars around you, the horizon, your side mirrors, and your peripheral vision. Your hands hold the wheel, determining your direction. Your soft gaze and awareness of your surroundings is your global consciousness and awareness of a stable force. Your hands on the wheel is your locally rooted intervention, ready to respond to changes as they appear.

Complexity and emergent behavior

Complexity is the inverse of simplicity. By studying the complexity of a system, we may be able to identify the underlying causes of a problem. This approach can reveal lasting, elegantly frugal (perhaps even simple) solutions to complex problems (Hawken, Lovins, & Lovins, 2001).

If we can see the details and the bigger picture simultaneously, the relationships that drive emergent behavior can be better understood. Emergent behavior is the autonomous response of groups of individuals to changes in their environment. When multiple actors exhibit the same response, complex emergent behavior results.



Emergent behavior

Swarming

Swarming is a type of emergent behavior that we often see in animals and insects. Swarming is the collective action of many autonomous actors which involves no formal organization or planning. Imagine a flock of birds taking flight suddenly and moving through the sky as a flock, or fish schooling through the ocean. This type of behavior can be seen in people, too.

Imagine 100 cars barreling down the highway at 65 mph. The drivers are proceeding at a predictable speed and in the direction determined by the road. But when a deviation is introduced, say a deer dashing across the highway, the predictable speed and pattern of the cars becomes emergent. As the drivers swerve to avoid the animal, they display an emergent behavior. At some point, drivers farther back are no longer responding to the animal on the road because it is out of their sight. Instead, those drivers are responding to the behaviors of the drivers ahead of them.

Complexity and emergent behavior in focus

When we assess scales, institutions, and the behaviors of people, the process of understanding urban climate resilience may quickly become very complicated. The complexity of systems, their emergent properties, and the complex autonomous behaviors that shape them can be difficult to predict.

When examining systems or the autonomous behaviors and emergent properties that they exhibit, we must evaluate the rules (e.g., of cultural and social institutions) or causal effects from which complexity emerges. As a group of people, or actors, in a system respond to a change in their environment, their collective action becomes a swarm of behavior that can result in a social movement or a mass migration. This behavior often plays a major role during disasters, for example, when communities self-organize responses long before the government or other formal organizations can take action. Emergent behavior is, as a result, one factor responsible for the resilience of a system.

Emergent behavior occurs in a complex system due to self-organization or unplanned development, or when a deviation or disturbance occurs, resulting in autonomous actions and a complex, unpredictable set of reactions of multiple agents. On a grand scale, we see emergent behaviors appear when a disaster happens somewhere in the world. Depending on the scale of the disaster, international communities may respond and local-level actions may be taken. The Boulder, Colorado, flood of 2013 provides a good example. The Boulder flood destroyed more than 500 homes, accounted for 10 deaths, and affected countless families and households (MacClune, Allan, Venkateswaran, & Sabbag, 2014). A vast network of agencies—including the Federal Emergency Management Agency, United States Army Corps of Engineers, Governor's office, and State Office of Emergency Management—responded and sent resources to assist Boulder after it was declared a national disaster area. Individuals and local organizations, however, responded far more quickly.

Concerns of legal liability prevented local authorities from mobilizing volunteers. Local citizens and organizations established for other purposes, however, responded autonomously. Groups of people with established friendships and professional relationships came together to form a group called

Below

Boulder, Colorado

The Mudslingers rally outside of an affected home to plan out their volunteer strategy during the Boulder flood of 2013. Photo by Aly Nicklas

Lenses for examining resilience
Complexity and emergent behavior



the Mudslingers with no formal input from the local government. Together, this band of about 750 volunteers racked up approximately 21,250 volunteer hours,¹ helping affected citizens dig their homes and belongings out of the mud, dirt, and debris. This emergent response provided relief to the county by assisting families who otherwise would have been left on their own as authorities responded to other situations.

¹ The number of volunteers and volunteer hours are based on estimates from the organizers of the Mudslingers (Aly Nicklas, personal communication, December 5, 2013).



Putting it all together

As complex adaptive systems, cities have many interacting parts, simple individual rules, and emergent properties that operate at different scales through dynamic flows—all of which are dictated by cultural and legal institutions. This complexity can quickly become overwhelming, and no single person or discipline can be expected to comprehend it in its entirety. However, an overall understanding, a view from 30,000 feet if you will, is critical. From this vantage point, we can look for patterns of behavior in the past and plan or anticipate potential scenarios toward a more desirable future. Understanding the dynamics that influence patterns of behavior can generate simple solutions out of the complexity. These solutions, or interventions, can slowly nudge a regime toward a transitional state or be used to transform entire systems.

Due to interconnectivity and emergent behavior, these solutions can generate cascading effects that bring us closer to our goals—supporting our planned interventions—or they can potentially create new challenges for the same problem. Changes at the household scale aggregate outward, affecting dynamics at the global scale, and vice versa. A change in one part of a system can create unintended consequences within the same system or situation, because flows connect many things and transcend scales. So how can we create a synergy between scales and adaptive cycles, especially as they become invisible and intangible the farther we get from them over space and time? How can tangible household-level actions become empowered and not constrained by invisible decision-making processes at the city and state policy levels?

As scales grow, the dynamics of large systems often become more rigid, particularly when change is blocked in the smaller subsystems of which larger systems are comprised. This situation can reinforce regimes that then become self-perpetuating basins of attraction—drawing in greater levels of resources and scaling patterns of behavior as individuals mimic the behaviors of others. The larger the scale, typically, the longer it takes for an adaptive cycle to complete and the more effort it takes to catalyze change.

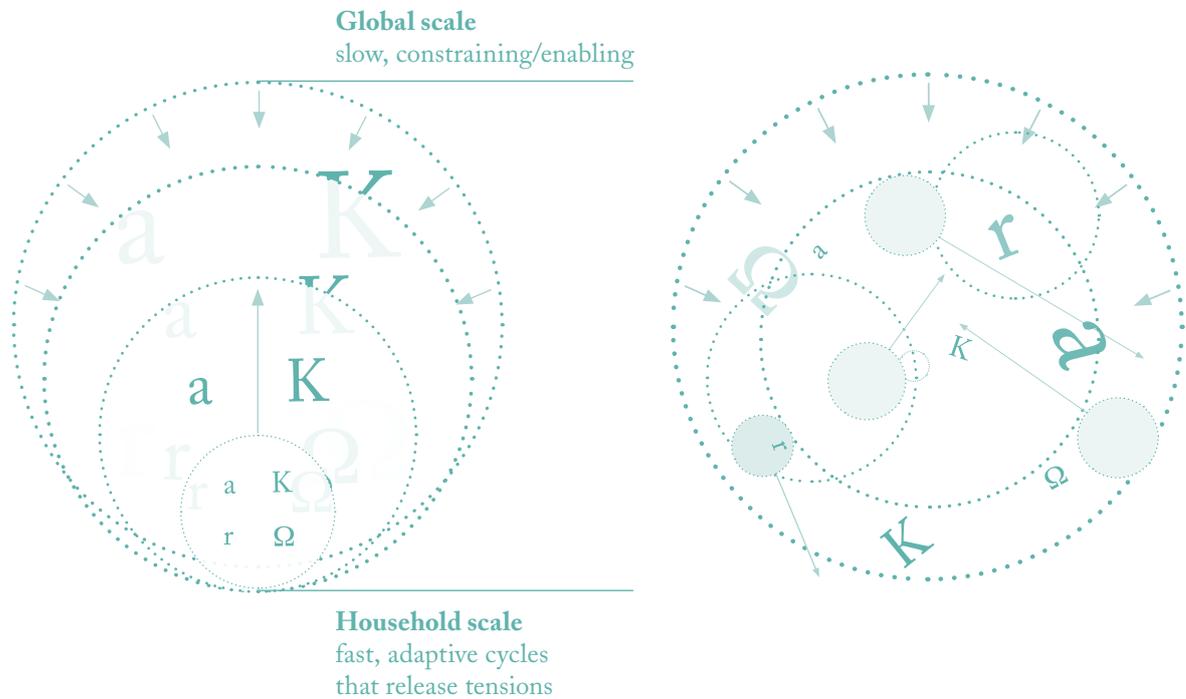
Change at the city or state level can take much longer than change at the household level due to the number of decision-making processes involved and the level of coordination required among multiple individuals, agencies, and organizations across multiple scales and sectors. In the case of infrastructure, different scales face change at different frequencies. At the household level, changes need to be made every few years (e.g., replacing the roof, water heater, furnace, etc.), in contrast to urban infrastructure, such as a bridge, which has a planning horizon of about 50 years (Min & Frangopol, 2005). Additionally, systematic planning can take up to 10 years to influence policy shifts and institutional rearrangements. In some cases it may take generations to release constraining, maladaptive patterns of behavior that are perpetuated by cultural norms. But cities around the world cannot afford to wait generations for solutions to be implemented and take affect—or 50 years before more resilient infrastructure systems are designed and rebuilt.

Synchrony in adaptive cycles

Autonomous adaptation, also known as spontaneous adaptation, is the way individuals, communities, and organizations respond to the risks and opportunities they perceive separately from any larger and more planned adaptation interventions by governments. It represents an expression of agency at a singular level. But can autonomous adaptation be a solution space? Traditional planning regimes are inadequate due to their lengthy and often bureaucratic decision-making processes. Furthermore, planned strategies often fail because they do not reflect the real driving motivations of different actors within society. With the rate at which urbanization and climate change are impacting our environments and systems, are we seeing the benefits of policy change in time—or at all?

Households in Gorakhpur, India, are already raising their homes onto stilts or plinths in response to the annual flooding and waterlogging that occurs throughout the city. Low-income households in Da Nang, Vietnam, have accepted microfinance loans to build or retrofit their homes to be resilient to typhoons and floods. Poor communities in Pakistan are painting rooftops white to reflect the sun's heat and adding small windows just below the roof

"Synchrony in adaptive cycles" is modified from a blog post by Kathleen Hawley (2014, June 10). Retrieved from <http://blog.i-s-e-t.org/autonomous-adaptation-is-it-a-solution-space/>



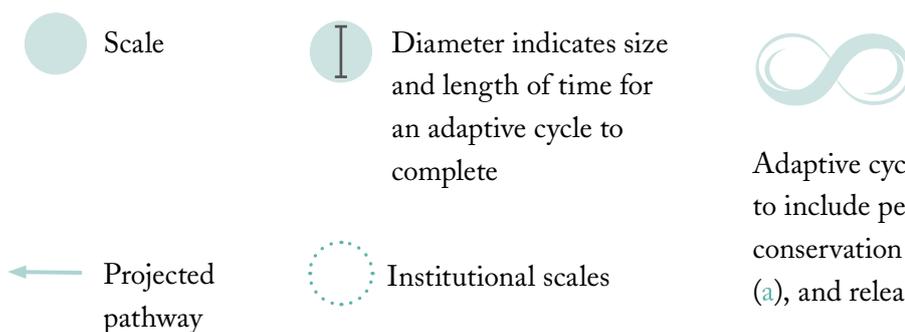
Small to big, big to small

The dynamics that play out at the smallest scales of systems aggregate upwards to define the characteristics of the systems in which they lie. Conversely, larger systems can influence the functioning and behavior of the smaller systems that rest within it.

Competing forces

In reality, these nested scales are not linear or neat. They are messy, interconnected, and entangled systems that often lack clear boundaries and definitions of space and time. In a panarchy environment, forces can work together between scales, or if misaligned, they can also become constraining or maladaptive.

Synchrony in adaptive cycles: Part 1



that act as an exhaust and provide daylight. These home owners are exercising autonomous adaptation by making investments with their own resources and decision-making power, with limited or no government assistance. The changes they are making autonomously are reshaping the landscape and their city's overall capacity to adapt to climate change.

In the case of Boulder, during the 2013 flood, households began placing sandbags along the perimeter of their homes. This effectively diverted the floodwaters away from their homes and into the streets. While this protected some homes, the diverted water may have increased the impacts of flooding on others. Behaviorally, this response reflected a pattern found throughout the world: whenever possible during a flood, water is pushed out of the spaces of private actors (individuals, households, businesses, organizations) and into public spaces, such as roads or other communities.

How can emergent behaviors be harnessed and enabled by governing institutions and policy? Why are we continuing to push the traditional planning path as the best option for problems such as climate adaptation? Why do we continue to work to integrate climate science models into planning processes in these locations when that information may take 10 years to be felt at a local level?

Planning needs to be coupled with and support the integration of what is already happening autonomously. In the effort to achieve resilience, or transition lifestyles toward a more desirable future, focusing only on high-level policy interventions will deliver results that come too late or that are ineffective by the time they arrive. Bottom-up solutions and the emergent behaviors of individuals and households need to be recognized, but also guided and influenced. Unless harnessed and directed, they may lead to maladaptive futures.

Instead of dividing these two areas of intervention, we may find greater success in synchronizing the dynamics at multiple levels by creating a shared vision and pathway toward a desirable future. We should incentivize household-level changes and move forward with planning and implementation together, and not put one before the other.

Vision, values, and voice

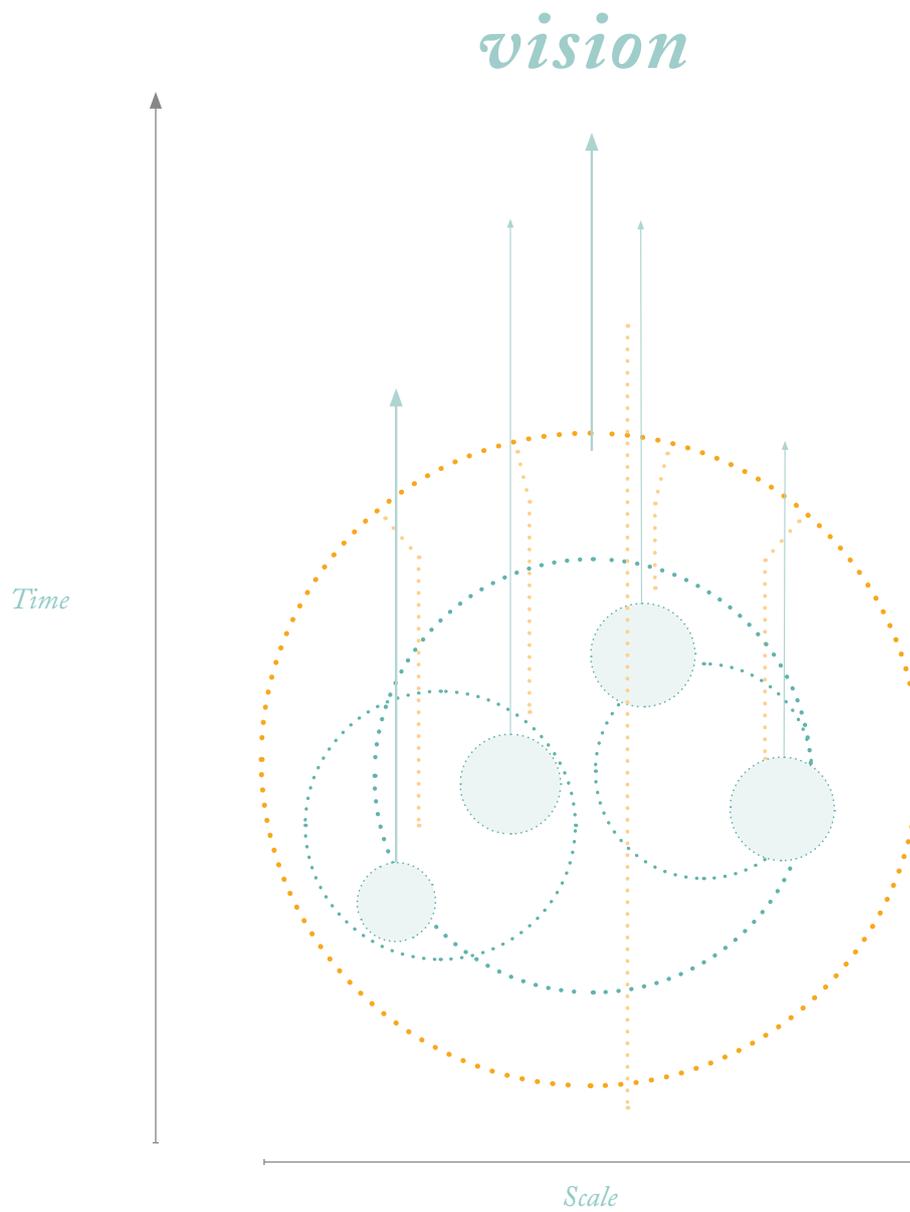
Resilience offers an approach for us to use to understand, design, and enhance the quality of environmental and social systems. However, resilience is just one approach. It alone does not reflect our value systems. Value systems differ across identity groups, businesses, cultures, and nations. And resilience can also support systems that threaten values and create undesirable states of existence. This calls into question the idea of “resilience for what and for whom” (Friend & Moench, 2013).

Developing an inclusive, multi-stakeholder process to collaboratively develop a shared vision of a desirable city or community is one way to clarify the actions necessary for building resilience. An inclusive process can help to ensure that issues of equity are incorporated, so each population segment has representation and a voice during the dialogues. Setting a vision, or goal, is like placing a mark on the horizon; it acts as a reminder that as changes occur over time, we are moving toward a desirable but distant future. Developing long-term metrics and milestones is critical to helping us measure whether we are making progress over time toward this vision.

Resilience is just one approach of many

Resilience has enabled the creation of tools and frameworks that allow practitioners, governments, and businesses to envision, articulate, and design new pathways toward a future that is capable of withstanding shocks across systems while maintaining the same level of functioning. But is resilience our end goal? Or is resilience just one concept among many that provides us with a framework to create meaningful change? Work on urban resilience has improved understanding of how our world operates. This has fostered interdisciplinary understanding of complex dynamics and the development of appropriate tools. It has supported recognition of the need for commitment, partnership, and iterative approaches to learning and development.

There are complex, interconnected systems that are transforming the nature of our world and the institutions and dynamics that govern human and natural



Synchrony in adaptive cycles: Part 2

The illustration above, while overly simplistic, represents how system dynamics can be aligned to build momentum and propel society toward a desirable future.

- Enabling/constraining institutions
- ← Projected pathways
- vision* Long-horizon goal

behavior. Man-made climate change is one example of how human behavior can not only shape our environment but also influence the way the environment behaves. While the development of man-made climate change may have been an unintended consequence of new technology and our dependence on fossil fuels, it has also revealed that our behaviors can have lasting and irreversible impacts on the nature of our world, creating forces that are seemingly out of our control.

Resilience versus transformation

The characteristics and dynamics that support the resilience of a system over time and space can become self-reinforcing. The paradigms that serve or hinder certain portions of society or the environment can become challenging or impossible to change. In these cases, dismantling a resilient system may be necessary in order to achieve a more desirable state; that is, transformation—not resilience building—may be required, as a steady, transitional change may not generate the rapid movement needed for society and the environment to avoid the continued impacts of, for example, climate change, conflict, and poverty traps.

Resilience works against rapid transformation in areas such as our energy supply. Our current energy system is highly diversified, with multiple self-reinforcing relationships; as a result, it is incredibly resilient. At present, the entire world relies, in some way or another, on fossil fuels for power. This means that change must occur at all scales of society. The resilience of the current energy system is precisely the reason it is so difficult to move away from our dependence on fossil fuels. Individuals, business models, and utilities must all change their practices and behaviors for this transformation to be successful. In the United States, improved efficiency in solar energy storage is causing the utilities—regulated monopolies—to change their business models in order to compete with an emerging market that threatens their business-as-usual practice system (Lovins & Rocky Mountain Institute, 2011). The emergence of new service providers and products is thus destabilizing an otherwise rigid and resilient system.

The limits of resilience

Resilience is often referred to as an idealistic, desirable state, but it is simply an attribute of a system. Resilience can characterize strongly self-reinforcing but very undesirable characteristics. They might, for example, conflict with the values and vision of a city, exploit human and natural resources, or marginalize and discriminate against people due to cultural, political, or gender classifications. In such cases, rather than increasing resilience, approaches that seek to transform these systems are more appropriate.

Sometimes the aspects of a system responsible for its resilience and survival can also lead to its collapse. This is the case with a viral contagion, where the interconnectedness of networks creates an optimal breeding ground for viruses and allows them to spread more rapidly. We saw this in 2014 with the Ebola outbreak. As people fell ill, family members and neighbors came to the aid of the sick and dying and became infected themselves. Relationships and social networks are critical to the resiliency of a community, but in this situation they accelerated the outbreak that has taken approximately 10,700 lives as of April 2015 (World Health Organization, 2015).

Situations can be highly resilient but also undesirable. For example, although the Kathmandu emergent water system is very resilient (modular, redundant, flexible, and diverse), it is undesirable because it excludes populations who cannot purchase and store their own water. Traditional water supplies like groundwater wells, stone taps, rivers, and streams have become polluted due to poor resource management and undeveloped urban services, such as a functioning sewage treatment and sanitation system. This leaves poor and marginalized households with few options to access potable water.

As these examples illustrate, the resilience of a system can at times be the enemy of the greater good. It can be used to promote the self-serving goals of a small subset of the population or serve only those populations who have a voice. Resilience can become the veil under which corruption and greed persist.

Conclusions

Resilience is an attribute of complex systems. It describes how those systems respond to disruption—the degree to which they “bounce back” or “bounce forward” or otherwise respond. As such, it’s inherently neutral. It’s also separate from the values we bring to a system—whether the relative resilience of that system reproduces and maintains desirable or undesirable social, psychological, environmental, or other characteristics.

From a scientific perspective, resilience is just a characteristic of systems. It’s like turbulence in water, the hardness of stone, or the flexibility of a willow branch. Turbulence, hardness, and flexibility all describe the nature of something—they don’t imply whether the thing is “good” or “bad.” In a similar manner, we shouldn’t imbue resilience itself with a “positivist” twist or a “negativist” twist. It just “is.”

Resilience has positive effects when it helps us maintain conditions we value or supports our ethical objectives; it has negative effects when it contributes to the maintenance of system characteristics that are undesirable relative to our values, ethics, and so on. In public usage, *resilience* often has a positive connotation because of its association with personal characteristics and the ability to cope with adversity. This connotation is not, however, inherent to the meaning of the term when it is used to describe attributes of complex systems, such as urban areas.

The social characteristics and visions society develops for urban areas are, however, dictated by value systems that may or may not be shared by all people. Thus, care must be taken to ensure we build resilience only in systems that reflect a broad base of shared social values. Such values are not necessarily well reflected in resilience concepts alone. Explicit statements of values are consequently important *in addition* to an understanding of resilience to prevent intentional or haphazard efforts from initiating new behaviors that may lead a

city, a nation, or the world down an undesirable path. Inclusive visioning and transparent dialogues may help to prevent such scenarios.

Scientific understanding of complex system dynamics and the factors that generate resilience are separate from the values and ethics that should inform how such understanding is utilized. To initiate intentional, ethical designs for a more resilient, equitable, and sustainable future, clear statements of values and objectives need to be explicitly embedded into resilience thinking.

In this publication we have shared an at-a-glance introduction to the concept of resilience and the complex system dynamics that it results from. We believe that an understanding of resilience will empower us with the tools and understanding necessary to catalyze change in our world today. However, this is just one approach to seeing and understanding the complex dynamics that control our world. It is up to society as a whole to decide what values and ethics we want to protect and manifest in our future.

More materials from the Resilience Narratives team can be found at www.i-s-e-t.org/beyondresilience

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