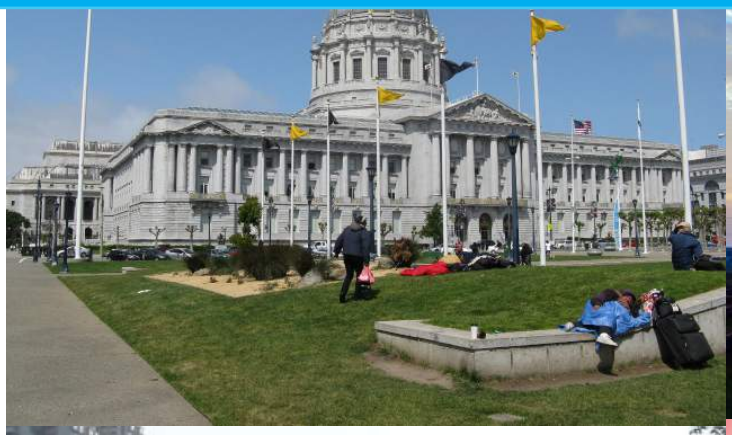
UNDERSTANDING THE URBAN ENVIRONMENT

Conceptualizing Urban Resilience and Stability through the GENETICS Framework



Capstone Project Report
Columbia University School of International and Public Affairs

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Conceptualizing Urban Resilience and Stability through the GENETICS Framework

Capstone Project Report
Columbia University School of International and Public Affairs
Course Number: SIPA U9000_035

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Abstract

Global urbanization is occurring at an increasing rate, creating cities with unprecedented population density, size, scale, and population totals that were nearly unimaginable just a century ago. Cities are home to some of the most vulnerable systems that large proportions of the global population rely upon, such as water and sanitation limitations, as well as the site of new and increasingly critical factors such as enhanced internet-connectivity and profound electrical dependency. At some point, these new population centers will likely experience crises that demand outside involvement. The United States military is uniquely situated as well as expected to assist in these crises and respond to future conflicts.

As such, it is critical that planners have a framework that can be applied when evaluating urban environments from which they may draw reasonable conclusions regarding decision-making. Existing DoD frameworks (i.e. PMESII-PT and ASCOPE) for analyzing and understanding current city environments are ill-suited to assess and evaluate the upcoming urban stability issues cities will be facing in the twenty-first century and beyond. This study highlights important factors affecting the stability of future cities, acknowledges the inability to bypass, surround, or ignore them as part of a larger conflict, and emphasizes the growing importance of human dynamics and people's expectations regarding urban situations and contexts. Dense urban environments are the hubs of technological opportunities and complications, increasingly interconnected international relations, and other significant risks and opportunities that impact and threaten urban stability.

The study offers a process to evaluates a city's stability through ACE dimensions - adaptive capacity, coping capacity, and expectancy benchmarks - and introduces a tool providing a visualization of our GENETICS criteria - Governance, Economics, Natural Environment, Energy, Technology and Communication, Culture, and Security - within an overall framework that is applicable to any large urban center, and that provides planners and decision-makers the ability to make informed decisions regarding urban stability.

Acknowledgements

Before we begin, we would like to recognize a number of crucial groups and individuals without whom this project would not have taken place.

We would like to thank Columbia University's School of International and Public Affairs, and the United States Military Academy West Point's Department of Geography and Environmental Engineering (GENE), for putting together a project that allowed us to explore this exciting topic.

We would also like to thank our project advisor, COL(R) Patrick J. Mahaney, Jr., for his leadership, advice, and encouragement throughout the project, as well as the GENE faculty who supported us throuhgout this project, in particular Dr. Amy Richmond and Dr. Richard Woefel for their participation and collaboration at various stages of the project along the way.

We also extend our gratitude to all our respective friends and families for supporting us through this process, particularly as we grappled with transitioning to remote work across multiple time zones due to the coronavirus pandemic occurring during the same semester as this project.

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Executive Summary

The increasing urbanization of the world's population is creating cities with unprecedented population density, size, and populations. As people crowd into these increasingly complex environments, it becomes inevitable that catastrophes will occur that stress the ability of these cities to their breaking point. Although major urban environments vary in a multitude of ways, their relative importance in regards to the economy, culture, and political structure of nations means that urban stability increasingly represents national stability. These cities all face unique difficulties and vulnerabilities that will be inevitably tested in a variety of fashions in the coming years. Whether a result of some natural disaster or as a result of war, these trials will represent some of the most important events for the United States Government and Military to properly analyze and respond to in order maintain urban stability.

Understanding this need for analysis, the United States Military Academy at West Point's Department of Geography and Environmental Engineering requested a project to explore the future urban environment from a resiliency perspective. What factors make the increasingly large cities of the future unique? What factors define and impact the resilience and stability of these urban environments? The project also called for development of a metric and visual resource to help explore and understand urban stability in a diverse range of urban environments. In response to this request, the GENETICS (Governance, Economic, Natural Environment, Energy, Technology and Communication, Infrastructure, Culture, and Security) Framework has been designed in order to help answer the pressing questions regarding how to focus resources and analyze risk in a dense urban environment.

Currently, the U.S. Army has several tools for approaching this topic, such as the ubiquitous PMESII-PT (Political, Military, Economic, Social, Information, Infrastructure, Physical environment, Time) and ASCOPE (Areas, Structures, Capabilities, Organizations, People, Events). Although useful in some context, these tools fall short of capturing the significance of these large cities and dense urban environments, and instead provide only a rough framework to list basic characteristics of an urban environment or region. The GENETICS framework moves beyond this attempt simply listing the general characteristics of a city, instead focusing on a systematic understanding of the unique underlying factors of a large urban environment that can make or break the ability of a city to respond to crisis. (See Appendix A for additional analysis on comparing the GENETICS framework with existing DOD methods)

Each factor defined in the GENETICS framework helps a policymaker or analyst understand the unique features that exist within the major urban environments of the future. The tool is not meant to be predictive, nor an exhaustive list of every possible factor that can potentially affect urban stability. Instead, it is designed as a system to encourage focusing upon the key metrics that have demonstrated the ability to influence urban stability as previously identified in previous examinations into the matter. In this study, each of these factors are defined and then assessed by three primary resilience dimensions – Adaptive Capacity, Coping Capacity, and Expectancy Benchmarks – which are populated by criteria and metrics that can help define whether these concepts are positively, neutrally, or negatively impacting Urban Stability. As every city and urban environment is different, this tool does not make an attempt to rank or compare cities; efforts to create this type of comparison exist in other publications and resources, but they do not necessarily help understand specific contextual factors that influence stability. Instead, it is designed to rapidly understand the factors influencing urban stability that have potential impacts on the severity of a stress or crisis. This tool refocuses the conversation around cities to the most critical factors, and will help make more informed, practical decisions in response to crises in the future.

We explore the GENETICS framework below; each factor is summarized in order to provide a reference for the overall structure of the framework. Factors are not inherently mutually exclusive; some concepts and areas of stability see mention in multiple factors. We find this to be a strength of the framework, as it highlights the interconnected nature of many of these concepts; a force moving in one direction does not influence each factor individually. In order to help shape this framework, we conducted an extensive literary review, which provided a significant amount of the background material that helped shape what each factor is composed of.

Additionally, in the full study, we highlight three primary weaknesses in existing resilience literature that we believe the GENETICS framework addresses: inconsistent usage and definition of terms such as resilience, a pervasive belief that increased density in urban environments is objectively and inherently beneficial in most, if not all, sectors, and a lack of city-specific context.

GOVERNANCE

Governance, both formal and informal, determines most of the day-to-day operations within an urban environment. Governing institutions dictate necessary policy and operations that contribute to ongoing cohesion of the city environment and its resiliency to potential shocks or stressors, and often act as the first point of contact for intervention forces. For this reason it is extremely important to assess all levels of relevant governance as a factor of a city's stability. However, it is important to consider aspects of governance beyond those limited to the city environment. For this reason, the specific criteria of governance examined in this study are municipal governance, provincial governance, national governance, and international presence. These criteria track, where relevant, each of the effective government levels within a city, assessed based on outcome oriented metrics like autonomy, authority, and experience. Based on the specific situation of the city, the circumstances described by these metrics can have a differing impact on adaptive capacity, coping capacity, expectancy benchmark, and therefore the overall impact on stability as a result of governance.

ECONOMICS

Economic factors dictate numerous aspects of a city's urban stability in the face of crises. A well-functioning economic system allows cities to cope and react to external and internal changes. Economic resilience reflects the ability to relocate or provide resources to those in need, thereby maintaining urban stability and preventing chaos. This study looks at four specific economic criterias: fundamental economic structure, market connectivity, financial stability, and informality and how those criterias contribute to a city's stability. The study assesses adaptive capacity from the diversity of economic activities and the credibility of the financial market, coping capacity from the personal and government income management, and expectancy benchmark from the economic expectation of people within society.

NATURAL ENVIRONMENT

Urban environments are intrinsically tied to the environmental and geographic factors that comprise their surroundings. The fact that the stability and design of the urban environment relies heavily upon the gifts and curses that the natural environment bestows upon them creates an imperfect relationship between man and nature. This study evaluates this relationship through the dimensions of adaptive capacity - the form, flexibility, and awareness of the urban population, coping capacity - the threats an urban environment faces in both the short and long term from environmental threats and stresses, and expectancy benchmark - the capacity to respond to natural hazards in a manner compatible with the expectations of the citizenry.

ENERGY

The networks that support energy flow are critical to the daily functions of all things within a city. Without functioning energy systems, other infrastructure systems, such as transportation, water, logistics, and information and communications technology, do not operate, and daily life looks drastically different. This study assesses energy system adaptive capacity as a function of supply modernization, network flexibility, and demand responsiveness, coping capacity as a function of supply diversity, supply responsiveness, supply robustness, demand efficiency, and network protection and maintenance, and expectancy benchmarks as a concept that identifies the minimum threshold of energy services expected by a collective urban population to maintain a standard of living.

TECHNOLOGY AND COMMUNICATIONS

Technology and communication are essential components of modern urban life. Technology development and media platforms shape people's lifestyles and attitudes towards information and society at large, thereby, in a sense, controlling how many citizens feel and speak about urban stability concerns. Meanwhile, increasing technological development and reliance have caused conflicts and raised new issues for urban stability. We emphasize the need to consider strategies to maximize the use of technology and communication in order to prepare for and mitigate possible conflicts and crises. We evaluate adaptive capacity from perspectives of policy making efficiency and social awareness, and coping capacity from prediction, preparation, and community response. The expectancy benchmark is assessed by overall technology and infrastructure development, citizen participation, and governing capacity.

INFRASTRUCTURE

Cities are often most identified by being centers of public infrastructure, the places where dozens of highways, bridges, tunnels, railways, utility lines, and airports converge. Millions of people depend on infrastructure to work for them, to facilitate commutes, to transport goods for sale, to keep homes and businesses clean, and to enable social connections. Infrastructure strengthens cities, grows economies, and improves quality of life. However, a lot of infrastructure is by definition fixed in place. This compromises its ability to be flexible and adaptive to crises. Certain shocks or stresses can also compromise the functionality of the infrastructure, causing instability and severing economic and social links within the city. The extent to which a city's infrastructure may be a source of strength or a detractor to stability will depend significantly on the crisis itself, as well as the location of the crisis relative to key infrastructure assets.

CULTURE AND SOCIETY

Differences in cultural background and social systems cause different reactions and create different problems when cities are faced with potential instability. In this study, we divide cultural and social factors into four criteria. Education and knowledge capacity are used to measure adaptive capacity. This analysis uses six sets of metrics including education level of cities, capacity of a city's education system, public access to knowledge, disaster prevention education to the public, disaster prevention education in school and professional talent reserve. Community support and health care are used as two criteria to measure coping capacity. In community support, our analysis includes disabled citizens protection, female citizens protection, children protection, elder protection, family support and ethic groups. In health care, health risk prevention, health care resources and emergency health care capacity are the main sets of metrics. Identity and culture criteria, meanwhile, are used to evaluate the expectancy benchmark. The benchmark considers three sets of metrics: traditional activities, cohesive identity and religion.

SECURITY

Maintaining security in a large city is an implicit but often overlooked component of urban stability. A lack of security can have deleterious effects on other stability factors and impede their respective abilities to contribute to stability, just as an overemphasis or overreliance on security can negatively affect the city's population and lead to acts of willful disobedience. While the range of elements that can constitute security in this context are expansive, this study focuses on four general criteria of: Military Forces, Non-Military Forces, Violence Potential, and Securing the Environment. Although the former two criteria represent more concrete and definitive elements of security that are occasionally covered by other studies, the latter two criteria encompass the elements that are somewhat unique to large cities, such as how a dense and confined population can lead to dramatic escalations of insecurity and instability, but also how it may contain extraneous elements that further hinder or support a secure environment. Collectively, these four criteria give insight into the specific security situation of the city and help refine policy and decision-makers focus.

CASE STUDIES

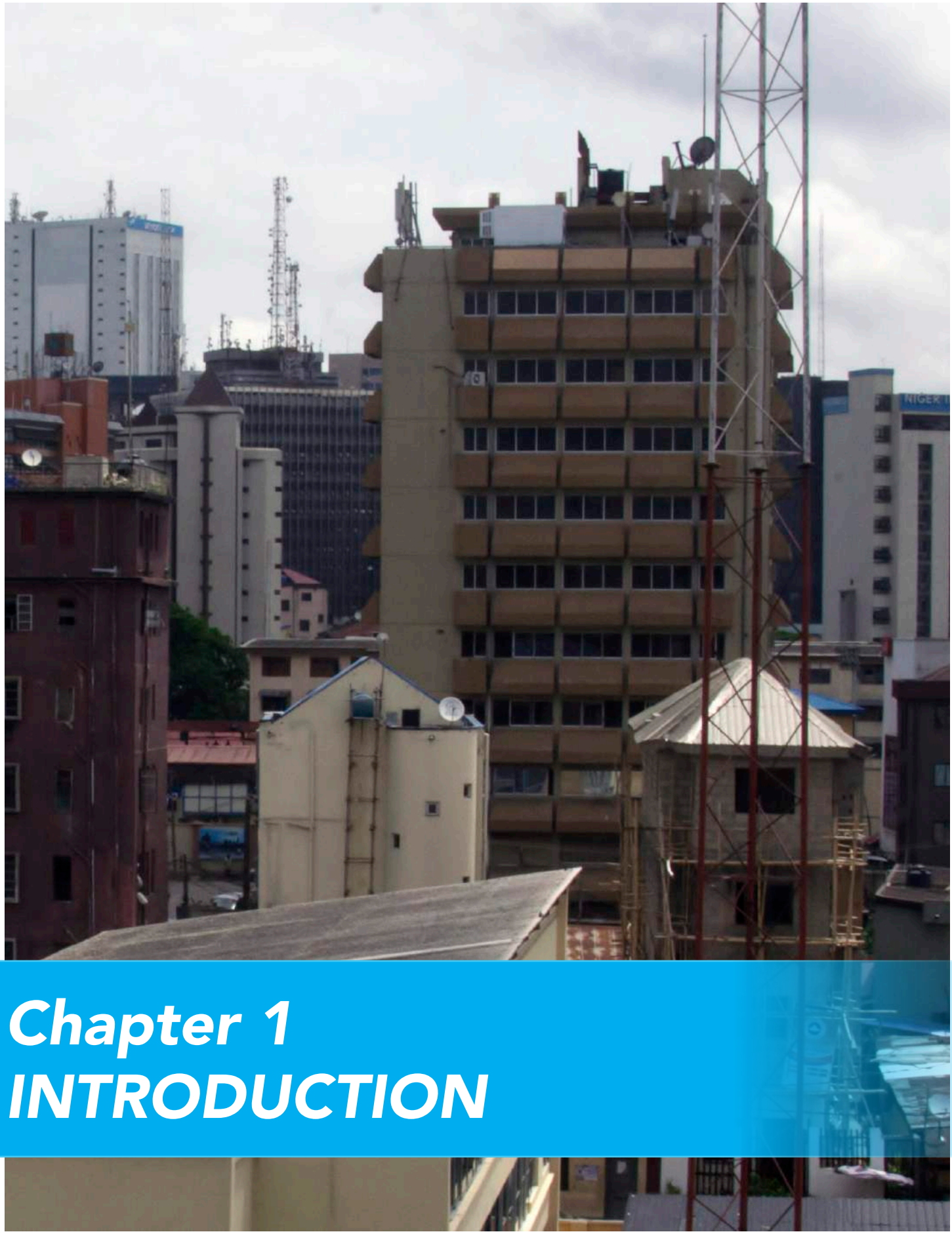
The factors mentioned above each play into and influence the critical events that influence and control urban stability. In order to evaluate these factors beyond the theoretical, we apply the GENETICS framework, and the associated ACE dimensions, to two case studies.

We first look at Hurricane Sandy, a devastating hurricane that struck New York City in 2012. We analyze the events before and after the hurricane in order to understand how each factor influenced stability; fortunately, New York City enjoyed a primarily positive response to the devastation wrought. We note the strong adaptive and coping capacity of the city, especially within the governance, security, and technology factors, while also noting that out-dated infrastructure, vulnerable energy systems, and natural environmental conditions created a city that could have potentially seen much worse consequences. We are confident that the GENETICS framework, when looking at potential natural disaster events in the future, can help target funds and priorities to specific urban stability factors.

We then look at the Umbrella Movement, a pro-democracy protest that occurred in Hong Kong in 2014. We explore why the movement occurred in the way that it did, and how culture, security, and governance especially created a movement that did not result in urban stability collapsing; Hong Kong remained operating and stable throughout. We consider the benefits and vulnerabilities of Hong Kong's unique political, cultural, environmental, and economic structure, and how this both played into the formation of the movement as well as the non-violent strategies undertaken by the protestors. Finally, we note the new social media and interconnected world, and how these communication systems can be both a benefit and a vulnerability for maintaining social order.

CONCLUSION

We conclude with the fact that the world is urbanizing at an increasing rate; conflicts, crises, disasters, and stresses to humanity will continue to occur most frequently in these large urban areas. Understanding the factors that contribute to urban stability will be key for any practitioner of policy, whether that be military or not. We have demonstrated a flexible, comprehensive framework in GENETICS that can be adapted and utilized in most contexts, and we believe that it will help anyone working within the field of urban stability prioritize issues, ask the right questions, and identify problems before they can destabilize the urban environment.



Chapter 1
INTRODUCTION

Introduction

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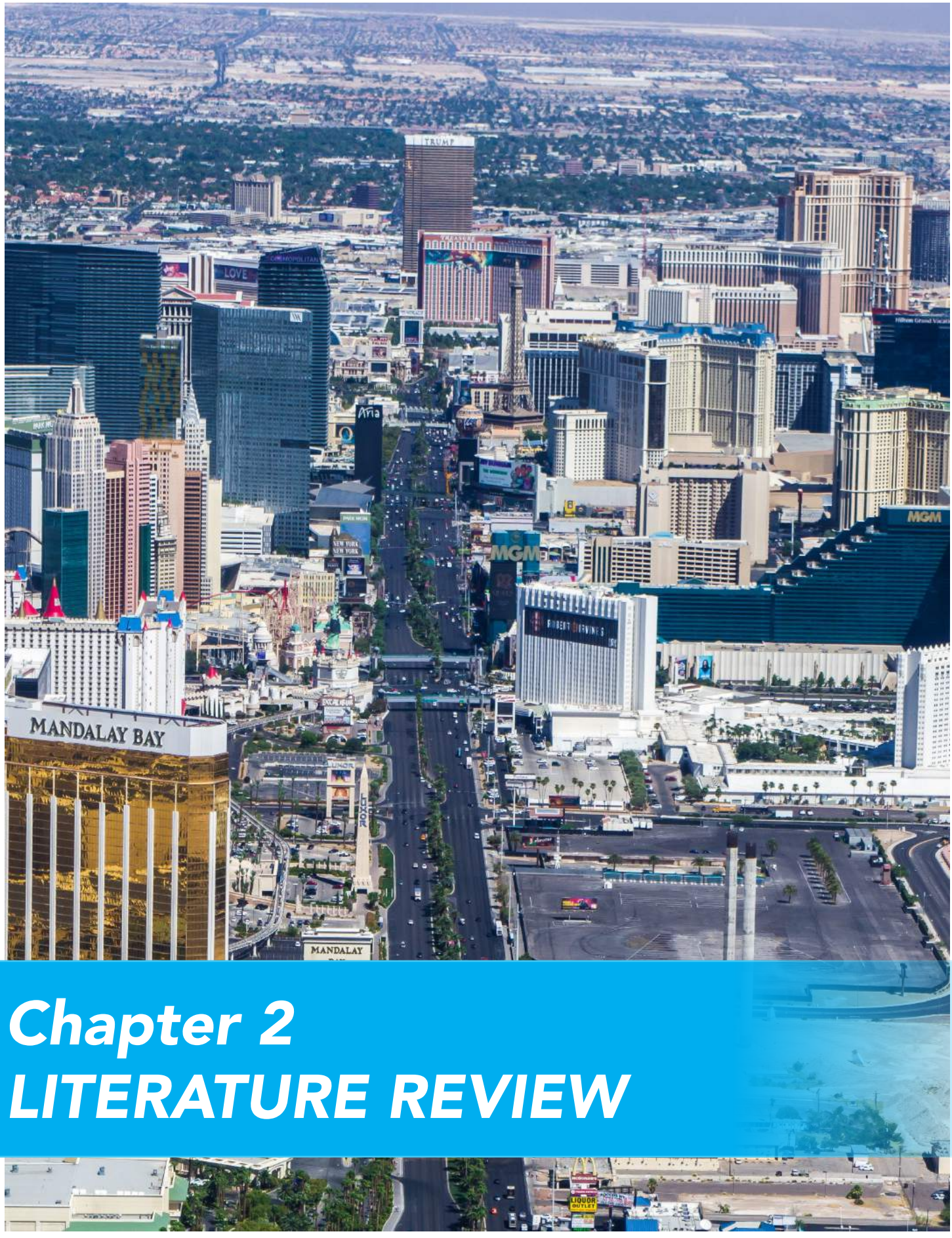

Chapter 2
LITERATURE REVIEW

Over the last decade, numerous commercial, non-profit, and academic organizations have published a wide range of material related to several of the factors critical to this project. In particular, the concept of city resilience received extensive attention, particularly looking at the effects of climate change and increased urbanization and how they impact the resilience of a city. As we will demonstrate in the following sections, there is a broad range of what these studies include in resilience, or even in the basic definition of what resilience means for a city. Though each had their own strengths and weaknesses, none quite captured the concept of stability that concerned this project, nor did any tailor the results to our specific target audience. Given these circumstances, and to better understand the foundations of the project, what follows is a synopsis of key studies and themes as well as a consolidation of some key terminology that informed our analysis.

Theme 1: Multiple Definitions of Resilience and Resilience Indicators

Our initial research into the concept of urban resilience began with an assessment of the literature produced by the United Nations (UN), and then expanded to include a variety of academic papers and tools for practitioners. One of our first takeaways was about how the term resilience was used: there were multiple definitions throughout the literature and that this resulted in many different methods for evaluating what was to be included in resilience metrics. Below are highlights of the literature's multiple definitions of resilience, which ultimately forced us to ask the following question: how could we contribute to the resilience concept without further complicating the term? We concluded that the concept of city resilience needed to be reframed to encompass all of these aspects, but in a clearer way. As we outline in the Definitions section, we shift the narrative from city resilience to city stability and add supporting definitions to that concept accordingly.

The UN, as part of the Millenium Development Goals and other concurrent efforts, has produced tools like the UN City Profiling Tool and the UN Resilient City Handbook for Government Leaders and has sponsored supporting research through the United Nations University Centre for Policy Research (UNU CPR) to develop urban resilience concepts. Before assessing these more modern tools, we first sought to understand the historical context. The origin of the use of the term resilience is typically attributed to ecologist C.S. Holling, who in 1973 defined resilience as an ecosystem's ability to maintain basic functional characteristics in the face of disturbances.[1] Recognizing ecosystems have multiple stable states and are constantly changing, Holling later distinguished between static "engineering" resilience, which referred to a system's ability to return, or bounce back, to its previous state, and a dynamic "ecological" resilience, which focused on how a system maintained key functions when perturbed.[2] As the urban resilience concept has gained popularity, the concept has morphed, so we turn our focus to assess these evolving definitions to outline how we elected to build our framework.

An October 2016 Working Paper for the UNU CPR introduced the concept of a city's resilience and vulnerability as "parallel and interconnected concepts" that could complement each other to fill research gaps. The authors emphasize a distinction between resilience and vulnerability in the literature, with resilience representing the key factors that enable "a city to maintain its core functions in the wake of shocks and stresses," while vulnerabilities are the the "key risks that when realized can lead to the instability of a city to fulfill its core functions."[3] Resilience is further defined "as a means of preventing, recovering from, and adapting to human and naturally induced threats while maintaining core functions."[4] With this understanding of resilience, the authors derive the following

resilience factors: effective policing and judicial mechanisms, social cohesion, microeconomic security and social protection, social networks and social support, greater income and social equality, strong community-government and intergovernmental cooperation, and the provision of basic services.[5]

A second UNU CPR publication from December 2016 further reviews the literature and highlights the multitude of evolutions of the term resilience: from a term that implies a return to a pre-crisis status quo to recognizing the new equilibrium following a shock or stress could result in a new, and sometimes improved, status.[6] This idea of returning to an improved status following a stress or shock is echoed elsewhere, most notably by Nassim Nicholas Taleb in technical papers as well as his book regarding the concept, Antifragile.[7,8] In evaluating the various frameworks that assess resilience in fragile cities, Table 2.1 summarizes the various categories and their overarching domains.

DOMAINS	SYNONYMS OR SUB-CATEGORIES
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, Organized Governmental Services, Coastal Resource Management, Warning and Evacuation, Emergency Response, Disaster Recovery
Physical	Physical Infrastructure, Infrastructural , Land Use and Structural Design
Natural	Ecosystem

Fig. 2.1 Domains and their synonyms or sub-categories of community disaster resilience[9]

Of the many definitions of resilience, a review of the efforts of the UN's Office for Disaster Risk Reduction (UNDRR, formerly the UN International Strategy for Disaster Reduction - UNISDR) produced a framework that conceptualized resilience as a function of supporting components, instead of a standalone endstate. In a 2014 article assessing the UNISDR's "Making Cities Resilient" campaign, resilience is defined as a function of resistance, coping capacity, recovery, and adaptive capacity, and defines those components as summarized in Figure 2.3. We incorporate and adapt some of these definitions in our framework, as outlined in our Definitions and Methodology sections.

Another important distinction regarding urban resilience lies not in the term resilience, but in the understanding the urban system, how that system's equilibrium is defined (for who, by who, over what period of time, etc), how it adapts, and how to understand the dynamics of the city as a bounded system or even an ecosystem.[11,12,13] Following a robust analysis of the literature around these concepts, authors Sara Meerow, Joshua P. Newell, and Melissa Stults derive the following definition of resilience:

Urban resilience refers to the ability of an urban system-and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales-to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity.[14]

To highlight their systems-oriented approach to conceptualizing an urban space, the authors include the following schematic, which we found informative to the development of our own framework and is shown below in Figure 2.2.

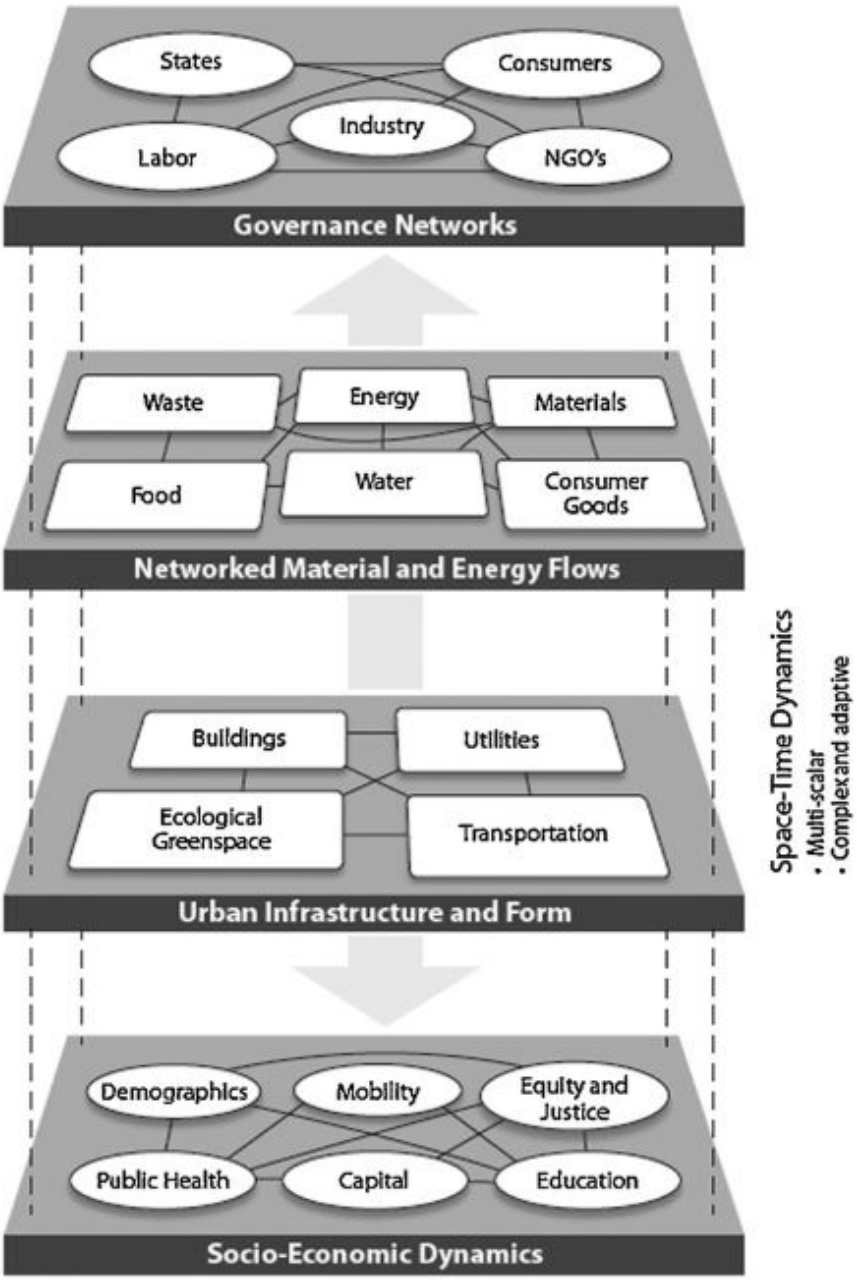

Fig 2.2 A simplified conceptual schematic of the urban 'system' [15]

DOMAINS	SYNONYMS OR SUB-CATEGORIES
Resistance	The ability to reduce or avoid the impact of a hazard. It includes construction of risk-reducing infrastructures, risk-sensitive construction practices and land development, accurate forecasting, early warning, and evacuation strategies.
Coping capacity	The ability of a city to avoid irreparable damage to the urban system from which it is unable to recover. A city with high coping capacity will experience hazard impact but it is able to continue normal functioning within a short period of time, without permanent damage to livelihoods, health or well-being.
Recovery	The period of reconstruction and rehabilitation following a disaster that is closely tied to coping capacity. Recovery is facilitated by the strength of local economies and the diversification of livelihoods.
Adaptive capacity	This is needed to ensure that past mistakes are not repeated and that cities can be flexible to changing conditions, by making changes to current policy and practice in order to improve resilience for the future

Fig. 2.3 Resilience = Resistance + Coping Capacity + Recovery + Adaptive Capacity[10]

Theme 2: The Competing Value of Density

Increasing urban density and the promotion of dense urban growth have been popular goals for many involved in urban planning and resilience planning, citing the quantifiable benefits of dense urban living. Compact cities are often cited to have lower per capita energy use,[16] healthier citizens, a stronger economy, operate more efficiently, and have stronger cultural dynamics.[17] The UN in particular often promotes urban density, stating that cities should maintain a density of "at least 15,000 people per km",2 due to more efficient land use, reduced public service cost, support for community service, social equity, reduced car dependency, and the ability to have more open spaces.[18]

This is certainly a reasonable argument; we do not intend to argue that dense urban environments are in fact a negative for urban health and resilience, nor do we argue that the increasing rate of urbanization must be avoided.[19] However, we do take issue with the assumption that is often made in urban planning that urban density is inherently positive, and that increasing density is an objectively correct decision in all urban situations.

Understanding that density can result in increased destruction and instability is a key issue we focus on from a variety of perspectives in our analysis. The most obvious concern regards the fact that more human life is at risk in denser environments; security operations and recovery efforts are made more difficult by every additional person and structure in an urban environment. Dense urban environments are often more reliant on infrastructure, technology, and transmission lines that may fail in times of crisis, creating large, unstable populations. To state it simply, the more people in any given area, the more lives are at risk in times of instability. Therefore, greater density can result in a higher risk of destabilization, and a greater loss of life potential in the face of disaster.

In this analysis, we acknowledge the fact that density can work against urban resilience in certain contexts. Additionally, we highlight specific cases where density works against efforts to stabilize after disruptions. While we do not seek to discourage dense urban growth, and fully acknowledge the variety of benefits dense growth confer upon a city, we find it important that the risks and dangers of urban density be more carefully explored when considering how best to promote and increase urban stability.

Theme 3: A City-Specific Context gap

Measuring a city's resilience is one of the primary pursuits of the resilience literature, and given the wide range of definitions, there's a similarly wide range measurement techniques. Some tools take a framework and apply it to cities across the globe, ultimately seeking to score a city on some sort of resilience scale.

In addition to the previously discussed studies, some examples include the 100 Resilient Cities Measurement Guide[20], the Grosvenor Resilient Cities Report[21], Swiss RE's Mind the Risk report[22], the UN City Profiling Tool[23], or the Food-Energy-Water (FEW) Nexus City Index.[24] While very useful in their own ways, we noticed these macro-level, top-down tools failed to truly account for the unique characteristics of different cities. We recognize the importance of being able to rank and compare cities in many settings, but elected to shift our focus on better understanding each city in its own context instead of creating a tool that could compare cities. Additionally, many of these evaluative tools are proprietary, so while they are informative to the overall project, we cannot simply import their data or methodologies into a military framework.

Understanding each city's identity before assessing its resilience is something we found important, but we could only glean limited indications of how we could do this from the literature. Our first lead was the Resilience Alliance's Measurement Framework. The Resilience Alliance (RA) is an international, multidisciplinary research organization that explores the dynamics of social-ecological systems, predominantly focused on building on Holling's work.[25,26] This framework uniquely introduced the concept of thresholds and tipping points within the urban system.

Building on this systems-oriented approach, a review of Complex Adaptive Systems (CAS) theory further introduced the value of understanding a social system's identity and the formation of this identity.[27] The creation of identity is known as schemata, which includes variables of identity, internal rules, and the perception of the external environment and rules of coevolving in this environment.[28] The majority of the contemporary urban resilience literature only refers to perceptions or expectations when discussing security,[29,30,31] social cohesion,[32,33] or environmental regime shifts,[34] which our team found inherently limiting.

We elected to close these two gaps in our project by developing a tool that would evaluate each city in its own context without ranking it against others, and applying the concept of a city's identity through an evaluation of expectations into each of our stability factors, as we further outline in our Definitions and Methodology sections and then apply in throughout the rest of the study.

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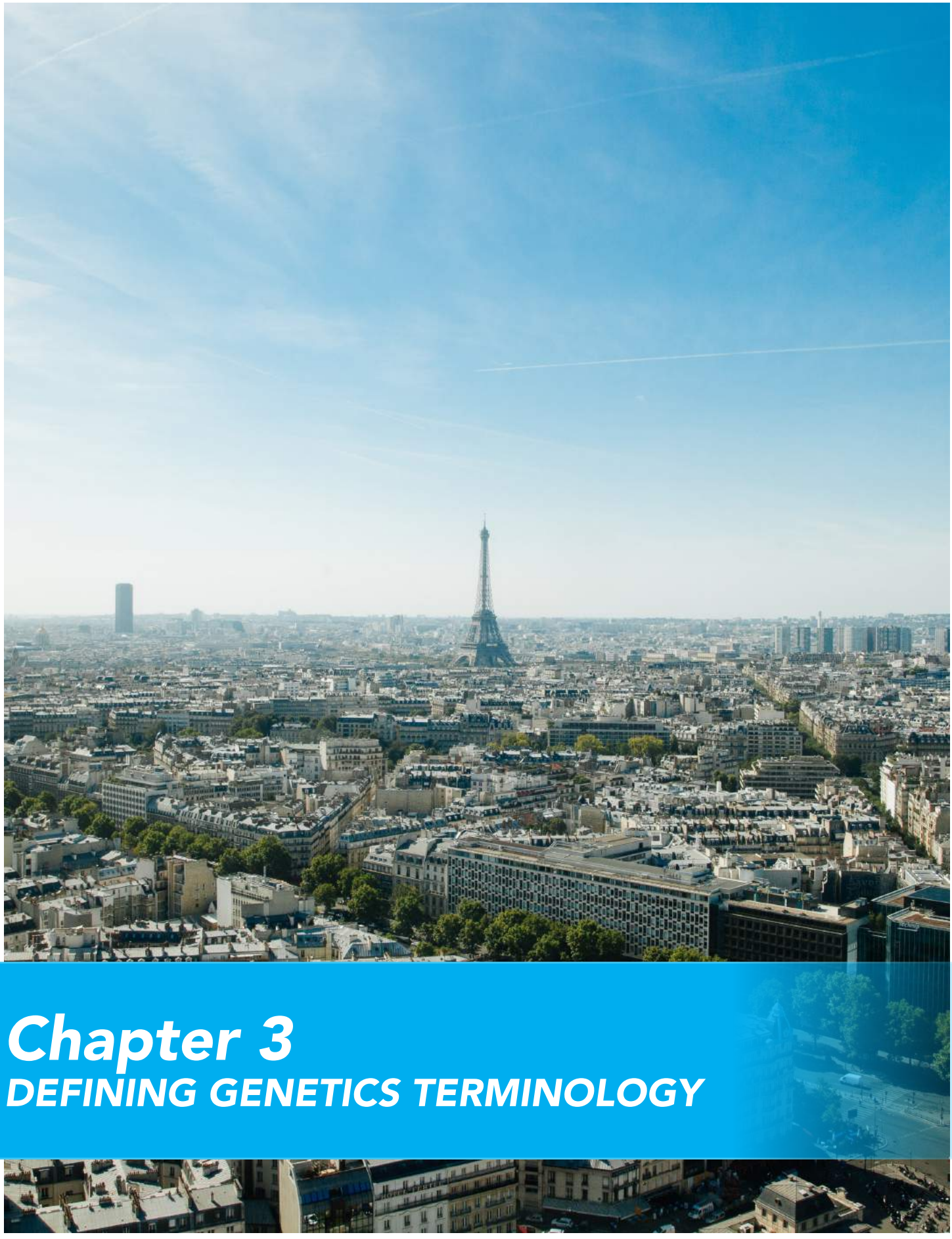

Chapter 3
DEFINING GENETICS TERMINOLOGY

TERMINOLOGY

Building on the introduction of various resiliency terms and concepts, and acknowledging the many other remaining but unmentioned competing definitions, we attempt to consolidate and clarify our own unique terminology that will be consistently used for the remainder of this study in order to mitigate varied perspectives, interpretations, and unclear terminology. Within this study, we introduce the overarching critical term Urban Stability for our own use that combines some of the stronger concepts from previous studies along with new ideas that collectively form a more comprehensive measure of how cities are able to respond to disruption. As we define this term as a function of several not-yet-introduced concepts themselves, our formal definition will follow at the conclusion of this section.

For clarity's sake when defining some key terms used in this study, it is worth revisiting the various resilience definitions previously mentioned, defined specifically as the "ability of a city to avoid or bounce back from an adverse event,"[1] a community's ability to demonstrate a "rapid return from a disturbance,"[2] and "the ability of groups or communities to cope with external stresses and disturbances as a result of social, political, and environmental change."[3] Each of these definitions are valid ways of applying more general resilience definitions to that of an urban environment; however, the use of resilience implies a return to some original state that limits potential outcomes that this study incorporates. With this limitation in mind, we use the UNISDR definition of Coping Capacity – "the ability of a city to avoid irreparable damage from which it is unable to recover,"[4] as a more appropriate foundational term as it continues the idea of a city's ability to resist a disturbance without necessarily measuring that resistance[5] relative to the original state while furthering the stability concept we wish to build. This leaves open the idea of a new state, wherein the city has been degraded permanently, or perhaps elevated to a higher form of normalcy – such as New York City after the catastrophic attacks on September 11th, 2001.

Further building on this foundation, the concept of a Coping Capacity is more effective when augmented with another UNISDR term – Adaptive Capacity, defined as "the ability to plan, prepare for, facilitate, and implement adaptation options," typically targeted towards unanticipated threat.[6] Whereas Coping Capacity refers to the ability of the city to resist a disruption, Adaptive Capacity refers to its ability to change, either as a preemptive measure to mitigate disruption or as a consequence of it. Together, these two terms highlight the ruggedness of a city to handle whatever it comes its way in a largely tangible and measurable fashion, as well as its flexibility to make the corrections needed to continuously put itself on its best footing.

At this point we move away from solely using UNISDR terms, and while some studies move on to detailed explorations of the nuances of just these two concepts in various guises, this study advocates for an additional concept that incorporates an often overlooked critical component of any city – and perhaps more so to larger, denser cities that this study focuses on: Expectancy Benchmark. We define this term as "the collective belief of the urban population of the city's ability to maintain a standard of living within a certain range in response to disturbances." Though highly intangible and impossible to measure precisely, Expectancy Benchmark highlights that within any city, the population has certain expectations as a product of shared experiences, culture, history, and circumstances. These experiences create an expectation of a certain quality or standard of life that life will continue through disruptions until the city recovers or stabilizes at a new equilibrium. For example, in an already impoverished, large urban-sprawl in a developing metropolis, the Expectancy Benchmark may be that, after a disruption, standards-of-living will diminish for a significant period of time. Having lived a meager existence with little support from the government or

access to basic infrastructure, these people's expectations remain relatively unchanged as they were already exceedingly low. This contrasts with that of a population in a much more modern and prosperous city, whereby the expectation may be that a relatively similar standard-of-living returns almost immediately, and lacking this return, animosity and unhappiness quickly follow.

As a result of these ideas and terms, we now define Urban Stability as the overarching concept we wish to measure, defined specifically by the three dimensions: Adaptive Capacity, Coping Capacity, and Expectancy Benchmark. Thus, Urban Stability is a measure of a city to maintain order and governance of the population without devolving into lawlessness and chaos.

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Chapter 4
GENETICS METHODOLOGY

The overall goal of this study is to determine the Urban Stability of a large city in such a way that a decision-maker is able to quickly determine what components need additional consideration or concern when evaluating a new city. As the large cities that are the focus of this report are inherently complex, we first take a broad deconstructive approach that separates the most important concepts we wish to highlight specifically into our three previously defined dimensions: Adaptive Capacity, Coping Capacity, and Expectancy Benchmark. These three dimensions are especially practical for the military practitioner as each relates to a common but distinct idea: that Adaptive Capacity generally relates to structural or policy changes that may require less physical resource support, Coping Capacity that relates more towards the tangible aspects of a city, and Expectancy Benchmark incorporates the often overlooked civilian and human element of a city.

With these three concepts at the forefront displayed with a visualization tool, a scoring mechanism is then supplied to a decision-maker who will be able to immediately assess a city's strengths and weaknesses, and thus where attention should be intuitively applied.

But just what is being scored? Providing an overall score for each of the dimensions did not provide much insight - just what would a high-scoring Coping Capacity mean, for example? To provide meaning for each, we break down each dimension into a list of Stability Factors that very much align with the components of other resilience studies as well as DOD frameworks. In fact, many of the eight Stability Factors are, on a surface level, identical to those in PMESII-PT (Social, Infrastructure, etc.). Beyond this superficial connection, however, the various Stability Factors deviate from their contemporaries. In this manner, when scores are applied to each of the three dimensions of the adaptive capacity, coping capacity, and expectancy benchmark, they specifically apply to one of the eight Stability Factors themselves.

Stability Factors

The stability factors were chosen by considering existing frameworks and academic studies, and noting concepts and issues that were frequently used as well as noting which concepts we felt were underdeveloped or entirely omitted. We believe the factors below constitute the fundamental parts of the urban system, and are most applicable to the largest of cities. Notably, we do not define a specific determinant on what constitutes an appropriately large city for this framework. Though there is no lower-bound limit, this framework was developed with the complications and considerations specific to extremely large cities in mind. Therefore, it is important to note that when attempting to apply this framework to mid-sized cities and below, many of the Stability Factors will be less present or less important, thus potentially reducing the framework's overall evaluative effectiveness

Within each factor, all three dimensions are separately evaluated using various methods of analysis, including micro-case studies, data analysis, and critical thinking, in order to evaluate the role each plays.

Listed in order, the eight Stability Factors provide a useful acronym: GENETICS.

G Governance
E Economics
N Natural Environment
E Energy
T Technology & Communication
I Infrastructure
C Culture
S Security

Using GENETICS provides a variety of benefits beyond just a helpful acronym. The word genetics associates the evaluation of large

cities and their stability with that of biology, just as previous resilience studies have made note of the similarities to how cities behave and relate to those of complex biological systems. Additionally, the GENETICS term provides an immediate distinction between this framework and its merits and those of other resilience studies. It also provides the acronym-friendly U.S. military with a comfortable term when determining which framework is more appropriate for their evaluations. For example, it would help when determining if the the more generalized PMESII/ASCOPE crosswalk is more appropriate than the new large city framework GENETICS.

Criteria

Using the same evaluative framework within each Stability Factor would be a fruitless exercise as the differences between each are large. Therefore, each factor is expanded individually in detail with its own respective criteria and metrics, where criteria provide the broader issues within each factor, while metrics provide a more granular option to evaluate them. Although there are ways to quantify portions of these criteria, this project instead uses categorical divisions, in keeping with the somewhat subjective nature that many of these factors demand. This brings the additional benefit of avoiding an overly complicated exercise in accounting for metrics individually and quantitatively, and also the suggestion that such a process is inherently linear and deterministic.

As an additional consideration, this categorical division and determination allow a Commander, decision-maker, or planner to use context-specific information, additional but unaccounted-for details, or wisdom from within each Stability Factor to adjust the overall scoring, if needed. Although this could potentially create situations where concerns may be artificially elevated or depressed to fit a larger narrative, this framework will force planners to "show their work" and question such actions, with data to back up suggestions and to resist such changes. Ultimately, though, these concerns can be overridden, and the decision-makers can exercise their inherent authority to conduct their operations as desired.

Scoring a Stability Factor

Each city around the world confronts a crisis from a different starting point of culture, development, and resources, making it challenging to give a thorough and objective quantitative assessment. Therefore, instead of scoring numerically, ranking and making comparisons between cities, this report focuses on the characteristics we deemed more significant. Despite the use of numerical scoring and weighting in many other resilience studies, we instead chose to maximize the benefits of our largely categorical approach and limit our outcomes to one of three options: Positive, Negative, or Neutral. These options are then applied to each of the three dimensions, collectively creating an ACE (Adaptive, Coping, Expectation) Score for each Stability Factor.

The result of this process, as seen below, is the ability for each criteria to contribute to the overall Stability Factor. This intuitively informs decision-makers and planners of the level of concern Security requires relative to other Stability Factors. For example, if Security was weighted as Negative overall while the other seven Stability Factors remained Positive or Neutral, naturally the outcome is directing a disproportionate amount of attention towards Security. Then, based on the Security criteria, it becomes clear where and why Security requires more attention, and thus can assist additional planning on how to mitigate and accommodate the issues that give rise to its elevated weighting.

As this study focuses on assessing cities as a collective unit, the final outcome is a measurement assessing just that – the city as a whole. Yet it must be acknowledged that, especially within the expectation measurement, the population is unlikely to be a homogenous, unitary collective of people. Although an overwhelming majority may exist that has a generally uniform set of expectations, fractional groups and minority groups may hold dramatically different expectations based on their unique circumstances and experiences. This consideration must be factored into the overall score, either solely through considerations of refined subset factors and assessments, or also through adjustment of the overall assessment of the Expectancy Benchmark itself.

Additionally, the expectation assessment may have other considerations to incorporate such as the frequency and severity of disruption; a frequently repeated disruption will likely have a significantly different Expectation Benchmark from that of an unexpected or unprecedented disruption. So too will it be the case for a severe disruption, where a substantial increase in the magnitude of a disruption, even though it may have precedence in a less severe manner, will also have a significant effect on the overall expectation score.

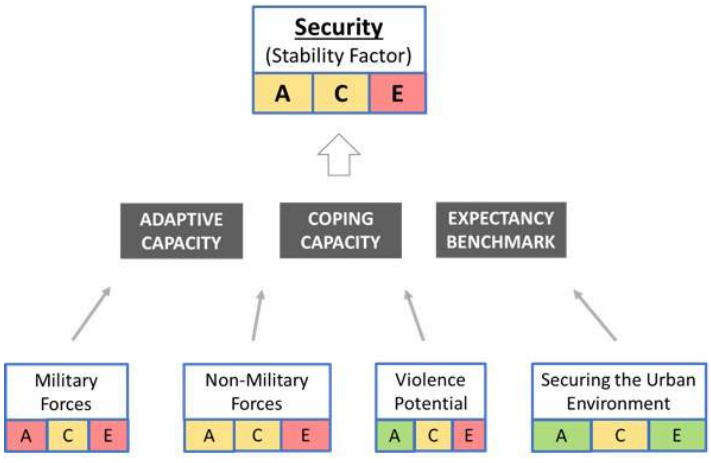

Fig. 4.1 A Potential Stability Factor outcome for Security

GENETICS Evaluation

With the evaluation of individual Stability Factors described, the overall GENETICS outcome must be determined. This will be summarized in a visualization showing the different levels of each capacity for quick reference, as shown in the example below.

The GENETICS visualization was constructed to provide an intuitive and immediate understanding of the analysis results. To provide an immediate understanding of the ACE scores, both color and spatial distances are used: where a short green node represents a positive outcome, a longer orange node represents a neutral outcome, and the longest red nodes represent a negative outcome. Each of the three clusters represents one of the ACE dimensions, descending from Adaptive Capacity on top, followed by the Coping Capacity Cluster, and finally with the Expectancy Benchmark Cluster". Although the length of the arms is not meant to signify severity, in that a longer arm is not meant to signify a higher degree of significance, the longer arms do suggest that the GENETICS molecule is somewhat less stable at these clusters, drawing the readers attention first to the negative outcomes that may require added focus and additional resources for planners and decision makers.

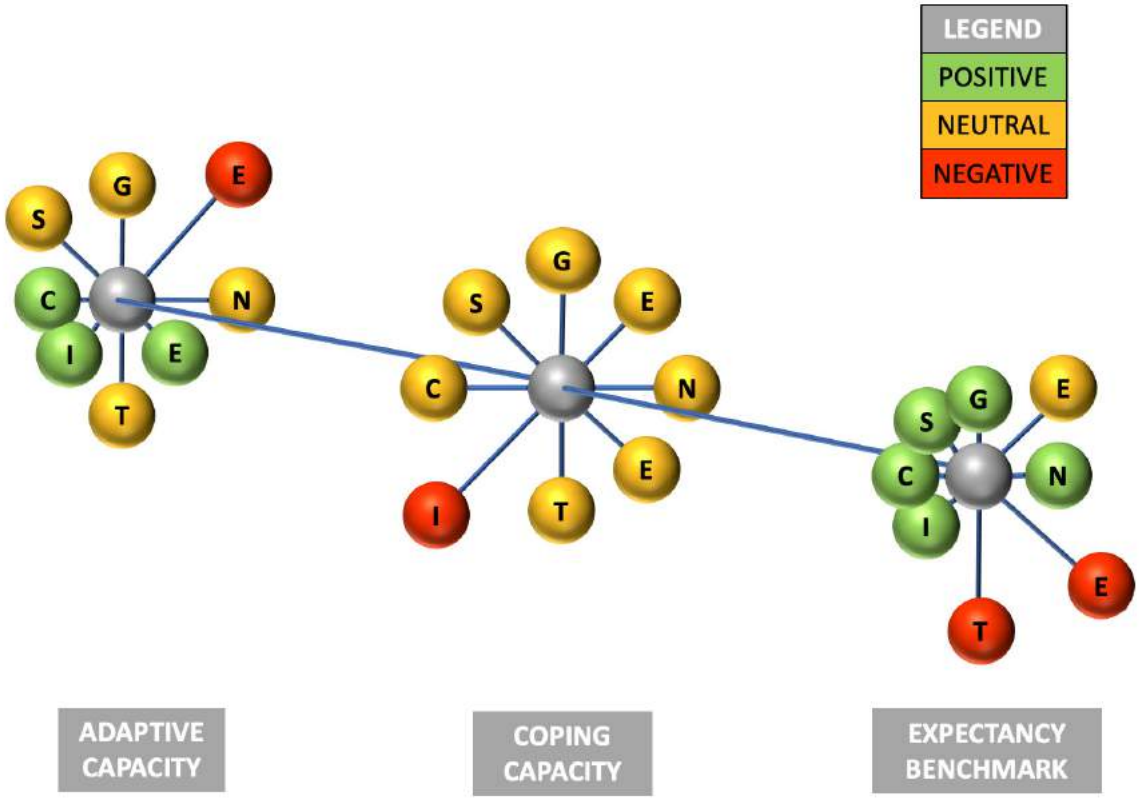

Fig 4.2 A Sample Visualization of the GENETICS Framework

Implementation of Case Studies

In order to both refine the GENETICS framework as well as to provide examples for analysts to conduct their own GENETICS evaluations, two larger case studies will be used as a guidance, specifically the Hong Kong Umbrella Movement and Hurricane Sandy in New York City. These case studies will then provide an in-depth evaluation on how to conduct a stability assessment within this study's framework, wherein each factor will be evaluated as having delivered a positive, negative or neutral contribution to overall Urban Stability.

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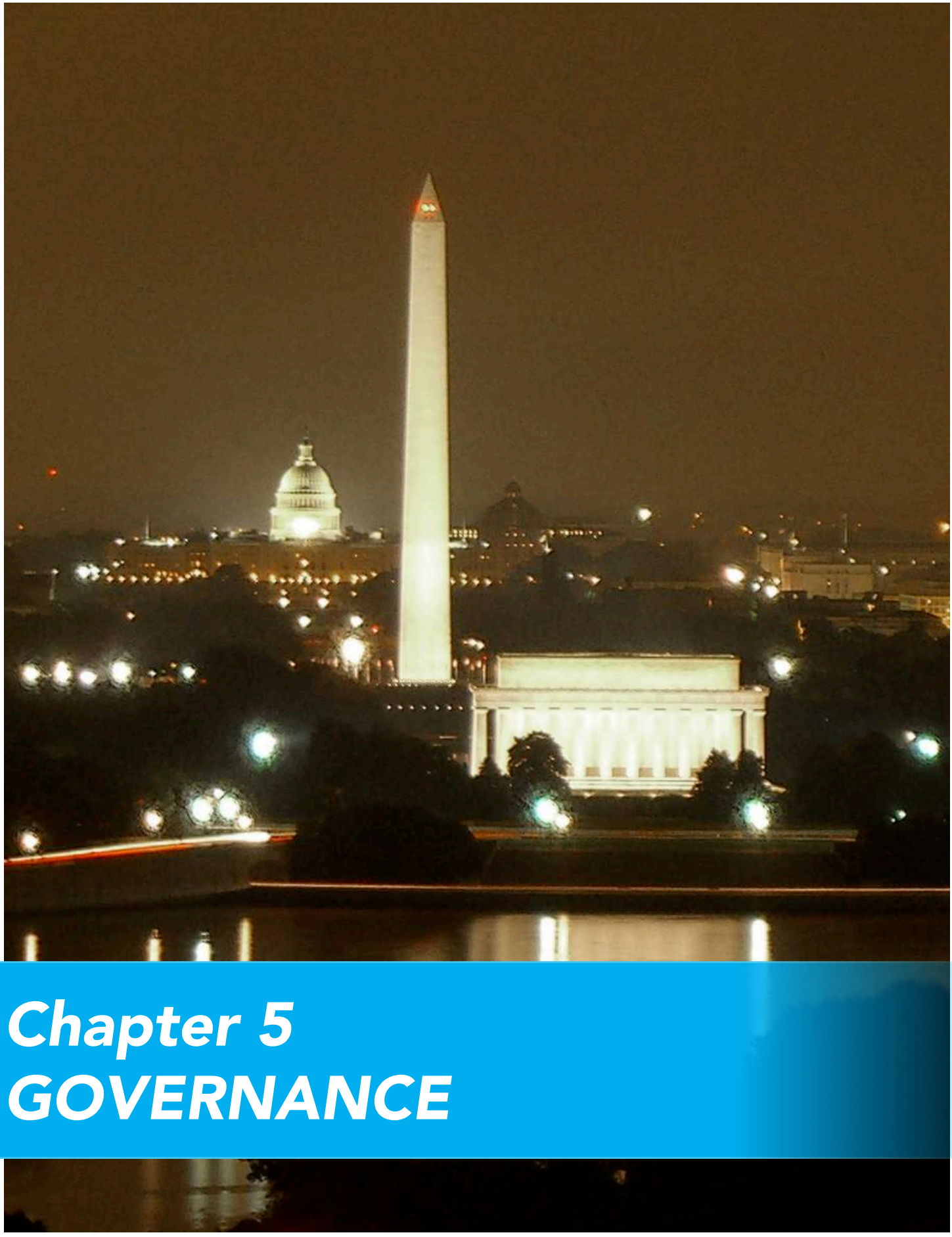

Chapter 5
GOVERNANCE

Governance Introduction

During a period of shock or stress on an urban environment, challenges will be faced by relevant governing institutions and leaders when managing the crisis. An understanding of the factor of governance, and how its component metrics contribute to the overall stability of an urban environment will be critical in evaluating the capabilities of local leadership and the potential weakness for collapse. Maintaining effective governance capabilities improves overall responsiveness and lowers the burden of management from an outside actor seeking to offer aid.

Perhaps the most obvious component of the governance factor is the formal institutions of management in the affected region. It is these governing entities, in all their various forms, which determine the local response and distribution of resources and authority on the ground. The leadership presented dramatically changes the environment for responding outside forces and can improve or decrease their burden of required aid. It also determines the compliance of the local civilian population, and the threat of civil unrest and increased instability. The presence of a military force, even one providing humanitarian assistance, should carefully be evaluated regarding the stress it may place on local governing institutions.

Expectations may change depending on a domestic or international deployment, as well as the country of deployment, but U.S. Army forces will almost certainly be required to maintain contact with local leadership in an affected urban environment. This leadership can take a variety of forms, from democratic mayors, tribal councils, informal criminal organizations, hereditary rulers and more. Each of these forms of governance will have specific variables relevant to the local environment, culture and politics. The governance factor and its component metrics does not intend to evaluate the detail of each possible form of government structure. While these differences are important, and should be accounted for on a case by case basis by subject matter experts, this instead offers a tool for the aggregate metrics that will be more broadly relevant to each potential case.

Furthermore, the actual governing responsibilities may extend outside of legal government authorities and instead include public institutions, private actors, civil-society organizations, academia and international organizations.[1] For this reason this analysis tool is not meant to specifically evaluate only the official government institutions but rather the general governing capacity of the region in aggregate.

To provide a framework for this inclusive analysis, this study offers four governance criteria: Municipal Governance, Provincial Governance, National Governance, and International Presence. Each of these criteria is comprised of metrics meant to evaluate the impact on the adaptive capacity, coping capacity and urban expectancy of the urban environment. These metrics were chosen based on representative cases to provide a largely applicable framework that should fit most cases. However, the use of this tool can and should be done with flexibility, with relevant changes applied as needed. For instance, the decision to provide an analysis of municipal, provincial, and national governance institutions fits an international norm of three levels of governance; however, this is by no means universal. Outlier situations which do not fit this norm should add or remove additional metrics of evaluation to account for the different levels and responsibility of governance.

The evaluations in each metric are not intended to be excessively detailed or comprehensive.

An examination of the municipal, provincial, and national governance as well as the international presence of any given region could each warrant a full study in their own right. However, the evaluation of each metric will allow for an assessment of which components within a governing environment most require attention, and which are contributing negatively or positively to overall urban stability.

Governance Assessment

Municipal Governance

For the purposes of this study, Municipal Governance describes the most local relevant governing body within an urban area or city. Often this can take the role of a mayor or city council. In less developed cities, the presence of informal actors, such as organized criminal groups or notable families, can fill this role instead. Cases with a decentralized network of Urban Governance can involve an extremely diverse and complicated network of formal and informal systems within civil society to fulfill necessary municipal functions.[2] The metrics to properly evaluate all of these subcomponents can be evaluated through the consequence of their effect on a number of common shared metrics of municipal governments. This reduces the burden on the individual commander or policy-maker to understand each component of local government, something that may be impractical in an emergency situation.

While legality and international recognition may be significant factors to consider when structuring the nature of support and cooperation, especially within a foreign nation, any groups with de facto governing authority should be considered. Thus the groups evaluated by this criteria are not exclusive to legally recognized government structures. Any actors with significant self-contained influence should be included and interacted with to the extent they are relevant.

Figure 5.1 shows a proposed list of metrics available to evaluate Municipal Governance, based on the governing legitimacy and capabilities of the local city institutions. Each of these metrics were chosen because they can be evaluated across different types of government structures and will likely be found to some degree within an urban context regardless of the unique circumstances of the local environment. Factors such as autonomy, authority, division of power, representation, crisis experience and governing experience are likely to be universally found, if not all equally important.
Autonomy describes the independence of the local government from provincial and national governing structures. For instance, to what extent is the local government able to issue its own policies in an independent mandate, and is the government popularly elected or appointed by a higher order government, in which case can they be dismissed at will?

Authority describes the ability of the government to utilize resources, and their mandate for doing so. It should be considered that this metric includes both legal and practical authority, so a local government that does not have a strong

CRITERIA	METRIC
Autonomy	· Elected/Appointed · Independent control of resources · Legal protection of independence
Authority	· Impact of policy · Time of policy implementation
Division of Power	· Executive authority
Representation	· Diversity of government
Crisis Experience	· Crisis plan/response agency present · History of recent crises
Governing Experience	· Time of government in power

Fig. 5.1. Muncipal and Provincial Governance Metrics Affecting Urban Stability

legal authority, but can nevertheless call upon loyal agencies and members of the public, will still rank highly.

Division of power applies only to the local government being examined and not the hierarchy of national governing structures. This would examine the specific authority of the local executive and what, if any, restraints are placed on their power within the context of the local government. This will also examine diffusion of responsibilities, and the number of supporting agencies and their size and authority. Representation accounts for the diversity of the governing coalition and executive. This is relevant to account for cases of minority rule on a tribal/ethnic/religious/linguistic basis. While a minority or non-representative government may still be popular and have high authority, it will likely still have ramifications on long-term stability, especially while considering the cross-influence of the societal/cultural factor. A non-representative government may see a higher risk of strife if other governing metrics are low.

Crisis Experience accounts for the experience of the government in dealing with or preparing for relevant crises. This includes something as simple as if the local government has an existing emergency plan or specific disaster mitigation agencies. It also accounts for if members of the government have had direct experience with governing during a previous crisis. Similarly, governing experience accounts for the direct experience with governing that a local government has. A recently elected government with no prior experience will not meet this criteria, while a government that has maintained power for several terms and has an experienced bureaucratic support structure will rank highly.

Each of these metrics can be evaluated according to the ACE dimensions by assessing their impact on adaptive capacity, coping capacity and expectancy benchmark. While there may be a degree of crossover, generally each of these outline metrics will have a unique impact on each of the three stability components. Based on the measured outcomes and the history of the examined region, one can determine if each metric is positively affecting, negatively affecting or has no notable affect.

Example 1: A city government experiences a dramatic shock crisis and takes on emergency powers to increase its effective governing authority metric. This would have no impact on adaptive capacity, as the government was unable to utilize these powers prior to the emergency, a positive impact on coping capacity due to the increased ability for the government to issue emergency policies, and a possible negative effect on expectation benchmark if the local population is resistant to an expansive government and the decision was unpopular. This means that depending on the

circumstances, a metric may positively contribute to some of the stability factors while negatively or not affecting at all other stability factors. When each metric has been assessed, an overall effect on the governance criteria can be determined. Some of these considered metrics may also experience relevant overlaps that can assist in evaluation; for example, a city government with low autonomy is likely to have a less relevant authority metric, even if what authority it does have is evaluated to be high. Based on the assessed impact of the metrics on the ACE criteria and the marginal importance of each of the metrics respective to another, an overall ACE evaluation can be given for municipal governance.

Provincial Governance

The provincial government criteria will use the same metrics of the municipal governance criteria seen in Figure 5.1. However, like with Municipal Government, this acts as a baseline, and can be expanded or condensed depending on the unique circumstances of the provincial government in a particular area. This is meant to uniquely evaluate the governance level above the municipal government that does not reach the national government level. Like the municipal level, each of these metrics will be evaluated for their contribution to the stability factors of adaptive capacity, coping capacity and expectation benchmark. If the municipal government is notably weak in an observed metric, like crisis experience, it is possible for this to instead be supplemented on the provincial level, if that government is particularly consequential. In this case it is important to assess the governance levels separately to acknowledge which level of governance is contributing the most to a particular stability factor. This would also be useful if intervention is required and the intervening force needs to assess which level of government to contact concerning different priorities. Additionally in the case that both the provincial and municipal levels complement each other and reflect similar results, this will be reflected in the overall impact on the ACE dimensions. Contrarily, if a municipal and provincial government compete on specific issues they can cause a net loss in the adaptive capacity, coping capacity and expectation benchmark, even if in isolation, each government is measured as being effective.

Fig. 5.1 State Capitol of Concord, New Hampshire

Example 2: A municipal government is experienced in resolving issues related to civil unrest and popular protests, and thus enjoys a positive effect on its adaptive and coping capacity when such events occur. However, the city government has recently lost much of its autonomy and the most recent protest has instead been primarily handled by a less experienced provincial government. Even though the crisis experience metric for the city remained the same, the impact it had on overall stability was reduced because of its low autonomy respective to the provincial government.

For this reason it can be relevant to examine the cooperation between levels of government on specific policy issues. The lower the autonomy of the municipal government, the more relevant the disagreement will become, and the more impactful the metrics of the provincial government will be in comparison. Provincial governments often fulfill an important role mediating between national and local authority, this is a role that should be considered when provided an overall assessment of government stability.[3]

National Governance

The final domestic level of governance to be analyzed is the national government. As the highest level of legal and government authority, the national government will always be relevant concerning the stability of an urban environment. Even a relatively weak national government will still be important to consider as a point of contact with the international community and as an intermediary with its own local governments. Conversely, a particularly empowered national government may preclude the need for significant cooperation with the provincial or municipal government. In the case of international intervention or aid it may often be the national government that sets the terms for an international presence.

To evaluate the National Governance metric, many of the same metrics of municipal and provincial governance will be used, with the exception of autonomy. As autonomy in this study is defined as the level of independence from higher levels of superseding governance, this is generally not a factor for national governments. Additionally, this level of examination will also include the metrics of government type and fragility. Government type will use aggregate evaluations to assess the level of democratic freedom and transparency of the national government. The type and legitimacy of national elections will also be examined. This will provide a determination of what kind of government or regime is in power and the unique effect on adaptive capacity, coping capacity and expectation benchmark. This study does not intend to make normative assessments regarding the type of government in each state, but rather acknowledge it as a relevant fact contributing to stability. Fragility will also be examined on the national level to account for the stability of the national government, and its vulnerability to a government collapse. It should be noted that while the national government is often viewed as the predominant governing body, this metric can be of varying importance to the stability of an identified city, depending on local autonomy.

Example 3: An unpopular autocratic government has collapsed as a result of public protests, and has been replaced by a nominally democratic provisional government. As a result of this shock, the national government is likely going to experience negative effects to its adaptive and coping capacity, especially as measured in the fragility, authority, crisis experience, and governing experience metrics due to the inexperience and instability of the new government. However, as a factor of the change in regime type, the new government is likely to

CRITERIA	METRIC
Government Type	· Democracy index/freedom house score
Authority	· Impact of policy · Time of policy implementation
Division of Power	· Executive authority
Representation	· Diversity of government
Crisis Experience	· Crisis plan/response agency present · History of recent crises
Governing Experience	· Time of government in power
Fragility	· Fragile State Index

Fig. 5.1. Muncipal and Provincial Governance Metrics Affecting Urban Stability

experience a positive effect to its expectancy benchmark as a result of its popular support.

It is also relevant to consider that capital cities represent an important intersection between national and municipal governance. While national governance issues can often be less important within an urban environment, the optics of national decisions are increased within a nation's capital. In such cases, these cities act as a hotspot for the intersection of national and local issues.[4] Popular action against a national government will be mobilized in these areas, and policies from the national government are sometimes first propagated through the capital city environment.

International Presence

The International Presence metric accounts for relevant metrics not included in the three previously identified criteria assessing governance stability. Accounting for the level of international support or interference within a national context can act as a significant positive or negative contributor to the ACE stability factors. While the given list of metrics was chosen based on research of some of the most impactful causes of international presence within a state, many of these metrics will not apply to all circumstances. This governance criteria is the most likely to substantially vary from case to case in relevant metrics. For example, a state like Bosnia and Herzegovina or the DRC have a far more extensive international presence relevant to the listed metrics than a state like Canada or France. Depending on the examined case, metrics that do not apply can be ignored.

Examining Figure 5.3, we can see an example metric set for evaluation that substantially differs from the previous levels of municipal, provincial and national governance. This is to reflect the substantially different impact that an international presence can have if relevant. The Supplemental Aid Support metric accounts for the presence of international actors in providing resources like food and medicine, and the local government's dependency on them. If a government is resource poor and unable to provide for its citizens, this can increase stability, provided that the support structure remains in place. If a government can adequately provide for its citizens without aid, this metric is unnecessary.[5] Similarly, Supplemental

Fig. 5.2 UN Headquarters in New York City

Governing Support accounts for the presence of international actors in providing governing or legal assistance to the national government. This can include multi-lateral actors like the United Nations or unilateral actors like an occupying or supporting government.[6] Both of these metrics vary in their effect on adaptive capacity, coping capacity and expectation benchmark. A high level of aid or governing support might increase coping capacity so long as the same level of support is offered, but it may decrease adaptive capacity if the government becomes dependent on outside aid. Alliances account for the number and strength of formalized agreements with other international actors to provide aid. The relevancy of this metric will depend of the type of commitment and aid offered, and the ability of the allied state to adequately provide that aid as needed. Foreign Military Presence describes the consensual presence of foreign military forces within local territory. This can prove to be a strong positive when dealing

CRITERIA	METRIC
Supplemental Aid Support	· Extent of resource distribution carried out by international actors (multi or unilateral) · Need for resource distribution
Supplemental Governing Support	· International supervision of government structures and institutions (multi or unilateral) · Need for governing support
Alliances	· Number of formalized commitments from international partners · Strength of allied partners (measured by size of economy, military size and other relevant factors)
Foreign Military Presence	· Presence of foreign military bases in relevant region
Occupation	· Presence and extent of foreign occupying force
Recognition	· Membership in UN · International recognition

Fig. 5.3. International Presence Metrics Affecting Urban Stability

with specific crises, if the foreign military is able/willing to render aid. However, it can also engender feelings of resentment and local tension, even among close allies.[7] Occupation accounts for a country that has been actively or recently in a conflict and some portion of their territory is not under their national control. Finally recognition describes the international recognition provided by the international community to a given national government. This notes the number of countries that provide formal recognition, if there are competing claims to governance, their membership in recognized international organizations and the presence of foreign embassies. The number of cases in which recognition will be relevant is small, but examples like Taiwan, Palestinian West Bank/ Gaza Strip, Russian occupied Crimea, and the Kashmir region are notable enough that this is an important metric to consider when appropriate. This proposed list of metrics is by no means exhaustive, and additional metrics can and should be considered if relevant.

Example 4: A country is experiencing a foreign invasion, which has taken control of significant amounts of territory. A dense urban environment with several million residents has been partially partitioned between government and occupier control, while an international body provides food and medical supplies to civilians. In this situation, the supplemental aid being provided is likely critical to the immediate coping capacity of the city to maintain basic subsistence functions. Furthermore, the occupation of part of the city has a significant negative effect on stability factors and impacts the other governance criteria by requiring cooperation with both the local government and the foreign government in their respective areas of control.As evidenced in the previous example, in extreme circumstances, an international presence can dramatically alter the considerations of any responding policy maker. A sufficiently entrenched international power may require cooperation with multiple national or local governments that are sometimes in direct conflict with one another. In cases where conflict is occurring within the country as a result of a local insurgency, then that can be assessed by adding additional levels of government where relevant and examining a similar metric set to the previously described levels.

Mini-Case: Administration of Sevastopol [8,9]

Following the Euromaidan Revolution and the removal of President Viktor Yanukovych, Ukraine was experiencing a unique political crisis. With the opposition control of the Ukrainian government following Yanukovych's exile, the low popularity of the new government in the Eastern, Russian-speaking regions, contributed negatively to local expectation threshold, adaptive capacity and coping capacity. These regions at the municipal and provincial levels, with international support from the Russian Federation, responded by drastically increasing their own authority and autonomy away from the government.

Fig. 5.3 Russian Soldiers in Crimea

This is particularly notable in the city of Sevastopol, where foreign military presence, occupation, and supplemental governing and aid support from Russia worked to positively increase the stability of the city, up to the annexation of Crimea into Russia territory. The lack of recognition from the rest of the international community was a negative contributor to stability but to a lesser extent. While this should not be seen as an endorsement of Russian activities in Crimea or Sevastopol, the extensive international presence Russia exerted worked to improve the stability of Sevastopol and the Crimean region above that of the Ukrainian Donbass, which saw a similar political crisis to Crimea but without a similar level of Russian occupation, it descended into persistent violence with the new Ukrainian government.

Governance Conclusion

The stability factor of governance is likely to be relevant in every urban environment to some extent. While not every governance criteria or respective metric will be significant, there is almost no situation in which the governance of a city won't contribute to stability, either positively or negatively.

From multiple stressors and shocks, ranging from hurricanes to protests, to outright war, the capability to manage resources, dictate policy and respond effectively will all rest on the shoulders of governing agencies, be they formal or informal.

For this reason, the Governance factor is something of an intersectional stability factor, broadly affecting most other corresponding stability factors and vice-versa. Scoring this factor with the ACE stability components and assessing that impact in conjunction with each GENETIC component will allow for an appropriate assessment of a city's stability.

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Chapter 6
ECONOMICS

Economics Introduction

The stability of a city depends heavily on its economic factors. Economics ultimately dictate numerous aspects of a city's ability to respond to challenges. A wealthy city can provide better disaster prevention infrastructure or distribute universal income to its citizens during times of disaster. A poorer city, in comparison, perhaps will struggle with providing these services and benefits to its people. In many examples around the world, we see richer cities doing better in dealing with challenges compared to poorer cities. For example, cities in the Northern part of Japan were quick to fix roads and rails during the 2011 Fukushima Earthquake.[1] Meanwhile, cities like Port-Au-Prince are still struggling to provide basic necessities to its citizens after the 2010 Haitian Earthquake.[2]

A well-functioning urban economic mechanism allows cities to cope and react to external and internal changes. Moreover, economic resilience also reflects the ability to relocate or provide resources to those who need it. The way a local economy responds to emergency events also showcases a city's ability to develop and evolve in response to economic crises. We look into what a city can do and afford based on its assets and wealth. Economic factors do not just look at a city's wealth, but also the wealth and assets of its citizens. Cities with wealthier citizens are more capable of affording insurance, health supplies, and sturdier housing. These factors also look at how citizens live. We also look at the urban informal economy as it usually falls outside the focus of official regulation and statistics, but can have strong impacts on economic stability.[3] A city with more informal workers can be more affected by external risks than a city with more formal workers. The structure of the urban economy in a city fundamentally controls the capability of an environment to respond to and manage a crisis.

Determinants ranging from how a city earns and operates its market activities to how its people connect to the city can decide a city's economic resiliency. With that said, this study looks at four specific economic criteria: fundamental economic structure, market connectivity, financial stability, and informality. Each of these factors have corresponding metrics that serve as determinants of economic stability. In this study, we evaluate the data of the metrics and determine the value of the four criterias and their contribution to the dimensions of coping capacity, adaptive capacity, and expectancy benchmark. We also apply equal weights to the criteria and come up with an overall score in each dimension of a city's resiliency based on economic factors. The overall economic score has a scale of positive, neutral, or negative effects to urban stability. Cities at the worst end of economic resiliency will be given the rank of negative. As the score improves or shows better contribution, the scale goes from neutral to positive.

In the following segment, we discuss in detail each criteria and metric, how they impact urban stability, and the metrics used in measuring them. For some of the data in this metric, we can easily retrieve the data from reputable databases like OECD, World Bank, the IMF, or city's database. However, some data may require the city's specific data to evaluate.

Economics Assessment

Fundamental Economic Structure

A country's economic structure is the foundation for economic development and performance.[4] The economic structure refers to the composition of production and its capability to produce, including technological, education, and the labor force.[5] We define the economic structure of a city with its basic macroeconomic profile. Cities with higher economic performance tend to have higher capability to absorb shocks and typically have faster and more efficient recoveries. There is also evidence that a city building resilience through its economic fundamentals leads to higher productivity, lower economic loss, less friction, and faster recovery from an event.[6] The metric of this factor will focus on two areas: the individual level of income as a proxy for private agents' wealth, and fiscal budget and management as a proxy for government wealth. The metrics in these indicators are macroeconomic variables such as GDP per capita of the city, the average of GDP per capita, budget for emergency support and debt service ratio.

Market Connectivity

Market connectivity is important because in times of disaster, a city's connection with their supply chain can help increase resilience. As demands of goods and services can fluctuate wildly, cities with high diversification of economic activities will be less prone to demand and supply shortage. Connections like economic trade and communications can enable a city to request help and emergency supplies during a crisis and this connectivity can help the leadership organize a stronger and more effective response. These activities can be observed by certain sub factors: trade openness, foreign direct investment, and the average of trade as a percentage of GDP. This connectivity is used as a determinant of a city's capability to seek assistance.

Financial Stability

When looking at a city's resiliency based on its economy, it is important to look at how stable it is in times of peace. A rich city can find its theoretically healthy economic growth to be unstable in times of a disaster if it created said growth through unsustainable means. Caracas, Venezuela, for example, was once the most expensive place to live in the world; however, it could not maintain its golden economic days and got worse by losing economic control during the banking crisis in the mid-1990s period.[7] Financial stability is also crucial to a city's resilience because citizens regularly rely on transparency, implementations of rules, and fair transactions in financial markets. Many citizens can rest well, assured that in terms of crisis, the economic system will still be there for them to make sure that there are enough supplies and business activities to keep the city running. For financial stability, we look at certain sub-factors: central bank independence, financial inclusion, and financial transparency. Central bank independence indicates the transparency of monetary policy.[8] Moreover, a robust central bank strategy helps facilitate price and financial sector stability which will eventually contribute to sustainable economic growth.[9] Financial inclusion is important because inadequate access to financial services can impact the most vulnerable populations. This lack of access usually stems from insufficient banking infrastructure. These vulnerable populations

struggle to improve their livelihoods without access to financial systems such as loans and bank accounts, and are therefore unable to , for example, easily purchase tools to enhance their productivity, or to seek additional economic or employment opportunities. Financial transparency is also important because it allows individuals to be held accountable and for the people to know how the money of a city is being spent, distributed, or collected. This can be seen when looking at cities that have been transitioning to mobile payments, for example, which has been beneficial to both the citizens and government. It has improved the government's ability to collect tax, reduce transaction cost, and furthered efficiencies for both parties, which ultimately improves financial transparency.

Formality vs. Informality

A city's resilience can also be impacted by the formality or informality of its economic system. If a city has more formal workers, it is more able to account for workers and collect tax as government revenue. With more formality, a city's government knows where the workers work, live, and how much they earn. This might seem like ordinary data, but it can be critical during a disaster. In efforts to measure informality, we found that simply quantifying the informal sector with monetary units will be misleading as the cities have different socio-economic structures. These can be observed by share of labor in the informal sector, percentage of households with a total income of less than the average household income of a city, difference between growth of electricity consumption and city GDP, percentage of city's population that is foreign born, percentage of households with bank accounts, and percentage of people with only primary and secondary education in the labor force.

Following the resiliency framework, we will assess the city's stability by the ACE (Adaptive capacity, Coping capacity and Expectancy Benchmark). Each sector will be asked with the important questions regarding its economic characteristics and will be provided with the key metrics to help evaluate the city's economic stability.

Economic Factors and the Adaptive Capacity

Adaptive capacity represents the ability of the city to plan, prepare for, facilitate, and implement adaptation options, typically targeted towards unanticipated threats. Under this consideration, the question to ask is whether economic activity shows the versatility and diversity of the economy. Adaptive capacity needs to provide mechanisms for institutional learnings[10] in terms of economic factors, and how connected they are. In order to evaluate economic freedom and the ability for individuals to participate in the economy, we evaluate the systemic barriers to entrepreneurship which can be tracked by evaluating the ease of doing business in a city. A city with a high ease of doing business indicates a business environment that is friendly to entrepreneurship. The ease of business can be measured by assessing the flow of business processes ranging from opening business, getting the location, accessing finance, dealing with daily operation, and operating environment. Key characteristics for economies with the high level of ease of doing business is the common usage of electronic systems -including online operation process, electronic tax filing platform, online access to property transfer, and electronic construction permission.[11]

We can also look at the availability of job opportunities after an incident in order to measure economic recovery. A city with a versatile and diverse economy will be able to quickly replenish its workforce after a period of economic inactivity.

Another question to ask is whether a city has a credible financial market. Many modern cities are the center of financial markets in which they financially operate - the New York Stock Exchange being located in New York City, for example. The level of reliability of this financial market is crucial to gain public confidence. If the city demonstrates a high level of credibility in its financial market, despite having shocks, the city will eventually gain interest and credit back.

Meanwhile, the independence of a central bank is also important because it demonstrates how much autonomy the country has in determining its interest rate as well as other monetary policy instruments . An independent central bank might be more capable in reacting to a sudden change in the economy. For example, the United States Federal Reserve reacted quickly to the Covid-19 Pandemic by adjusting its interest rate without political red-tape and bureaucratic back-and-forth.[12] Their quick decision was met with criticism, but the policy changes buffered the country from some negative financial impacts.

Another example is the policy of various central banks during the 2008 financial crisis; most of the independent central banks issued debt of their own currency in order to increase money supply.[13] This significantly helped ensure the stability and maintaining function of the financial system.[14] While federal monetary policy is not under the control of cities, effective federal monetary responses will help maintain economic stability within cities as well.

Economic Factors and the Coping Capacity

Coping capacity represents the ability of a city to avoid damage. Given the same disaster or circumstance, a high coping capacity city will experience less jeopardous impact to its economic system and eventually be able to resume normal operations in a shorter time. Moreover, negative impacts will not be long lasting as the city has prepared and created awareness in the community.

At an individual level, we analyse the current economic status and how potential risks can harm individuals. The question to ask is whether a person or a city has sufficient income. The term sufficient can be difficult to measure; however, we cannot neglect the fact that almost every person needs to work in order to earn and make a living. In this case, GDP per capita, unemployment rate, and percentage of account ownership of the city can be a measurement of individual coping capacity. GDP per capita is not just about money; it also indicates the economic power and the wellbeing of the city.[15] The level of GDP per capita depends on both its GDP size and population size. Cities in general have a high GDP and population. The city that has a higher GDP per capita reflects its ability to produce more revenue and tax for the government due to its production capability. For example, New York City, Tokyo, and London, all cities that have a high GDP per capita, generate tremendous amounts of income. Their government can invest that income in other, less developed areas.

Meanwhile, a city with a low unemployment rate means most of its population has jobs or the city offers high job opportunities. The presence of a job enables them to earn, improve a working skill, invest, and expand savings which helps citizens prepare for crises.

Another question to ask is how cities manage income. For the city level, the budget and plan of an emergency response shows how the city views threat potential. Providing access to essential services before and during an emergency is fundamental for building city resilience. Risk reduction, even in small investment, is more important than doing damage control after the disaster. As the city is the center of economic growth and prosperity of the country, it is vital to prevent the catastrophic event by providing enough resources to the city, for both physical and human capital.[16] For

the individual level, having a bank account is the safest tool to keep money.[17] However, different income economies also have different percentages of account ownership. The bank account proportion in high income economies is significantly higher than middle and low income economies. This can lead to a problem when residents need financial help from the government. For example, under the COVID-19 pandemic, the US government announced a stimulus package through direct deposit. Since most people already have an account, they only needed to register online, if at all.[18] However, a lot of people in Bangkok and other cities in Thailand risked their health to line up in front of the bank in order to open new accounts to receive financial aid from the government.[19]

At the government level, the questions to ask regard income and financial management. In addition, it is important to evaluate the big picture of market connectivity and the formality of the economic system as a whole. As we look at government financial coping capacity, debt service ratio can show whether the government has the ability to repay debt in the long term. A city with a high debt service ratio can find itself in a debt trap and will not have enough financial flexibility to support itself in times of a disaster and not enough assets for a quick recovery. It represents the partial fiscal health of the city. As all sectors connect, high debt ratio can be a source of fiscal vulnerability to the city as a whole.[20]

Mini-Case: 2015 Kathmandu Earthquake

New York City and Hong Kong are major financial and cultural centers of our world. Both cities possess superior economic strength and high-quality infrastructure that allow them to survive challenging disasters and disruptions. On the other hand, we have growing cities in the developing world that do not have the capabilities or assets that can buffer them from such risks. One prime example is Kathmandu, the capital city of Nepal, which experienced devastation during the 2015 Kathmandu Earthquake. With a population of 2.5 million people, Kathmandu is one of the fastest growing South Asian cities in the world. The city is the center of the Nepalese economy, a largely agricultural one that has been growing rapidly in the recent years.[22] The aspirations of continuing such rapid economic growth were shattered due to an earthquake on April 25, 2015. The earthquake measured 7.8 on the Richter scale, killed over 9,000 people, and left over 3.5 million people homeless.[23]

In regards to the coping capacity of the city, Nepal is one of the poorest countries in Asia[24] which has a GDP per capita of only $792.55 in 2015.[25,26] Therefore, its fundamental economic structure is considered fragile to any shoc. The disaster had huge impacts on Nepal with negative economic impacts on production and service sectors, such as in agriculture, industry, and trade. According to the Post Disaster Need Assessment of the Nepalese government, the total value of direct and indirect impact of the earthquake to Nepal was close to ten billion USD, equivalent to one-half of the country's GDP.[27]

For the adaptive capacity, the city needed external help from external organizations. In order to help Nepal get back to normalcy, the Asian Development Bank provided a three million USD grant to Nepal for immediate relief efforts, and up to $200 million for the first phase of rehabilitation. According to IHS Global Insights, the estimated cost of rebuilding infrastructure in Nepal could cost up to five billion USD. As agricultural activities are heavily based on natural weather conditions, the individual citizen cannot easily adapt or prepare for natural shocks. This also limits their ability of higher economic growth.[28]

For the expectancy benchmark, although the unemployment rate of Nepal overall remains low, we cannot conclude that all citizens have a secure job. This is because most of the population (approximately 63%), work in the agricultural sector, but only contribute to 29.38% of GDP in 2015.[29] Hence, it shows a high informal economic activity level not only within the city but also at the country level.

Percentage of small and medium enterprises and trade openness can be used for the outlook of market connectivity from a coping capacity perspective. The portion of small and medium businesses in the economy shows how the city's economic activity connects to one another by the number of businesses. Small and medium businesses are often more vulnerable in terms of financial resources and external economic shocks. However, they also reflect how amiable the city is to starting a business. Small and medium sized firms can create new jobs faster than big companies and also contribute to the growth of its economy.[21] Therefore, not only the city should have a proper portion of small and medium enterprises, it is important for those firms to be protected from potential risks or disasters. If those firms have insurance for the emergency situation, they will be less vulnerable. Trade openness of a city also indicates its willingness and ability to take in imports or exports that can be critical during a disaster.

Moreover, if a city has a more liberal and open economy, it might be more capable of receiving aid from outside sources. If a city tends to be a closed economy, it might struggle to receive foreign aid, but might have a good system of distribution in place.

Another question to ask is what are the characteristics of the labor force. Percentage of labor in the informal sector and the educational level of labor in the workforce market can help identify the types of labor and their vulnerability to emergency events. Cities with more formal economic systems will be able to provide assistance and protect worker's rights and health in a more effective manner than those dealing with highly informal economies, where lack of payrolls and worker information can hamstring an effective response.

Fig. 6.1. Damage to Durbar Square from the Kathmandu Earthquake

Expectancy Benchmark

The urban expectancy benchmark is the faith of the urban population regarding a city's financial and economic management. The definition focuses on the ability to maintain a standard of living within a certain range in response to disturbances. Therefore, the question to ask is whether the city meets the urban population's expectations financially and economically. As the reason for the inflow of population to urban areas is the expectation for economic opportunity, the economic expectancy benchmark can evaluate through the economic growth. We look at the overall growth to see if it shows a recovery and stable over time. The average GDP per capita can be an indicator of a city's wealth and its people's wealth. Foreign direct investment shows how connected a city is to the international economy and the attractiveness of a country to the world. The average value of city exports as a percentage of GDP also shows the level of connectivity of a city but from city to the globe.

We can assume that the average of those indicators should be stable or show positive change. The average unemployment rate can also be the expectancy benchmark as it shows the availability of overall job opportunities in the city to its citizens. In terms of overall welfare, we consider the income distribution in the city, particularly those who earn less than the city's average, to evaluate the income equality among members of society. To keep up with expectations, as a city is driven by high economic activities, it is vital to maintain trust to keep people participating in the economy. The city government should provide suitable policy to attract business or investors into the city which can implement through special investment policy, tax incentive, and ease in investment regulation. Moreover, the city also needs to invest in its people by human development policies such as education and technology. Meanwhile, the city is supposed to maintain its fiscal stability by diversifying its budget allocation.

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Chapter 7
NATURAL ENVIRONMENT

Environment Introduction

Urban environments are intrinsically tied to the environmental and geographic factors that comprise their surroundings. This is easy to see in any urban form – Venice, Italy, with its canal system; Amsterdam, in the Netherlands, with its series of levees, etc. While obvious, it is clear that the stability and design of the urban environment relies heavily upon the gifts and curses that nature bestows upon them. And these environmental factors vary greatly between urban locations – there is no one set climate profile, geographic profile, or weather profile that could be applied consistently across international locations, nor is there much value in attempting to define each and every type of natural environment a large urban environment can be located within.

Due to these variations, we find that it is inherently unhelpful to spell out what creates environmental risk, as these vary to an extreme degree and in no consistent fashion outside of exceedingly broad and generalized geographic trends. Additionally, the threats posed by these geographic factors are typically obvious to any informed observer – coastal locations in tropical climates will be under threat of hurricane. A major urban environment such as Los Angeles faces a cataclysmic threat in the form of a severe earthquake due to its location on the San Andreas Fault. A variety of international urban environments experience annual flooding, or extreme heat, especially those located along river valleys, oceans, or deserts in the case of extreme heat situations. Fortunately, these hazards are rarely difficult to identify by even a casual observer. Even the most routine observation of a city's climate and structure should make clear the environmental factors that threaten urban sustainability through either individual catastrophic events such as a hurricane, or through more long-term impacts such as drought that project to increase in severity as climate change continues to threaten urban environments.

Due to the ease and specificity of observing on site the potential environmental hazards of an urban location, we find it to be tedious and overly technical to spell out how to identify these hazards through any sort of metric. Ways to identify precise hazard degrees are available through a variety of published metrics by various world weather organizations,,, but the specificity these tools provide will rarely be useful in informing and defining urban stability and expectations. Much more important to this discussion is the way to evaluate the impacts these hazards may potentially have, and identifying ways cities have either proactively, or not proactively, begun to address these concerns. We analyze these concepts through the ACE dimensions, beginning with the concept of Adaptive Capacity.

These three concepts of awareness, adaptive form, and flexibility in provision of basic necessities will form what we consider the adaptive capacity of a city from environmental impacts. Cities that score highly in all of these regards are not immune to serious natural disasters due to the lack of ability to control the city's coping capacity, as discussed above, but should be able to effectively mitigate and reduce damage in the most effective way possible. Cities that consistently fall into the bottom tier of these categories should be considered high risk urban environments that will almost certainly require international action and support if serious inclement events are to occur.

Adaptive Capacity

Adaptive Capacity is the ability to prepare for, facilitate, and implement adaptation options, typically targeted towards an unanticipated threat. In environmental considerations, it is rare to see an unanticipated threat since most risk factors are easily identified, as discussed above. However, many of these threats can strike without warning, especially a threat such as an earthquake, a hazard that is basically impossible to predict even with modern technology. [1,2,3] Adaptive capacity in this case is not the ability to prepare for unanticipated threats, but instead prepare for and respond to the unpredictable threat of generally known factors. To determine adaptive capacity, we have identified a series of questions that can be asked and observations that can be made in order to assess the preparedness of a city to respond to the most common environmental threats it faces. This list is not meant to be completely exhaustive, and individual cases may present novel and unique ways to measure the adaptive capacity of a city. However, we have identified three primary factors that affect the way that a city can build adaptive capacity in order to maintain urban stability: climate awareness, urban form, and operational flexibility. Each of these factors assess how prepared - or unprepared - a city is to address and respond to climate threats.

Climate Awareness

The most important step a city can take is beginning to attempt to address climate impacts. This feels obvious, but a huge spectrum exists among global urban environments regarding the care and attention the local government and populace has put towards addressing these issues.

One metric proposed by researchers at McGill University simply observes if a city has published a climate change plan; this first step having happened is shown to greatly improve climate resilience, even if much work remains to be done.[4] Is it on the city's radar to address the long term threats created by climate change? Are there formal governmental structures that are in place to explicitly address climate adaptation in order to protect against future threats (both long term and individual) as discussed above? We break these into three tiers of awareness:

Positive awareness: The city has a published climate change response plan that has legal requirements of action. Structures are in place to actively fortify vulnerabilities within the built environment. Work is underway to minimize future impacts of climate change. If vulnerable to individualized risks, common strategies are being used to minimize those high risk events.

Neutral awareness: The city has begun to take steps to address climate change impacts, but has no formally published plan. Inefficiencies and a variety of problems in urban development restrict the ability of local government to make significant change. Political resistance to applying public funding to climate policy as opposed to other potentially more lucrative avenues.

Negative awareness: Little to no regard to climate change. Central authority and planning are light, and ineffective at minimizing environmental hazards. Most responsibilities in response to climate events fall to outside actors and citizens themselves. Generally at high risk to repeated events, but are failing to provide any form of meaningful response.

Urban Form

Fig. 7.1 Amsterdam's canals and low elevation mean it can be particularly prone to flooding.

The second question to be answered regards the urban form itself. How adapted is the city to the threats it faces? While this sometimes will go hand in hand with the previous response, it does not inherently do so. This can be answered by both formal[5] and informal[6] structures. For example, has the city been designed to be flood resistant by placing informal coastal structures on stilts above flood lines? While sometimes not designated by any governmental authority as mandatory[7], it can be an incredibly effective strategy to minimize the risk to those residents. More formal structures such as public infrastructure projects like levees and dams will be more consistent with high awareness cities such as Amsterdam, a city that has invested immense resources in protecting itself against flooding.

Positive form: The urban environment benefits from both historic and modern construction techniques that have insulated the city for a significant period of time from common environmental effects. Even serious events are mitigated and can be responded effectively to. While not invulnerable, the form is capable of absorbing serious events without complete infrastructure failure. Active efforts are being made to further insulate the urban form. Few informal structures exist that can be extremely vulnerable in a serious environmental event. Few to no fatalities occur outside of extreme events.

Neutral form: A more recently modernizing and urbanizing environment that still carries some historic vulnerabilities. A lack of resources may be preventing large scale infrastructure projects that will be necessary to address future climate issues such as sea level rise. The form is resistant to most common effects due to the citizenry and traditional resilient construction methods. Some informal development exists, but not in the highest risk areas. A low number of fatalities occur during more predictable, seasonal events.

Negative form: A modern urban environment that has created new environmental hazards such as mudslides and increased flooding or drought. Most of the urban development is haphazard and extremely vulnerable to any inclement weather. Significant damage occurs on a regular basis to population hubs. Informal development is common, and located frequently in high risk areas. Fatalities are common during even routine events, and extreme events will result in mass casualties.

Environmental Flexibility

The third question we find valuable to ask is regarding reliance upon specific natural resources. Generally, the more diverse the access to food, water, and shelter a city can maintain, the more resilient to inclement environmental events. Conversely, a city heavily reliant upon a particular food or water source can fall into near chaos almost immediately if these connections fail either at the source or in transit to the urban environment. A city without food or water is a city that has failed to provide the most basic needs to the citizenry. While losing access to these mandatory resources can be caused by a variety of factors, the most common examples involve negative environmental events such as heatwave and drought killing off agriculture and livestock in vulnerable areas, and a failure of other structural systems to replace these lifelines.[8]

Positive flexibility: The urban environment enjoys a suite of access points that make importing and distribution of basic necessities simple. The city is actively supported by both surrounding countryside as well as national and international supply chains. Water access is diversified, and the government has backup plans and alternative sources in the case of emergency or pollution. Single seasons of inclement weather will cause little to no damage to the process of providing basic necessities.

Neutral flexibility: The urban environment may be located in a difficult to access geographic location, but still enjoys support from a variety of supply chains. Active water supplies may be limited, and are a potential concern in any drought conditions. The surrounding geography is potentially hostile to agriculture, building a reliance upon state, national, and international supply lines to provide basic necessities. Government is stable and has plans in case of disruption.

Negative flexibility: The urban environment is highly reliant upon vulnerable sources of basic necessities. Poor weather seasons cause legitimate starvation and hydration concerns to large swaths of citizenry. State and national infrastructure provide little in the way of higher level support. Outside actors may be relied upon to provide basic necessities on a semi-frequent to frequent basis. Local government is incapable of providing necessities in times of emergency.

Coping Capacity

Coping Capacity is the ability to avoid irreparable damage from which it is unable to recover. As cities cannot control environmental threats, only respond to them, the coping capacity dimension relies upon understanding the inherent environmental threats an urban environment faces. If catastrophic potential exists, an urban environment and the associated stability will be unavoidably vulnerable. The primary step to identifying the environmental stability factors that impact the coping capacity for any given region fortunately should be relatively straightforward in most contexts. The observer must survey and record the environmental factors that pose a threat to urban stability. The planner then must analyze and understand the risk posed by these events; as mentioned previously, a variety of tools available are capable of assisting in this effort. When analyzing the coping capacity of a city, these hazards should be broken into two categories – individual and long term events.

Both of these factors must be considered when analyzing the coping capacity of the city. Cities that face high risk profiles in one or both of these areas are going to be less stable, more compromised environments that need to be considered riskier regardless of other stability factors discussed in other portions. Other cities may score highly in one capacity, but low in the other. This is at the discretion of those making the decision, as there is simply too much environmental variation on planet Earth to try and prescribe strict environmental conditions that would define these statements. They are designed to be relatively flexible, in order to allow for any city to be comfortably slotted into a single category.

Fig. 7.2 Haiti in the aftermath of Hurricane Matthew

Individual Event Coping Capacity

The most important question to answer is what is the worst case scenario. Is there potential for a cataclysmic event that even the most adapted, highly prepared city cannot recover from? This includes serious earthquakes, hurricanes, volcanic eruptions, and other various environmental threats. While very rarely can a city truly never recover, a 10.0 earthquake hitting will disable all city operations for an extended period of time, which in a short term context is an inability to recover. This is why it is key to consider coping capacity from a worst case perspective. Most cities can be placed relatively simply into the tiers below:

Potential for total urban failure: cataclysmic risk from an individual event that can and will shut down all urban operations for an extended period of time, and will be a mass casualty event regardless of any preparation or work undertaken by the city to prepare. Examples: hurricanes, high magnitude earthquakes, volcanic eruption

Potential for harmful events: high risk from more annualized events that can cause significant damage to urban infrastructure and operations, but can be mitigated by proper planning and infrastructure. Severity of these events will vary from city to city. Examples: flooding, blizzards, heatwaves, mudslides / rockslides

Low individual risk: urban environments existing in temperate climates away from coastlines and any serious geographic threat such as fault lines, mountains, and volcanoes. Rarely, if ever, experience serious disruption to city operations from a natural cause.

Long-Term Risk Coping Capacity

The question remains: what is the worst case scenario? Long term risk focuses on the threats that project to increase in severity as the climate continues to warm, namely heat, drought, and annual flooding. Some urban environments located in desert climates will become legitimately uninhabitable within the next 100 years if temperatures continue to climb and certain vulnerable ecosystems face complete failure whether due to increased temperatures, erosion of water supplies and drought, or sea level rise.[9] Obviously, a city becoming uninhabitable will constitute complete system failure. We again separate these into three categories of risk:

Negative future climate impacts: cities that project to be uninhabitable within the next 80 to 100 years. These include cities that will face destruction from sea level rise and increased temperature. At some point in the future, unless drastic action is taken to reduce the effects of climate change, these cities will need to be effectively abandoned and relocated.

Neutral future climate impacts: Cities that, while not projected to fail, will face challenges in the future, especially in existing problematic areas that already impact the urban environment. This category includes many coastal cities that, while not as vulnerable as some low lying urban environments, will still struggle with sea level rise and increasing heat.

Positive future climate impacts: Temperate or low temperature urban environments that may see no consequence, or even potentially benefit from the warming climate. These cities project to remain remarkably stable through climate change, and will not be impacted by sea level rise, increasing storm intensity, or drought.

Mini-Case: Miami

Flg 7.5 Miami Beach Skyline

Miami is a cultural center of Florida, and one of the most recognizable coastlines in the world. An economic powerhouse of Florida, Miami ranks as one of the fastest growing cities in the United States, and will likely continue to be a large, diverse city in the near future.[10] The wealth and financial support Miami enjoys are obvious, as the city will not lack for resources as long as the United States resembles its current form. However, despite the numerous first world benefits that Miami enjoys, it is impossible to view the city as anything besides an environmental liability. According to nonpartisan think tank Resources for the Future, Miami faces the largest coastal flooding risk of any major coastal city, with approximately $3.5 trillion in assets at risk by 2070.[11] In terms of adaptive capacity, Miami has an extremely climate aware government, strong resource availability, and an urban form capable of adapting to future climate threats – sea walls, planting lines, emission reductions, stilt construction, etc. – that provides the city an extremely positive adaptive capacity. This does not change the fact, however, that Miami is massively vulnerable to both climate change as well as large hurricanes, both of which can rapidly destabilize even the most adapted city.[12] NOAA data identifies Miami as the most at risk large city in the southern United States to hurricanes, which indicates that in any given year, the likelihood of a hurricane is approximately 14%. As climate continues to change, and hurricanes continue to increase in severity, the coping capacity of Miami will continue to fall, and planned abandonments of coastal are already being proposed. Despite Miami's immense adaptivity capacity and high expectation threshold, the city cannot change its geography, and will be liable for an extremely negative coping capacity and the instability that may result. Any analysis of Miami in the future must be frank about these environmental liabilities regardless of resource availability and form.[13]

Expectancy Benchmarks

The final level of analysis that should be undertaken regards the Expectancy Benchmark: the collective belief of the urban population on the city's ability to maintain a standard of living within a certain range level in response to disturbances. This is a key concept to examine with environmental impacts due to the range of responses an urban population may have to an inclement environmental event. Somewhat counterintuitively, low expectations of urban governance can increase urban stability, as the general population is more willing and prepared to undertake responses to disaster into their own hands. In the case of a cataclysmic individual event, populations completely unprepared to manage and respond to significant damage to the urban environment, as you may expect in many first world countries, may have a greater difficulty maintaining order than a city with a more prepared populace.

However, this does not mean by default that low expectations are beneficial. In some cases, a low threshold may result in an unwillingness to listen to authorities, while a high threshold may empower local authorities to respond in a more effective manner. This can be seen in a variety of cases such as Hurricane Sandy, which is elaborated upon later. High thresholds in New York ensured that the urban population both took warnings seriously and also allowed for proper state response to occur prior to attempting to take matters into their own hands.

Positive Expectations: The response of the people is beneficial, providing a net positive to recovery efforts. If necessary, the individual citizens step in and take proper care of environmental damage. Overall recovery is smooth, regardless of the source of support. Proper precautions are taken when available, and the general sense of panic around hazards remains low.

Neutral Expectations: The response of the people is predictable, but not notable. While proactive actions are taken, nothing extraordinary occurs. Some distrust of systems creates logistical issues. These issues compound into creating a less predictable and efficient response. Some panic and social anxiety occurs due to this lack of organization and support.

Low Expectations: Formal systems are not relied upon for success. A looting mentality may seize the population, and social constructions begin to fail. Major inefficiencies and rejections of systems occur, and some violence is possible. The response of the people is chaotic, and there is no central trusted authority (formal or non-formal).

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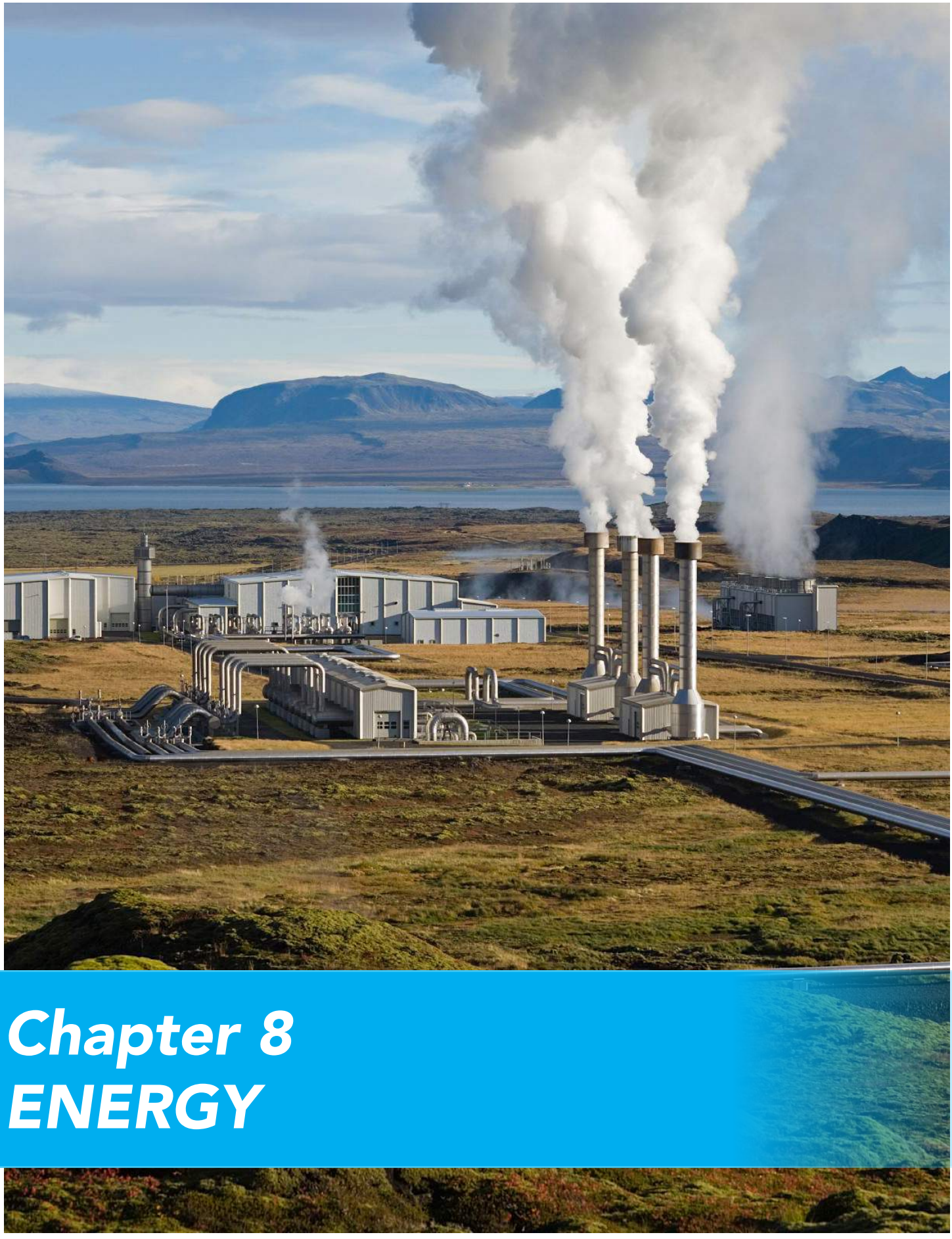

Chapter 8
ENERGY

Energy Introduction

Energy systems are ubiquitous in urban environments: the networks that support energy flow are critical to the daily functions of all things within a city, such as oil, gas, and electricity. Cities mostly tend to rely on external generation for much of their energy needs - oil and gas are rarely pumped directly out of the ground and refined on site for a city's consumption, while electricity is similarly generated and transmitted over vast networks before reaching a city. Without energy systems, other infrastructure systems, such as transportation, water, logistics, and information and communications technology, do not operate. Restoring energy systems after a major disaster or other disruptive event is critical to restoring all other systems and is therefore a critical stability consideration. [1] Urbanization continues to shift energy demands into cities, as more people in these environments inevitably require more energy.[2] As the world grapples with the threats of climate change, from sea level rise to more intense climate events, sustaining energy flows into cities becomes an even greater challenge. While previous resilience studies have reduced energy considerations to evaluate electricity available as a sub-category to infrastructure, or physical service delivery, this study recognizes the importance of specifically addressing energy systems due to their significant contributions to daily urban life.

Energy Assessment

The International Energy Agency defines energy security as the uninterrupted availability of energy sources at an affordable price.[3] This section reframes this discussion by assessing an urban area's energy system stability, a similar but broader and more comprehensive concept. A city's energy system stability is contingent on its energy supply consistently meeting its energy demand - during periods of low demand, peak demand, stresses, and shocks, now and in the future. Energy system stability is, as with all stability factors, further defined as a function of energy system adaptive capacity, energy system coping capacity, and energy system expectancy benchmark.

Adaptive Capacity

A city's energy system adaptive capacity is defined as the ability of the energy system to plan for, prepare for, and respond to emerging challenges. Cities must manage and prepare for current as well as future risks and establish a foundation to respond to emerging challenges with some degree of flexibility. The energy system that supports a city is no different in this regard, and perhaps is one of the factors that is most aggressively pursuing adaptive capacity under the guise of modernization and smart grids. In order to assess a city's energy system adaptive capacity, we refine it as a function of supply modernization, network flexibility, and demand responsiveness, per Figure 8.1 below.

CRITERIA	METRIC
Supply Modernization	Ability to meet future needs Smart Grid Index Grid Modernization Index Report Smart Grid Maturity Model
Network Flexibility	Coordination of key actors Policy
Demand Responsiveness	Consumer driven Financial incentives Behavioral programs Direct utility control of consumer appliances

Fig. 8.1. Factors affecting Adaptive Capacity of Energy Systems

One of the biggest developments for electricity grids is the expansion of smart grids that are more dynamic and better able to support the increasing demands on the electric grid. We expand this concept to the larger energy system and call these efforts supply modernization. Supply modernization contributes to a network's ability to prepare for future needs by monitoring current opportunities to improve operations and by anticipating future challenges. As noted previously, most of these efforts are oriented on electric grids, with tools like the Smart Grid Index[4], Grid Modernization Index[5], and the Smart Grid Maturity Model[6] providing similar conceptual frameworks to evaluate how electric grids are modernizing. We recommend incorporating similar metrics that are used to evaluate smart grid efforts across the city's energy systems to fully evaluate supply modernization.

These utility-side modernization efforts are complemented by the network's administrative flexibility, a criteria we recommend evaluating with metrics including how effectively key actors are able to coordinate and the sorts of government policies that govern the energy markets. The greater the degree of coordination between asset owners, distributors, and regulators, as well as how future-oriented the corresponding policies of these actors are, the more adaptive the energy system is likely to be as it prepares for future challenges. The policies and regulations should be evaluated to consider how effectively they are prepared to adjust to new technology, new users, and respond to emerging stresses and shocks. Key to note here is that many of the aforementioned modernization indices already evaluate similar metrics, but we separate them here to assist the analyst to understand their value and ask the right questions about the network flexibility of their city of study in detail.

Another criteria that is incorporated into smart grid indices is the concept of demand responsiveness, or how effectively demand is able to adjust to changing circumstances. Demand responsiveness can be consumer- or producer-driven. "Strategies include financial incentives and behavioral programs to encourage demand shifts as well as direct utility control of a customer's appliances."[7] Again, this is considered distinctly from supply modernization as it is primarily a demand-side process that prepares the energy system to be more adaptive. Utilizing the aforementioned indices as a framework can be a helpful shortcut when and where applicable, but is important for an analyst to understand the supply and demand dynamics as complementary but distinct as they evaluate the energy system's adaptive capacity.

Coping Capacity

A city's energy system coping capacity is defined as the ability of the city's energy system to resist disruption and continue to have sufficient supply for its associated demand. A city under stress or experiencing a shock needs an energy system that is prepared to cope with said event, ensuring a reliable supply fulfills the demand of the city without significant interruption. To better develop the concept of a city's energy system coping capacity, we consider it to be a function of the following criteria: supply diversity, supply responsiveness, supply robustness, demand efficiency, and network protection and maintenance, per Figure 8.2.

CRITERIA	METRIC
Supply Diversity	Source Variety Source Balance Source Disparity
Supply Responsiveness	Reliability Dispatchability Energy Storage Capacity
Supply Robustness	Alternative transmission network pathways Interconnectedness Node centrality Resource security
Demand Efficiency	Buildings *Building Energy Rating (BER) scores* *LEED Score* Transportation *Vehicle fleet fuel economy* *Public transportation penetration/usage*
Network Protection and Maintenance	Critical system energy restoration plans Critical system "islanded" from main grid capability Maintenance Considerations Ease of access to maintenance points Repair costs

Fig. 8.2. Factors affecting Coping Capacity of Energy Systems

Supply diversity ensures that the energy sources that support the city are distinct enough to withstand a shock or stress. Supply diversity is informed by metrics including source variety, source balance, and source disparity. Source variety is defined as the number of groups of technologies present in the local energy production system, which is the basis for flexibility in response to shock or stress.[8] Source balance is defined as the share of technology groups in energy production, which demonstrates how much the region relies on one energy technology group in their energy portfolio.[9] Finally, source disparity is the qualitative difference between technologies, which demonstrates how diverse the technology sources are that underpin the energy system and facilitates response to emerging shocks and stresses.[10]

Supply responsiveness evaluates how well energy supply is responding to energy demand. Common metrics used across industries include evaluations of the percent of demand that is met throughout the day and reliability ratings. Supply reliability is also commonly evaluated by metrics known as the system average interruption duration index (SAIDI) and system average interruption frequency index (SAIFI), while there is an even broader discussion about electric grid reliability that refines the definitions and metrics.[11] We also recommend incorporating energy storage as a supply responsiveness metric. It is seen as a critical step for incorporating renewables and a major contributor to resilience in the electricity energy system. As electricity storage capacity increases, peak demand can be supplied through stored energy instead of requiring additional generating

facilities, and electricity can also be supplied when a stress/shock threatens either generation or transmission networks as well. We differentiate this sort of capacity from a more traditional strategic energy reserve capacity based on the employment of these capacities. In this criteria, energy storage facilitates dispatchability of the energy resource, particularly electricity, on very short time scales. Supply robustness, the next criteria, incorporates strategic reserves intended to replicate and/or replace whole-system energy supply for longer durations.

The final supply-side criteria is supply robustness, which includes metrics that evaluate the ability of the energy system components to adjust to challenges in the supply chain. The ability to deliver energy despite a shock or stress is contingent on the effectiveness of transmission, so we incorporate a consideration to evaluate whether the network has any sort of alternate pathways to maintain energy supply. Further, meshed microgrids and interconnectors between main grids can support networks to cope with rapid fluctuations in load and supply, as well as node failure, in order to maintain overall system functioning during stress and shock events.[12] Supporting this factor is an evaluation of generation and transmission node centrality. Electricity, for example, requires step-down facilities to take ultra-high voltage and transform it to more usable voltage levels. Node centrality evaluates how many critical distribution nodes there are in a given energy system and the ability to replace/replicate a critical node with alternatives.[13] A final factor considered within robustness is how secure the various supply sources are, which is a factor of source availability and strategic reserve capacity.

On the demand side, demand efficiency is the sole criteria developed for this framework, but more can be added as the field matures. The efficiencies of the primary consumers of energy reduce the demand for energy, which is critical to effectively supply sufficient energy during periods of stress or shock. Demand efficiency metrics can be considered across all sectors - transportation, built infrastructure, construction, etc. There are already some indices designed to evaluate demand efficiencies in key energy consuming sectors, such as LEED scores or Building Energy Ratings for buildings and the UN Economic Commission for Europe's (UNECE) WLTP procedure (world harmonized light-duty vehicles test procedure) or the US Environmental Protection Agency's (EPA) fuel economy standards for vehicles. For example, a building's LEED Performance Score evaluates a building's sustainability and efficiency based on performance data on energy, water, waste use, transportation and human experience.[14] While LEED scores cover a broader range than just the energy system's efficiencies, the index is informative. Ultimately, more efficient demand-side actors reduce the burden on the energy system, minimizing the likelihood that a disturbance on the supply side would hinder the urban system's ability to cope with said disturbance.

While fairly straightforward, the energy system's coping capacity is also a function of how well the network is protected and how well it can be maintained or repaired. Within this criteria, we incorporate metrics that evaluate whether or not critical systems can be isolated, or "islanded," from the main grid: for example, can hospitals withstand an electricity outage through their own generation and storage facilities, or can geothermal systems support building heating requirements despite interruptions in natural gas/coal/oil supplies? Supporting this effort is a metric evaluating if these critical systems have energy restoration plans. If government agencies have a plan for how to manage disruptions and phase back restoration capability, the city is more likely to be able to cope with the disruptions. Restoration efforts are complemented by maintenance considerations, such as how easy it is to access key maintenance points and how expensive the systems are to repair.

Expectancy Benchmark

A city's energy system expectancy benchmark is defined as the minimum threshold of energy services expected by a collective urban population to maintain a standard of living. Energy system expectancy benchmarks are the minimum energy delivery expectations of an urban area, above which daily activities occur, and below which social unrest is more likely to occur. Different cities will develop different expectations for similar metrics, while some will expect completely different metrics. What is most critical for an analyst is not to adhere strictly to the list of criteria in this section, but to understand that these criteria are designed to help ask the right questions for how they analyze information about the city they are assessing.

For example, a common metric for most cities is the reliability of their energy system - how frequently their energy systems are interrupted, how long those interruptions tend to last. While this metric may be used across many cities, the level of expectation will change between cities, for various reasons. Part of the foundation for this benchmark is prior performance: citizens adjust their expectations based on the norms they've experienced. Across the United States, outage frequency and duration change dramatically, and we should expect expectations to adjust in parallel.[15,16] Sub-saharan Africa provides another example of how expectations change and behavior adjusts, such as in Lagos, Nigeria, where frequent outages are the norm, not the exception, resulting in individuals and businesses taking measures into their own hands to meet their own energy needs.[17,18]

Another potential metric is the speed of restoration of service after a shock or stress, and the amount of information the utility provider is sharing with the public about the outage and recovery process.[19,20] Expectancy benchmarks in the energy system could also include the price of the energy commodity and the potential for pollution or other negative externalities of the energy source(s). Different cities, of course, will have different thresholds for their expectations about these metrics, while there are certainly other considerations that can be incorporated on a case-by-case basis.

What's more, the level of expectation is not static - external circumstances can change the benchmark.[21] For example, in California, citizens in large cities anticipate power outage frequency changes by month, and have now come to expect utility-planned outages "during hot, dry days with sustained winds or strong gusts to prevent power lines from sparking wildfires and threatening human lives.[22] Similarly, following certain stresses or shocks, such as extreme weather events, most citizens tolerate outages lasting anywhere from minutes to days, depending on the seriousness of the incident, without resorting to protests or riots. The key for analysts when assessing the expectancy benchmarks of the energy system are to understand the dynamics of the potential metrics to incorporate and how the urban perception of the energy service adapts to changing circumstances.

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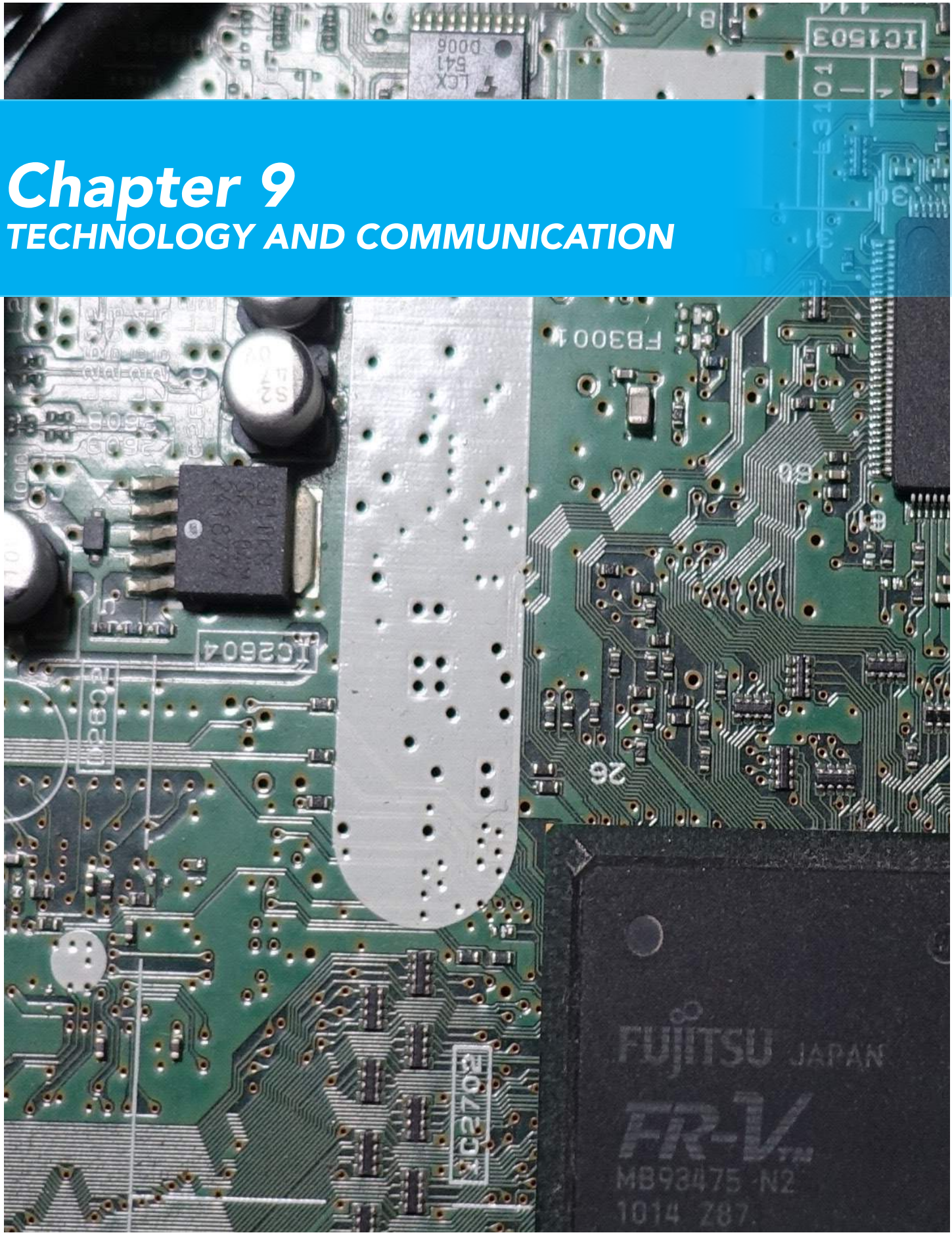
Chapter 9
TECHNOLOGY AND COMMUNICATION



Technology Introduction

The urban environment is a human-dominated ecosystem, and the development of technology largely changes the organization of such a system, shaping the lifestyles of citizens through information exchange, creating flows of trade and migration, and building new networks and relationships.[1] Technology and communication are important to urban stability as well as development due to them providing an effective approach to resource management and facilitating individual involvement, helping to ensure an adaptive and resilient city.[2]

The technology capacity of a city involves the use of big data, Artificial Intelligence (AI), cloud services and computing, and numerous other advancements that can strengthen the information foundation, skills, and knowledge of the entire population. Technology also creates learning opportunities, thus engaging low-income community members as well as more privileged groups across societies.[3] Most recently, improvement of online technology has fostered the emergence of new business models and strong, growing industries that provide various online goods and services, a trend which also increases the complexity of the financial system and supply chains. In the long run, high-tech and creative industries can even shape the economic structure, growth pattern, and living-style of a city.

The development of technology also plays an important role in telehealth and telemedicine, solving the problem of long-distance travel resulting in unavailability, thus providing affordable medical care and education for less developed areas. The usage of technology at the government level is also broad, such as digital solutions that can improve infrastructure functions as the Internet of Things (IoT) connected sensors help to predict and react to breakdowns in the system.[4]

The remote sensing infrastructures and databases can then be used to build up more efficient transportation networks, guarantee cyber security, recognize crimes, and even forecast incoming disasters. Information and Communication Technologies (ICT), Global Positioning Systems (GPS), and Geographic Information System (GIS) are all used in risk disaster management, and allow for the allocation of resources after the disaster while reducing secondary disasters.[5] These information databases can also be used to calculate the costs and benefits of each measure in the reconstruction period, permitting nations and cities to share their disaster information, data, effective and ineffective measures, and key solutions for faster future responses. Big technology companies can also help set up infrastructure, for example, such as Google's balloon project that was used to provide emergency network connectivity in Puerto Rico after Hurricane Maria.[6] Clearly, technology is foundational to a city's current and future context by building up an information system, and is a key component to understanding and reacting to stresses and shocks.

Meanwhile, we should not only consider the development level of technology, but also citizens' access to it. This includes the prevalence of technology infrastructures, a mature legal system for online business and intellectual property, people's acceptance of technology products such as e-payments, and the adoption of using the internet and media to participate in social discussions. The system capability of telecom operators involving electronic and digital technologies is also important, whereby the utilization of network infrastructure is fundamental to supporting economic and political efficiency and to enabling social, cultural, and urban development. When a disaster happens, large parts of the telecommunications infrastructure can be

destroyed or incapacitated for several days and those systems that do survive may suffer overloads.[7] The failure of one system can then lead to more failures, making it impossible to transfer information.[8]

The term 'smart city,' also connected with the concept of digital city, shows a future development of urban areas, where technology and information management can be used to make intelligent responses and provide services.[9] A general goal of smart cities is to improve sustainability with the help of technologies. However, the high digitalization and technological level may expose the city to an increased risk of cyber-attack, sudden breakdowns of communication systems, and challenge traditional industries. For example, as New York City seeks to enhance its technological resiliency and protect its increasingly digitalized infrastructure and services, a city-specific Cyber Command was created in 2017 in order to consolidate and centralize its own cyber defenses in order to defend the collective city cyber backbone.[10]

With the sharing of opinions and communication amongst different groups, society develops based on common values and motivates people to collaborate.[11] The technology revolution further facilitates communication methods and whole social networks. As a result, media and internet have had both positive and negative influences on urban stability, wherein enhanced communications can further the sharing of either positive or negative sentiments, information, and views to vast portions of the population.

With the spread of PCs and mobile devices, people now have access to more complex communities and their government, and even low-income groups can be included in social activities such as voting, social empowerment, and neighborhood activity.[12] Social media platforms allow people to reach out for self-education and to self-organize within their communities, build trust and social bonds, and create new forms of story-telling for people to have detailed and constructive interactions.[13] Rural areas can also be included in larger discussions and participate for their own benefit with low-cost communication and debates happening on the Internet and other media platforms.[13] Thus, the usage of media helps to eliminate the gap between public and individual, urban and rural areas, and regional and national decision-making processes.[15]

The internet and media can also be used in emergency responses and for reconstruction. For example, ICT systems can provide timely and effective delivery of early warnings to individuals and communities at risk, and they can better understand threats, share awareness, and take action more promptly. People may get information from Twitter and Facebook faster than official channels, which facilitates taking immediate action to protect themselves. It can further provide rapid two-way communication between local people and government, including information exchange with front-line responders and while looking for family and friends.[16] The internet is also useful in public education and for panic alleviation, as people are able to get information and instructions from experts and the government directly.

On the other hand, although media offers opportunities for community engagement, it may also cause difficulties when the goals of certain projects do not correspond to differing expectations of the community, resulting in the ability to make rapid public denouncements.[17] Meanwhile, being connected to a global network enables local communities to become part of larger global economic, social, and cultural spheres. This then creates connection and dependency on outside resources and information, and the society may become more fragile while facing opinions with conflicts and disagreement.

Furthermore, the use and adoption of new technologies can deepen inequalities[18], as areas with rich resources and opportunities could support the latest and make better use of

technologies compared with those with initially lower endowments.[19] With the potential self-educating ability and group polarization caused by social media, the internet may strengthen biases and a sense of inequality. As modern media spreads, it is important to consider the original, imbalanced stability levels of different cities, not to mention neighborhoods within cities. Areas with unstable foundations, such as communities incorporating new migrants or facing other socioeconomic stresses, may show less resilience when further technology-inspired changes occur.

Adaptive Capacity

Adaptive capacity is "the ability to plan, prepare for, facilitate, and implement adaptation options, typically targeted towards unanticipated threats." This capacity requires a systematic decision-making process and amicable interaction with and among citizens, as well as a highly flexible technology and media foundation that can adjust to the conditions at hand. Two of the primary contributors to this flexibility are in the city's ability to make policy through technical assistance as well as its ability to affect social awareness through technology.

Policymaking Efficiency

For the central government, it is important to have the ability to conduct long-distance exchange of information with local governments.[20] Official departments can use urban planning tools, computer-based analysis tools, and systems dealing with maps and various kinds of data to realize a more digitalized decision-making process and digital governance. Determining whether a city has some version of this capacity could be partially determined by the number of digital talents (such as people working in high-tech companies or R&D departments) involved, the number of services accessible online, and the number of mobile services provided by the government, and the approval ratings in customer satisfaction surveys, such as those asked during the establishment of e-governance in Singapore.[21]

After the application of technology, it should also be asked whether the technology-enhanced policy-making process actually becomes more transparent and democratized, and whether it actually facilitates public and private services

delivery.[22] Some interviews and surveys could be conducted to see if the services improve scientific and political education, facilitate the approval process of decisions, and increase public engagement in community issues.

It is also important to ask if the government cooperates with private and commercial enterprises to propose a recovery plan. For example, in Japan, a "BCP" (Business Continuity Plan) is built in order to minimize damage in the event of a disaster, wherein the government and large businesses prescribe action guidelines in the event of an emergency to quickly rebuild systems and resume business.[23] The plan includes information management, collection and sharing. The existence of these types of efforts will help assist in determining the overall adaptive capacity of a city, contributing positively when many of these aspects are in place or negatively when the city appears underprepared to adapt and work to its fullest capacity.

Social Awareness

The content of social media can sometimes be influenced by communication strategies, and 'objective' data may also lead to a 'subjective' discussion, and thus some investigation highlights the importance of leadership of key persons and their ability to affect overall social awareness through dialogue and communication. Key opinion leaders help to establish social awareness since they can filter fake information, lead the discussion, and form hot issues. In China, some changes in legislation, government reaction, and social awareness happened when the key persons realized a problem and raised it to the public. For example, in 2007, following public outcry over pollution in Tai Lake and insufficient government response, the central government quickly punished the related officials and increased regulations for industrial pollution.

Additionally, following a 2016 scandal regarding illegal vaccine sales, the central government published new regulation on vaccine circulation and management in as few as 36 days. Therefore it is necessary to count the number of key opinion leaders, their potential network reach, and the influence of parties involved.[24]

Another question is about the accessibility of information, information distribution, and transparency.[25] Evaluating a city's ability to adapt to changing social awareness patterns can be partially measured by whether there are effective measures to control false information, the leaking of information not intended for public audiences, and the impact of false information on social media; both in a social context as well as whether technical solutions exist for the same purpose.[26] Another evaluation criteria is whether there are means for easy and open access to government information, such as annual budgets and other public databases. In some cases, the government may publish manipulated information or instant updated news without fully confirming authenticity. The measurement is still the diversity of resources and the transparency of information.

Coping Capacity

Coping capacity is "the ability of a city to avoid irreparable damage from which it is unable to recover," and technology and media both play an integral role in a city's ability to absorb and respond to disruption. In order to deal with irreparable damage caused by disasters such as earthquakes, hurricanes, floods, and other significant shocks, there must be a quick response from both the government and individuals in order to mitigate further harm and cascading effects. Collectively, using the predictive capabilities of technology combined with its communicative abilities and media's reach, large portions of a city's population can be updated almost instantly, supporting the notion that both play a major role in a city's overall coping capacity.

Prediction and Preparation at the City Level

One important question when evaluating a city's coping capacity is whether the government has the capability to predict some disasters with the continuous development of the information and technology systems. This can be determined by evaluating its use of big data, ICT, GIS, GPS systems in risk disaster management, and whether the city developed digital solutions for its fundamental infrastructures, as well as the ability to quickly respond when systems break down.

In addition to making predictions, the city's preparedness also needs to be considered. One consideration is if the city has the ability to deal with the stressors such as sudden stops of electrical power and breakdowns of signal towers after disasters, and also the ability to reduce the chain reactions among those and related systems. Whether the government has a system of preparedness including mass media at the time of disaster, and whether the information environment is strong enough to use during the event are both important evaluation considerations, which could be adjusted according to the individual experiences of each city.

Community Response

Another important question is whether the public can be provided with safety information from a wide range of information sources. Firstly, devices including mobile phones, computers, and televisions should be checked against existing data to determine the internet penetration and the percentage of active users of the total population using mainstream social media. Secondly, effective and redundant mediums should be identified such as radio, television, broadcasting, and the internet. Thirdly, it should be determined whether there are already regulations to prevent or systems to monitor the spread of fake news and disinformation. By collecting and evaluating these three things, the city's overall ability to meaningfully and reliably connect with and provide appropriate and timely accurate information to its populace can be determined.

It is also important to address the ability to build up community response based on the information. At the time of the Great East Japan Earthquake, social networking sites such as

Mini-Case: The 2016 Kumamoto Earthquake[27]

Within 14 hours after the Kumamoto earthquake, one of the main issues was the loss of critical communication infrastructure. When an earthquake occurs, communication networks can be cut off, resulting in the loss of internet access in places where information is really needed, such as in the disaster area itself. In fact, in areas affected by the tsunami in Japan, it took about a month for the full restoration of the telecommunications infrastructure, and some places were essentially turned into an isolated island that lost effective communication with the outside cities. Interestingly enough, the 2016 Kumamoto Earthquake actually occurred while local governments and businesses were strengthening their disaster countermeasures. After drawing lessons from the 2011 earthquake of the Pacific coast of Tōhoku, in the Kumamoto Earthquake, there were relatively more areas where communication services were available when the disaster occurred. In 2011, 12 cabinet meetings were held to discuss the problems in response to the earthquake and methods to improve the emergency management system. During the Kumamoto Earthquake, the central government and local government responded in five minutes. NHK (Japanese Broadcasting Corporation) cut off the regular TV program within 30 seconds after receiving the warning and continuously broadcast information about the disaster.[28] The time required for restoration was shorter than that of the Great East Japan Earthquake, and almost two weeks after the occurrence, the restoration was almost complete.

Twitter and Facebook were especially useful for information dissemination, assisting with the search for missing people, and sending support messages to the affected areas. The Kumamoto Earthquake Resource Map, which displays information such as shelters, supermarkets, restaurants, and gas stations on Google Maps, was operated by volunteers from students, showing the great power of supporting disaster-stricken areas.[29] In addition, Kumamoto mayor Kazushi Onishi called on the citizens on Twitter to further encourage the dissemination of information on the affected areas.[30] In this instance, the availability of such a reliable source of information greatly contributed to the prevention of confusion caused by hoaxes and misperceptions.

Expectancy Benchmark

The Expectancy Benchmark shows the collective belief of the urban population on the city's ability to maintain a standard of living within a certain range in response to disturbances. Technology and information not only influence current activities, but also create economic activities and entrepreneurs that rely heavily on information and knowledge; their expectations on how technologies will continue to operate during disruptions is of considerable significance. These expectations further shape the majority of the population's perspective of what a future city should look like.

Overall Development

As technology assumes a larger role in modernizing economies, a city undergoing a stress or shock is faced with the question of how they expect technology to impact a response to that event. It should be considered that does the city have enough technological resources such as well-educated workforce, sufficiently resourced industrial or academic clusters to recover? Will technology assist the city's recovery, or will an over-reliance on technology overwhelm the recovery process? Will an R&D center shoulder the role of collecting information and offering technical help to the local residents and government? A high level of technological development within a city may lead to high expectations regarding the continued role of technology, regardless of the circumstances, thus leading to a negative score for a city's expectancy benchmark if the population feels the city is not well prepared to fulfill this. Conversely, a city with a heightened level of technological robustness may have a positive score in this regard if its citizens realize this and the city is able to deliver.

Mini-Case: CenturyLink Network Disruption

In the early morning of December 27, 2018, CenturyLink experienced outage across the US on its fiber network that lasted for almost 37 hours, affecting 22 million customers in 37 states across the United States and blocking or degrading an estimated 12,100,108 calls.[31] The outage also affected communications of state government entities such as the temporary shutdown of phone services and network isolation, including 911 calls handled by CenturyLink, as 8.4 million users potentially lost the ability to call emergency services. According to the Federal Communications Commission, these interruptions were deemed "completely unacceptable, and its breadth and duration [as] particularly troubling.". In addition, this outage also impacted other service providers such as AT&T and Comcast. This case demonstrates the need to maintain a response plan for critical ICT systems - otherwise, an overreliance on a system can lead to a total collapse and an inability to meet expectations.

Citizen Participation

Creative expressions on social media will lead to an expectation for innovative approaches to community engagement in the urban planning process, as well as a level of continued availability through disruptions. The city should be evaluated on its capacity to deliver new media techniques and provide guidance and training resources to its population, and to ensure that these benefits are continuously available.[32] The ability to overdeliver when expectations are otherwise low may result in a positive score, or an instance where simply delivering the high level that is already expected may do the same. A negative score may be the result of a lack of any of these abilities, or from a population that has had cause to doubt the ability of a city to maintain its current level, either through historical perspective or by some other means.

Governing Capacity

Governing capacity, aided by technology, is expected to further address questions on environmental sustainability, public health, social equity, mobility, and economic development. The city's technological ability can be evaluated based on data regarding the city's efforts towards leveraging technology to pursue environmental improvement, medical capacity, the self-sufficiency of low-income families, and the GDP contribution of technology-related industries.[33]

A city's ability to harness technology in its continued development and recovery from disruption in regards to maintaining low-levels of environmental pollution and overall environmental sustainability are increasingly important to much of the world's urban population. In this regard, some cities may have the expectation that cities will utilize mostly or only "green" technologies and solutions, even when recovering from disaster, and may negatively view a governing body that fails to acquiesce to this demand. However, other cities may not give much thought to such issues and thus have very low expectancy benchmarks. In these circumstances, the government is likely to meet, or even exceed, the expectancy benchmark if it takes its own initiative or is otherwise pressured by outside influences. Less technologically advanced cities may give little or no consideration to the application of technology towards sustainable government and recovery, and the evaluation of their expectancy benchmarks would reflect that as well.

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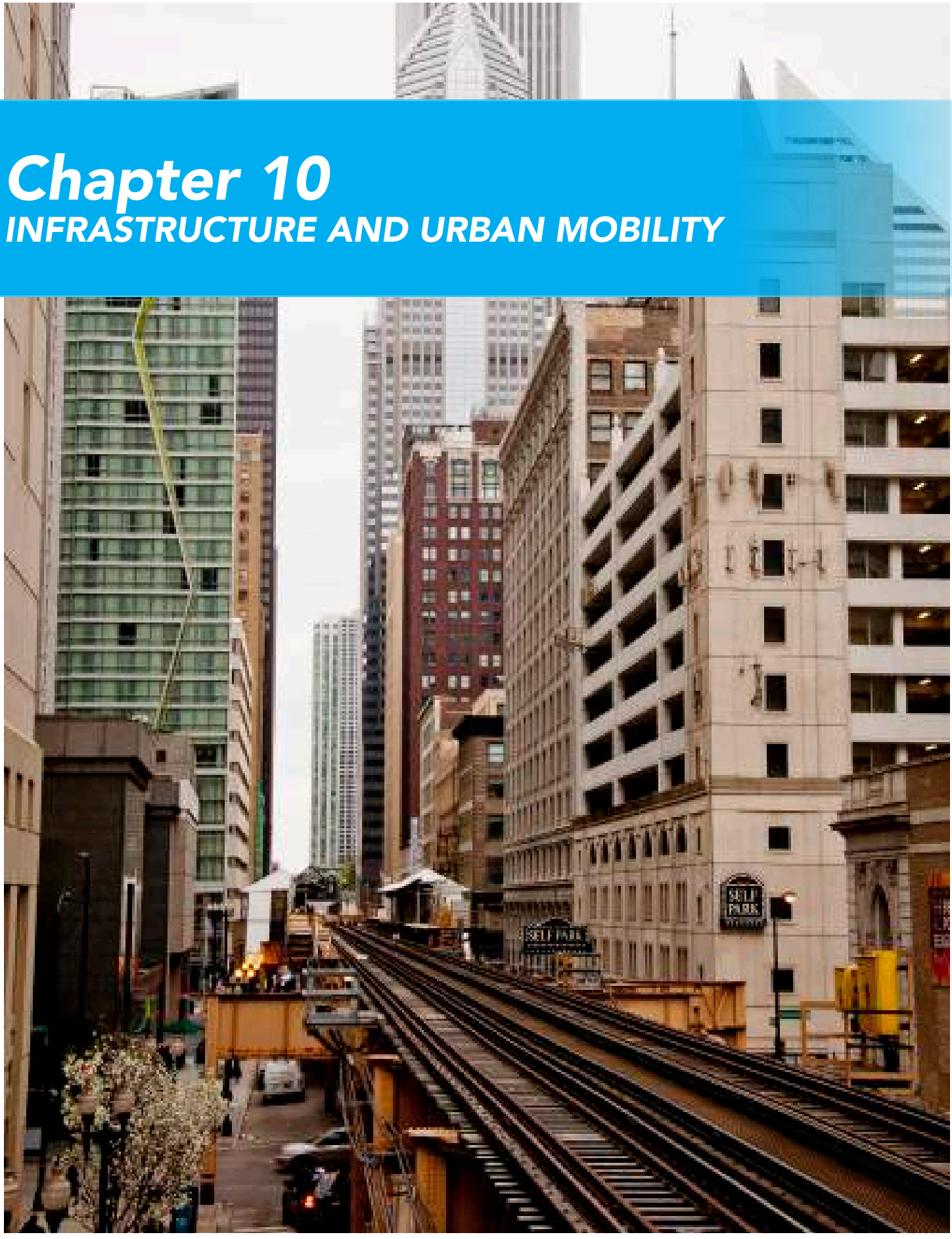
Chapter 10
INFRASTRUCTURE AND URBAN MOBILITY



Introduction

Infrastructure is a key component of every city. Cities are often most identified by being centers of public infrastructure, the places where dozens of highways, bridges, tunnels, railways, and airports converge. Millions of people depend on this infrastructure to work for them, to facilitate their commutes, to transport goods for sale, to keep their homes and businesses clean, and to enable social connections.

Infrastructure used to transport people and goods forms the arteries and veins of the city, but much like the analogy suggests, disruption to any of these pieces of infrastructure can cause major damage to a city's social, economic and political fabrics to the point where it can cause instability. A key component of urban infrastructure is the mobility it provides to citizens, who can drive cars, ride motorcycles and bicycles, and walk around on the city's streets, and take various forms of transportation provided by government and private enterprise.

Broadly speaking, the adaptive capacity of infrastructure refers to its ability to act flexibly within changing circumstances for the benefit of urban stability; its coping capacity refers to its ability to handle the strains of various potential disruptions and continue operating; and its urban expectation threshold as the performance expectation of the infrastructure assets to its citizens.

The inherent ability of infrastructure and urban mobility to provide stability to citizens depends on five principal factors, as shown below and as broken down between the above capacities:

1. The criticality of individual infrastructure links to the overall urban form

2. The extent to which mobility depends on fixed-guideway infrastructure

3. The operational and access characteristics of urban airports to contribute to relief efforts

4. The vulnerability of key infrastructure to climate-induced disruption

5. The extent to which urban mobility depends on institutions to operate infrastructure assets.

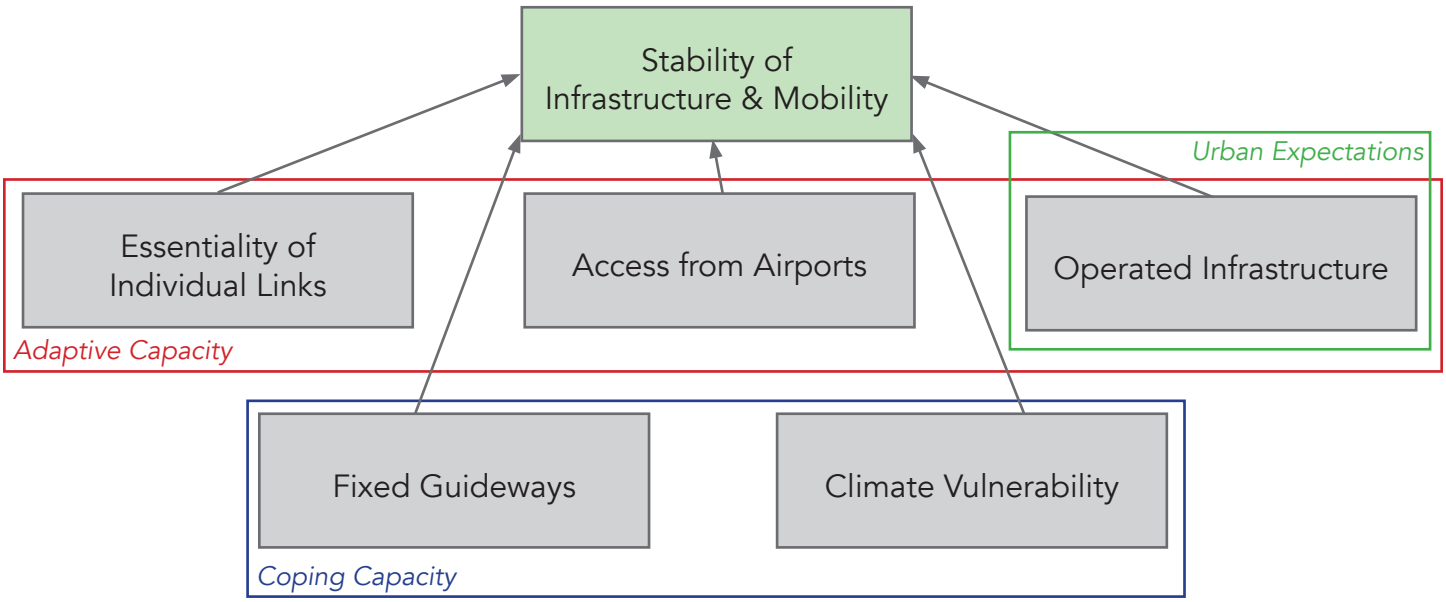


Fig. 10.1 Factors and metrics associating Infrastructure and Urban Stability

Adaptive Capacity

CRITERIA	METRIC
Link Essentiality	Proportion of trips taking place over key single-link infrastructure assets (bridges, tunnels)
Infrastructure Flexibility	The extent to which physical mobility infrastructure can be rerouted or adjusted to maintain appropriate levels of service during a disruption.
Institutional Adaptation	The extent to which government institutions, labor unions, and other bureaucratic functions responsible for infrastructure operations and maintenance can reorganize in response to a disruption.
Airport Equipment	Airport runway length, parking space, tarmac quality, fueling and maintenance capacity
Highway and Road Network	Ability to leverage road infrastructure to distribute resources, based on quality of infrastructure, capacity, and network

Fig. 10.2 Factors and metrics associating Infrastructure Adaptive Capacity and Urban Stability

Fig. 10.3 A jet transport aircraft landing at the Mineta International Airport located in downtown San Jose, Calfifornia.

Link Essentiality

The reliance of a city's functions on a handful of pieces of infrastructure that each deliver a significant amount of necessary capacity is key to understanding how the city functions in the case of a disruption to that piece of infrastructure.

For example, New York City's Manhattan Island is physically separate from the New Jersey and New York mainland, but features twelve road crossings that provide access to the island as well as twenty separate rail crossings.

These ensure that if one or more of these links are disrupted, there are other methods of ensuring outside help can reach the island.

Similarly, if a situation of civil or political unrest, such as a large protest, blocked one of the tunnels or bridges, the remainder of the links would generally be able to accommodate diverted traffic with minor to moderate delays.

This approach is similar to the approach an investor might take to distribute risk across a stock portfolio. By investing in multiple different industries (in this case, modes of travel within the city), the investor protects against one industry experiencing a disruption. The same is true with the criticality of each infrastructure connection for a city.

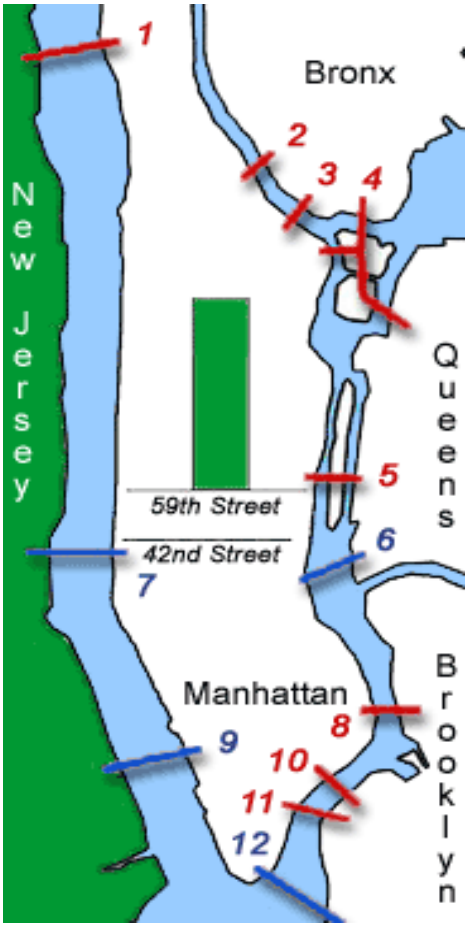


Fig. 10.4. Twelve river crossings connect Manhattan to different borouhgs of the city, as well as the New Jersey and Bronx mainland.

Infrastructure Flexibility

Assessing the flexibility of fixed infrastructure depends on whether mobility can be assured around a localized disruption. This crucial aspect of stability depends largely on which infrastructure assets the city is most dependent on, and how critical each one is to the functioning of the city.

A key factor in this is whether there are alternate routes of infrastructure capable of connecting two important destinations if the primary link is severed, and how easily and quickly resources and/or people can switch to these alternates. In urban resource systems, this depends largely on the design of water, sewer and power systems and whether or not there are alternate mains and transmission lines so that the service can continue to be provided.

Mobility can be largely conceived in the same way, with roads, bridges, tunnels and railways being the "transmission lines" However, this also depends on the mobility modes used in the city. A rail system's lack of overall divertability and flexibility in a crisis situation, as elaborated in the Coping Capacity section, may render it unadaptive and inflexible. More free-flowing transportation such as buses or personal vehicles have the ultimate flexibility to be able to travel around a disruption completely while still preserving the intended overall origin and destination.

Institutional Adaptation

Whether or not a city can adapt to a crisis depends on the quality of its government and private institutions to respond to the crisis. These institutions will likely be responsible for directing policy and operations in the midst of a crisis and leading both managed and operated infrastructure.

This will depend on existing governance factors, which are further elaborated in the Governance section.

Airport Crisis Response

The infrastructure characteristics of a city also determines its capacity to bring in outside resources. In an HADR situation, most supplies would arrive at a city by air in order to provide the quickest possible response. The extent to which this aid could support a city and reinforce regional stability depends not only on having a functional airport or airbase within the region, but also having appropriate infrastructural links that can distribute this incoming aid.

While resources may be brought in using other means such as rail and sea, airborne aid or resources are more critical to maintaining stability since they can be deployed far more quickly due to the higher speed of airplanes relative to rail or seagoing modes. While rail and sea have a higher carrying capacity, they may not be able to arrive at a city in crisis in enough time to preserve stability and respond to immediate needs.

There are four principal assessments to determine the extent to which a city's airport(s) may serve as stabilizers of a crisis situation:

Whether the airport's runways and parking facilities handle the level of traffic consistent with the extent of aid needed
Whether the airport's critical facilities (air traffic control, radar, lighting, instrument landing systems, terminal buildings) are expected to be available and operational during the apex of the crisis

Whether the airport has (or can bring in) the necessary equipment and personnel for unloading, allocating, and distributing the resources flown in

Whether there is a sufficient distribution network through existing roads and rolling assets (i.e. trucks. trains) to transport resources from the airport to the specific disrupted area(s).

Mini-Case: Haiti's 2010 Earthquake

Unfortunately, none of these characteristics could be said of Haiti when an earthquake struck the country in January 2010. Significant infrastructural challenges delayed the disaster relief effort, many centered around the Toussaint L'Ouverture International Airport located in the capital city of Port-au-Prince (PAP).

While numerous overseas organizations, including the United States Military, contributed large volumes of aid, PAP could not handle the influx of large transport aircraft.[1] Damage to the control tower and radar equipment made PAP virtually uncontrollable, reducing the number of aircraft which could land or take off in a given hour.[2]

The airport had a long runway, but minimal parking space since it previously only handled 10-20 flights per day Later, the airport ran out of fuel, stranding airplanes on the valuable tarmac space.

Additional damage to the road network in the capital city made it incredibly challenging to move aid away from PAP, further contributing to a bottleneck at the airport. Many resources were not moved off the tarmac for weeks, with thousands more deaths as a result. In the resulting chaos, many flights were diverted to the Dominican Republic, but had no way of reaching Haiti until the airport could be reopened. As a last resort, supplies were parachuted into certain regions from American C-130s.[3]

Had a coordinated HADR effort previously assessed the infrastructural challenges faced by PAP, a better-planned aid effort could have been undertaken that would not have exposed these supplies such major bottlenecks. This approach would have taken into account that the airport would be a factor driving instability and not the other way around.

Fig. 10.5 The US Navy landed helicopters in the grass adjacent to the Toussaint Louverture airport in Port-au-Prince.

Coping Capacity

CRITERIA	METRIC
Operated and Managed Infrastructure	Ratio of operated to managed infrastructure
Containment	Ability to contain managed infrastructure (legal, operational and physical)
Rail Mode-Share	The extent to which mobility depends on less-flexible rail infrastructure.
Governance Environment	Building codes and regulations that impact the quality of infrastructure.

Fig. 10.6 Factors and metrics associating Infrastructure Coping Capacity and Urban Stability

Rail Mode-Share and Divertability

Rail is a particular weakness in terms of coping capacity, since rail systems are one of the least flexible modesof transportation. Since trains are reliant on the location of tracks, they cannot easily be rerouted to fit a changing crisis situation, unless the rerouted area is also equipped with tracks and all the requisite equipment (signals, power, etc.) for the safe operation of a train. Unlike a street grid where pedestrians, cyclists, cars and buses can simply use a different street, trains—particularly in dense urban areas—cannot easily be diverted.
This means that small, localized disruptions can cripple a rail line and thereby, a distribution system of goods, resources, and people.

Rail's lack of divertability also posed significant challenges in situations of political unrest. A series of blockades by indigenous rights groups led to major closures of the Canadian railway system in 2020, causing massive disruptions to freight and passenger travel. By blocking tracks in a small number of locations, protestors managed to cripple the entire network.[4] Since rail is often one of the highest-capacity methods of transportation and boasts a very low per-mile operating cost, it often becomes a key link in regional supply chains as well as passenger journeys. Its low level of resilience to even localized disruptions can cause instability for cities and supply chains which depend on rail.

Containment

Infrastructure is not necessarily only relevant in its ability to move people from one place to another. In fact, its contribution to stability in a crisis might be just the opposite. Control over infrastructure —my governments, companies, or institutions—may be leveraged as part of a crisis response.

More broadly, the prevalence of public transit usage in a city can cause a large impact to its resilience. For example, in the case of the COVID-19 pandemic, public transit reliance became a significant weakness for a number of cities, in particular New York City.

With citizens unable and unwilling to spend much time in such close proximity on the subways and buses, many people without other forms of transportation were stuck at home. At the same time, the fact that private car ownership is fairly low in New York City provided a form of de facto isolation, since people were left with no mobility options, which contributed positively to the government's ability to contain the pandemic.[5]

This presents an interesting conundrum: certain features of cities may reduce individuals' quality of life and living status during a disruption, but may in fact aid response and containment efforts.

Consider a situation, such as a pandemic or a situation of civil unrest, in which it is imperative to limit the movement of citizens. If most people in that city own a private car, limiting movements becomes much more challenging and requires authorities to stop each individual vehicle. However, if most people in that city use mass transit that is either government-operated or government-regulated, it can easily be shut down by executive decree—potentially stranding individuals but benefiting overall response efforts. Broadly, a city with greater proportions of operated infrastructure may restrict individual freedoms, but it can enable greater coordination in the response to a crisis.

Governance Environment

Effective regulation and capable institutions will result in mandated quality inspections and preventative maintenance of infrastructure assets, building codes which affect the build quality of infrastructure, such as whether highways and railways are earthquake-proof, and planning that mitigates any infrastructure project's risks both to and from the environment.

Not only does this play a role in assuring day-to-day safety, but regulations can also require certain levels of adaptive capacity to be available and deployed during a crisis.

Examples of this include:

Requiring flood-proof barriers to be available to protect a coastally located infrastructure assets

Requiring multiple backup water/sewer pipes to be constructed into a new development avoid potential blockages

Authorization of overtime work by infrastructure workers during a crisis event

Mandating the use of earthquake-proof building materials in an earthquake-prone city

Expectancy Benchmark

CRITERIA	METRIC
Infrastructure Performance	Relative performance (on-time performance and service effectiveness) of the transportation system
Operated Transportation Trip Share	Proportion of population using operated transportation systems
Personal Transportation Mode Share	Proportion of population with access to personal transportation (car, bike, motorcycle)
Governance Environment	Building codes and regulations that impact the quality of infrastructure.

Fig. 10.7 Factors and metrics associating Infrastructure Expectancy Benchmarks and Urban Stability

Infrastructure Performance

The extent to which citizens will expect their infrastructure assets to hold up in the course of a disruption will depend significantly on the facilities' performance outside of a disruption. A system which has low citizen confidence is unlikely to work better when it is most strained, however a high-efficiency, high-performance system which falters during a crisis may be a significant driver of urban instability. As a result, the extent to which infrastructure performance affects instability is not determined by its pre-crisis or post-crisis levels, but rather by the gap in between these performance levels.

Instability as relates to infrastructure can be affected by both direct and indirect considerations. Consider a disruption in a city heavily dependent on mass transit during which the transit network is closed down.

A direct consideration might be that essential workers cannot access their jobs. An indirect consideration might be that citizens feel unsettled and uncertain because they realize the crisis is of sufficient gravity to close down the transit system they depend on.

Because this stability is focused on individual citizens' expectations, using technical performance measures (transit on-time performance, water system flow rate, etc.) are not as crucial as measuring infrastructure user satisfaction. While it may not be feasible to create a scientific survey of customers, assessing social media and news media trends may help create a picture of overall sentiment that would help create qualitative pre-crisis and post-crisis benchmarks.

Managed, Operated and Personal Infrastructure

Mobility infrastructure can be broadly placed into two buckets: managed infrastructure, and operated infrastructure.

Managed infrastructure refers to facilities that are provided but upon which mobility is at the will of the user—such as sidewalks, roads, and bike lanes. An entity (usually a government) builds and maintains the infrastructure; however, it is generally open to be used when and in the manner desired by its users.

Managed infrastructure also includes various forms of urban infrastructure which is vital for modern urban city life. This includes the infrastructure necessary to provide water, sewer and power on-demand to the public.

Operated infrastructure refers to facilities which depend on the operations of a government or corporate entity, and when the facility is in use at designated times and/or on designated routes—such as buses, subways, and ferries. Rather than simply drive a car onto a road, the user arrives at a designated facility and waits for a conveyance to arrive at a designated time.

Crucially, all the operating parameters of the facility are established by the operating entity, not by the users. A subway system may be closed at night, for example, because the operating entity has chosen to do so. However, a bike lane or a road is not closed at night and remains accessible to any number of users.

Broadly speaking, cities with greater urban density tend to rely more on operated infrastructure, given the sheer numbers of people which need to be moved within them. This in turn means that these cities are more heavily reliant on the institutions that operate these facilities, and that in the event of a disruption event, these cities depend on these institutions' own ability to be resilient in the face of crisis. This is measured in their coping capacity and their adaptive capacity.

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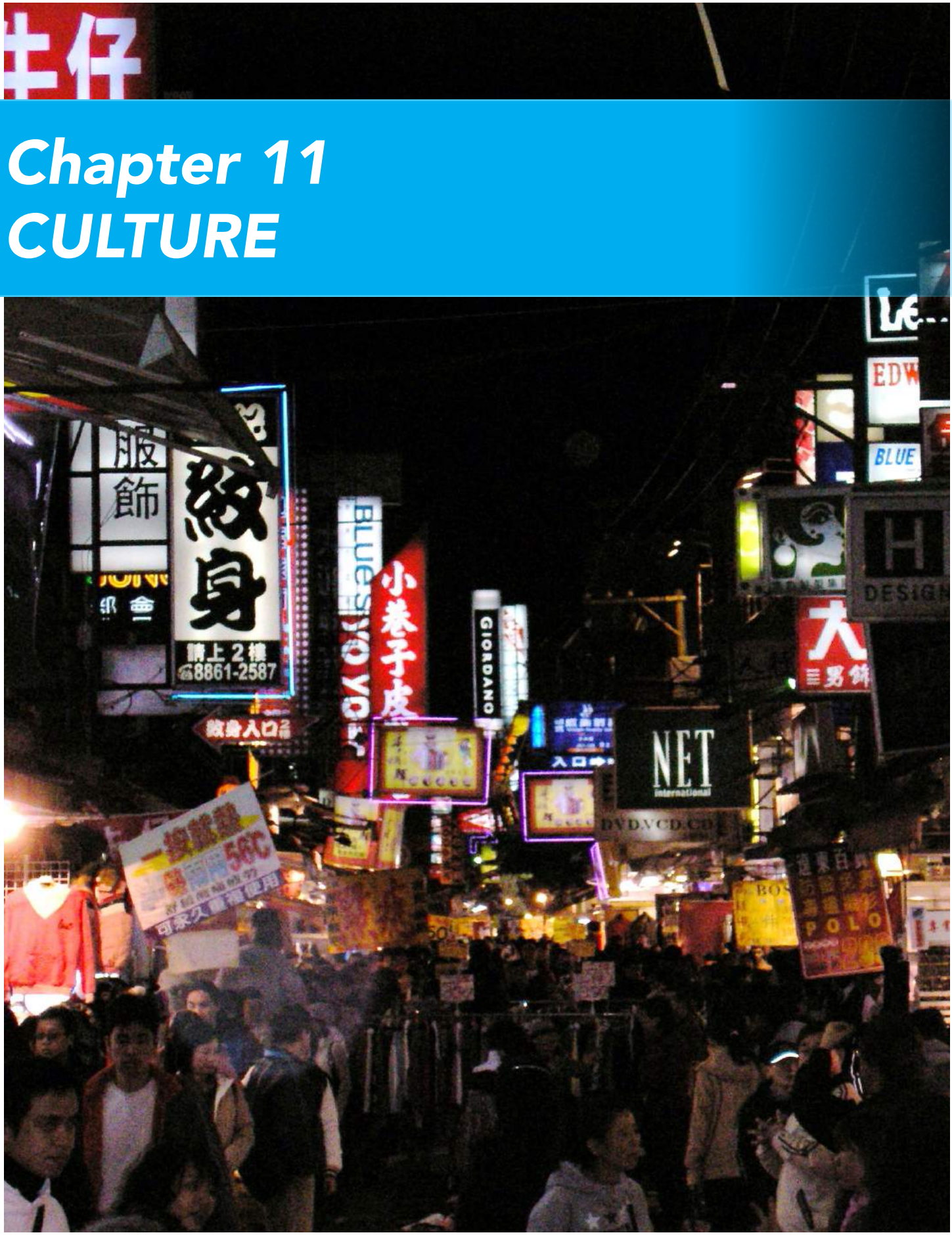
Chapter 11
CULTURE



Culture Introduction

When discussing the issue of urban stability, cultural and social factors are often placed in a dispensable position or directly ignored, whether it is to analyze the city's potential to resist disasters or the ability to recover after disasters. There are two main reasons for this phenomenon. First, whether it is natural disasters such as earthquakes, landslides or man-made disasters like riots, epidemics, they are all formed in a very short time and they affect or even destroy a city at a very fast speed. Even a disaster with a long incubation period, such as an epidemic disease, has a very rapid impact on an urban system after the outbreak. Therefore, when we study how to prevent disasters, we tend to focus on the direct solutions of defense which require short time to implement. However, most of the social and cultural factors impact the city over time which requires long-term thinking. The second reason is that social or cultural factors are often difficult to define and because of the problems involving different cultural values, it is difficult to form a unified standard. For example, in the face of an earthquake, if a city has an early warning system that can organize citizens to enter the fortification in advance, it can be agreed that the city has stronger resilience. But in the face of the earthquake, it is difficult to judge whether a city that believes in Islam or Christianity is more resistant. Although it is difficult to set a standard, these cultural factors have a great influence. Taking the current covid-19 as an example, in the face of the mandatory home quarantine policy, the East Asian countries like China, South Korea and Japan seem to be more cooperative with the policy. One reason is the citizens are deeply influenced by the spirit of self sacrifice in Confucian culture.

Cultural and social factors are often ignored because of these two reasons, so we list them independently in order to highlight their importance. Social and cultural factors are closely linked with residents in a way that affects the attitude of urban residents in the face of disasters, the level of residents' knowledge of disasters and the relationship between residents in the disaster period. In the face of the second reason in the latter paragraph, we try to avoid judging the value of different cultures and hope to form a universal measurement system.

In our definition, the stability of a city needs to consider three indicators: coping capacity, adaptive capacity and urban expectation. Coping capacity emphasizes the direct ability to resist disasters while adaptive capacity emphasizes the ability to prepare and plan alternatives in advance. In the four subcategories of this part, the community support considers the resilience of different groups of people within the urban area, especially vulnerable groups. The health care metric focuses on the ability of the urban medical system. Both of them are more inclined to measure the ability of cities to withstand disasters directly, and therefore contribute to copying capacity. The education and knowledge metrics focus on measuring social awareness and talent reserve. These two things strengthen the city's ability to create adaptive plan so it is used as a measure of adaptive capacity. The culture and identity metric served as a metric of expectancy benchmark. Whether it is traditional activities, identity or religious belief, this metric measures the spiritual world and subjective feelings of citizens. These subjective feelings will impact the response facing the crisis.

Culture Assessmemnt

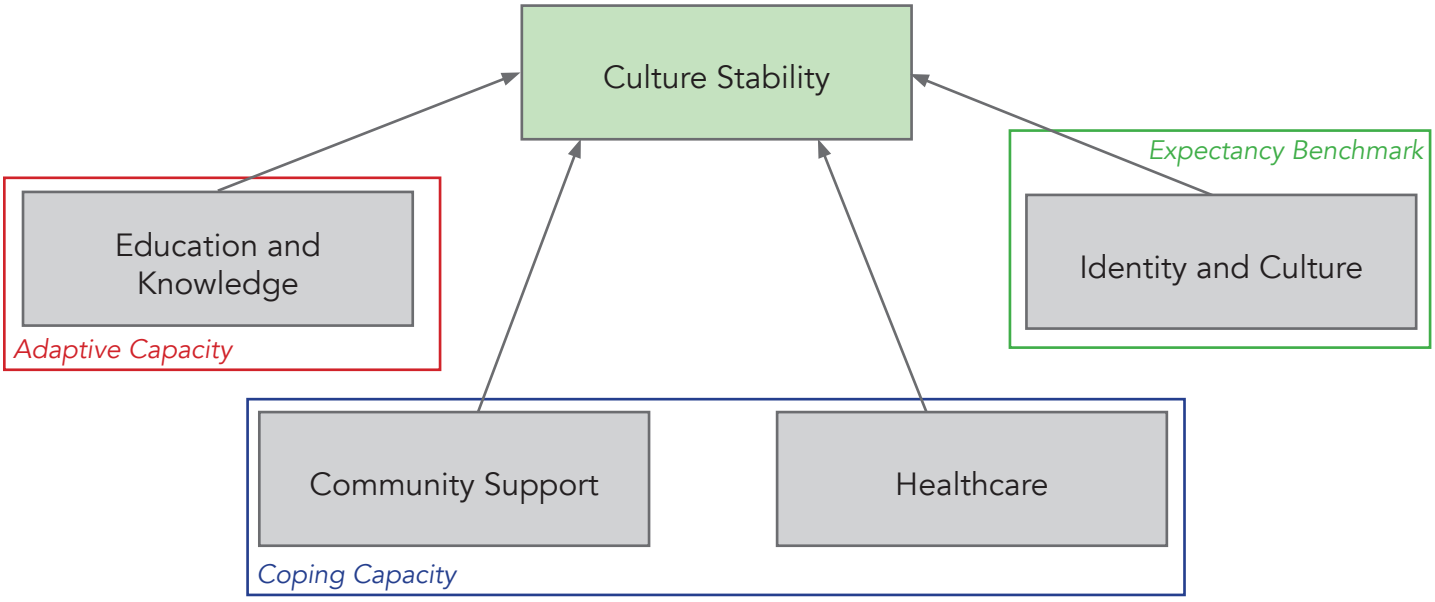


Fig. 11.1 Factors and metrics associating Culture and Urban Stability

Education and Knowledge

Education and knowledge are divided into three primary concerns. The first primary metric is an overall evaluation of the urban education system and residents' education level. The second primary metric is public awareness of disasters. If the education system provides relevant knowledge to the citizens, there will be a higher possibility for the public to have a accurate response to disasters. It is clear that no matter what kind of disaster happens, for a city, it is not only the work of the government but also the responsibility of all residents to manage a proper response. The more the public knows about a disaster, the more vigilant the residents themselves will be about it and the more effective preparations will be. On the contrary, the more ignorant the residents are about a certain disaster, the greater the damage they will eventually suffer.

There are two main ways for the public to have basic knowledge of disasters. First, the education system has carried out relevant education for residents since childhood. The second is to use media or public libraries and other public resources to publicize relevant knowledge to adult residents. Japanese cities are an example in this regard. Many cities in Japan are at risk of earthquakes every year because they are in seismic zones. Primary and secondary schools in Japan have taught residents relevant knowledge since childhood, such as where to hide when an earthquake comes, what kind of materials to store at home, etc. At the same time, local governments continue to carry out publicity through the media to strengthen residents' awareness of prevention. Although many cities in Japan experience earthquakes every year, most of the residents respond correctly and in a timely fashion. [1]

The other metric is the reserve of professional talent. The education system not only cultivates citizens' awareness of disaster prevention, but also cultivates disaster prevention professionals. In the face of disaster, cities need relevant talents to carry out policy consultation, scheme design and even participate in the first-line disaster relief. On the one hand, in the face of a pandemic, the city needs medical experts to give timely suggestions and specific programs. On the other hand, the city also needs a large number of doctors and nurses to participate in the treatment work. If a city lacks the reserve of relevant professionals, it will have to rely on external forces in the face of this disaster. And the delay or lack of external reinforcements will probably make the situation worse.

CRITERIA	METRIC
Education level of citizens	The percentage of population that has been educated The percentage of population that has least graduated from middle school The percentage of population that has least graduated from universities
Capacity of a city's education system	The numbers of middle school/university/kindergartens Average number of students of a middle school/university/ kindergartens Average numbers of teachers Geographic distribution Install rate of advanced teaching facilities(in-class computers, presenters)
Public access to knowledge	Public media anti-disaster propaganda The numbers of public libraries Online access to city's book resource How many citizens have used the public knowledge system
Disaster prevention education to the public	Disaster prevention curriculum in each level of education institutions Whether credits of disaster prevention course are included in graduation Regular disaster prevention drills organized by schools
Disaster prevention education in schools	Disaster prevention curriculum in each level of education institutions Whether credits of disaster prevention course are included in graduation Regular disaster prevention drills organized by schools
Professional talent reserve	Number of universities with relevant majors Numbers of officials in the government that possess professional background Research institutions focused on anti-disaster

Fig. 12.2 Factors and metrics associating Infrastructure Adaptive Capacity and Urban Stability

Healthcare

This section contains three main measurement directions. The first is risk prevention. In addition to the other disasters which make casualties that require the medical system, epidemics are the biggest challenge facing the medical system. Epidemics not only cause a rapid increase in the number of patients in densely populated areas, therefore overwhelming healthcare systems, but also have a great risk of infection for medical staff. Therefore, in the face of such a disaster, the medical system needs to carry out risk prevention in advance. From the point of view of public prevention, to guide public awareness requires a close connection between the medical system and education system. In addition, the medical system also needs to carry out physiological prevention work, including vaccine injection, epidemic disease monitoring and so on.The physiological prevention can reduce the possibility of spread of viruses which make the city safer. The second direction is the overall measurement of urban medical resources. The city's medical resources are divided into two main parts. Part of it is high end medical technology and equipment. This part examines whether the urban medical system has the capability to provide adequate medical care to a population. The other main measurement is the proportion of medical resources to the population. This metric examines whether the medical resources of the city can be effectively and fairly allocated to most of the residents. The third direction focuses on the ability of medical supply in an emergency situation. In a disaster, the needs and operation management of the medical system are different from those in normal time. Emergencies require the healthcare system to have stronger ability of fast response and greater capacity.

CRITERIA	METRIC
Health risk prevention	Percentage of children 12-23 months who have received specific vaccines Health education programmes that implemented in the city Public awareness of the risk of certain disease and the methods to prevent them
Healthcare resource	Number of physicians (MD/DO degree) working within the city per 100,000 population Number of hospital in the city per 100,000 population Number of mental health practitioners per 100,000 population
Emergency healthcare capacity	Number of hospital bed per 100,000 population Percentage of hospitals that have carried out epidemic preparedness drills in the past years Reserve of emergency medical resources such as masks and protective clothing

Fig. 12.2 Factors and metrics associating Infrastructure Adaptive Capacity and Urban Stability

Community Support

Community support focuses on the policy resources and services obtained by different groups of people in an urban environment. The first focus of the community support metric is vulnerable groups, including children, women, the elderly and the disabled. In the normal urban system, they are already in a vulnerable position due to intrinsic population characteristics. When disaster strikes, they are more likely to be harmed than normal people because of their physical disability. The elderly, children and the disabled often need long-term and sustained service and material support from the outside world due to lack of ability to live independently. Additionally, lack of support or disruption of supply due to a disaster will directly lead to their inability to continue to live. Because of the particularity of vulnerable groups, in the practice of disaster prevention, in addition to considering individual policy support, we focus on support for families. In the vast majority of cities, especially in large cities with high populations, it is insufficient to provide support for the vulnerable only through the public system or market services. Families are often the first front for vulnerable groups to resist risks. In disaster time, when family members help each other,

CRITERIA	METRIC
Disabled citizens protection	Number of hospice / nursing facilities for disabled citizens Travel service for the disabled Emergency contact service
Female citizens protection	Percentage of referred cases of sexual and gender-based violence against women that are investigated and sentenced Number of cases of sexual and gender-based violence among all reported cases Harmful traditional practices, like female genital mutilation/ cutting"
Children protection	Number of cases of violence against elder Percentage of families that elders live alone Numbers of nursing home facilities for the elder"
Elder protection	Family benefits public spending as a percentage of total city GDP Living support plan for families below-poverty line Average family size"
Family support	Family benefits public spending as a percentage of total city GDP Living support plan for families below-poverty line Average family size"
Ethnic groups	Numbers of hate crimes reported Percentage of citizens that claimed to have been attacked based on race/different culture/birthplace Obvious living distinct between different ethnic groups

Fig. 12.2 Factors and metrics associating Infrastructure Adaptive Capacity and Urban Stability

family will become a risk prevention for citizens.

The city's support to the family is directly to help the vulnerable groups, maximizing the value of the family as a risk mitigation. The third focus of this section is ethical groups. It is the characteristic of many super large cities that different ethnic groups share urban areas together. In the face of disaster, we first consider the relationship between harmonious coexistence between ethnic groups and stable social orders. A more harmonious relationship will make the city more resilient. In fact, when the disaster breaks out, the disaster itself will become the fuse of the potential conflicts among ethical groups at a specific time point and group conflicts will further expand the effect of the disaster.

Identity and Culture

This part includes three factors. The first is traditional activities in cities. The relationship between traditional culture and disaster prevention is relatively distant, but it plays an important role. For city residents, urban culture is their emotional and spiritual support, and one of the important sources of urban identity. Shared culture is conducive to strengthening the emotional link between residents, helping residents to be more united in the face of disasters, and more inclined to form self-help groups. The second concern is cohesive identity. Behind the identity is residents' sense of belonging to the city. For residents born in the same city, it is relatively easy to form the same identity. However, for a large number of immigrants, the formation of this identity is not only from the identity of urban culture, but also from the residents' subjective feelings or satisfaction with their own lives. In addition to physical damage, most disasters often cause deep mental trauma to residents. This kind of trauma will form a common memory of a generation which is hard to heal within a short time after the disaster. The sense of identity to the city is one of the ways to heal this kind of spiritual injury. Cohesive identity will encourage residents to share the responsibility of "we get through difficulties together" rather than fall into the personal pressure of "I face difficulties alone". The third concern is religion. Although we can not judge the role of different religious beliefs in enhancing urban resilience, we can briefly measure the role of religion in the

CRITERIA	METRIC
Traditional activities	Numbers of traditional festivals Participation rate of traditional activities Vacation related to traditional festivals
Cohesive identity	Percentage of citizens reported high level of a sense belonging to the city Citizen satisfaction survey, Percentage of citizens that are satisfied with the government's work
Religion	Numbers of major religions Proportion of believers in the population Relationship between religional leader and government

Fig. 12.2 Factors and metrics associating Infrastructure Adaptive Capacity and Urban Stability

cohesion of urban residents. On the one hand, religious belief is still the spiritual pillar of many residents, especially in the period of disaster. It is beneficial for urban management in disaster periods that people can gather together through religion. On the other hand, the coordination between religious leaders and secular governments in the face of disasters is also worth exploring. When they do not reach a consensus on some policies, they may also have negative effects. For example, in the early days of the epidemic of COVID-19, Shincheonji Church of Jesus in South Korea organized a congregation to publicize that the virus was not terrible. This was different from the perception of the Korean government at that time, which led to many citizens' confusion about following religious leaders or government proposals.[2]

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Mini-Case: Riots in Urumqi

At around 8:00 PM on July 5th, 2009, a series of violent crimes, including rioting, killing, and burning occurred in Urumqi, Xinjiang, China, causing many innocent people and police to be killed, a large number of citizens and police to be injured, many vehicles to be damaged, many shops to be smashed and burned.[3] The specific process of this incident is as follows: at about 17:00 on July 5, more than 200 Uighurs gathered with arms in the People's Square of Urumqi. The police carried out the corresponding disposal work according to the contingency plan, forcibly took more than 70 rioters away from the scene. And then a large number of Uighurs gathered in Jiefang South Road, Erdaoqiao, Shanxi Lane area and other areas. At about 19:30, thousands of Uighurs gathered in front of a hospital in Shanxi Lane. At about 19:40, more than 300 Uighurs blocked the Renmin Road and Nanmen road. At about 20:18, the gathering people started to attack citizens and burn shops and vehicles. At about 20:30, violence escalated and the gathering Uighurs continued to burn police cars and beat up passers-by along the South Jiefang Road and Longquan street. About 700 or 800 Uighurs rushed to the People's Square, making constant smashing, looting, burning and killing incidents along the way.

At about 21:00, about 200 Uyghurs youths chanted slogans near the government building trying to attack the gate. This incident is also known as the "7.5" incident in Urumqi. On August 5, 2009, Hanmin Hou, spokesman of the Information Office of the people's Government of Xinjiang Uygur Autonomous Region, told the public in an exclusive interview that up to that time, more than 1700 people had been injured and 197 died in the "7.5" incident in Urumqi. Among them, 156 people were innocent residents. The "7.5" incident caused great economic losses with 331 shops were burned, 627 buses, minivans, cross-country vehicles, vans, police cars were smashed and 184 of which were seriously burned. The direct economic property loss reached 68.95 million yuan.

The incident in Urumqi in 2009 is the most serious conflict between citizens and government in China in the past 20 years. It is also a case that we can evaluate the resilience of Urumqi from cultural and social factors. First of all, a core of this incident is the relationship between religion and government. In 2009, the total population of Urumqi was 2419338, of which 1749351 were Han nationality, accounting for 72.5% of the total population of the city while 309853 were Uygur nationality, accounting for 12% of the total population. For a long time, Han citizens and Uygur citizens are the two largest ethnic groups in Urumqi. The two ethnic groups have different religious beliefs. Uyghur people believe in Islam while Han people mostly believe in Confucianism or Buddhism. Different religious beliefs make the two groups have different living habits and ways of thinking. Before the incident, several religious leaders of Uighur mobilized Uighur citizens in local and international media, releasing the view that Xinjiang should be independent, Uighur citizens should use force to obtain their rights and Uighur citizens and Han citizens cannot coexist. Whether these views are correct or not is not what we can evaluate, but it is obvious that this is totally contrary to the opinion of the government.

Based on the large number of Uighur citizens in Urumqi, this contradiction between the government and religious leaders reduced the resilience of the city. Secondly, from the perspective of identity, Urumqi citizens showed dissatisfaction with life and low sense of belonging to the city. Uighur citizens stated that their traditional culture has been suppressed and they attributed it to the influx of Han citizens. At the same time, the Han citizens also expressed their dissatisfaction with the Uyghur citizens focusing on two points: first, the high crime rate; second, enjoying preferential policies over the Han citizens. (such as less taxes) This situation not only reflected the contradictions between different religious beliefs but also showed the city's insufficient ability to deal with the relationship between the two major ethnic groups. This kind of unfriendly relationship reflected the subjective feelings of the citizens which made it easier for the two groups to break out large-scale conflicts at a certain time point due to some small friction.

Chapter 12
SECURITY

Security Introduction

In the event of any crisis or conflict in an urban area, there naturally occurs tension and fear of the unknown. Existing tensions and hostilities may be in a state of flux as some problems are relegated to the sidelines, all the while new issues suddenly come to the fore and add additional variables to an already complex and dynamic situation. Otherwise predictable people and situations may quickly devolve into further conflict, leading to violence, damage, and destruction to the surroundings. These conditions are true in any location; however, in large, dense urban environments, circumstances and stressors may become amplified by the overwhelming number of fearful civilians and the growing need for resources to cope with such disruptions. Maintaining security in such an environment is a critical component of a city's overall Urban Stability, where insufficient or ineffective security factors may further stress other affected Stability Factors and their ability to respond to the disruption. Without the ability to maintain security, to adapt to evolving security needs, or to meet the security expectations of a city's populace, it is unlikely that any other recovery element will be able to contribute to a city's stability, and the result will be an unmanageable disaster requiring significant outside assistance.

Evaluating the Components of Security

As a critical component of an overarching network of security factors, the military is an easy starting point from which to explore the notion of security lending to Urban Stability in a large distressed city. In this sense, Security applies both to the service that the military itself brings as an organization, lending security to the civilian population and government agencies, but also that the military must prioritize its own security and safety during any operation; in this case relating to protection of the joint force.[1] The introduction of any military forces into urban environments typically brings an additional layer of tension and uncertainty for its civilian inhabitants, even when used domestically and for the purpose of providing needed assistance. The introduction of a foreign military presence can add yet another layer of tension, further compounding the complexity even under the best of scenarios.

The U.S. Army represents the best-trained and led organization for conducting large-scale operations anticipated in tomorrow's complex urban environments, and it is already anticipating the need to increasingly operate in them or for them going in to the future.[2] Even so, the myriad of factors worthy of consideration may overwhelm even the best-prepared and equipped units, and as such, this study attempts to highlight the existence of many issues that may be inadvertently overlooked while operating in a new, dense, and largely populated environment; and also to highlight many of the most important factors that demand attention during the planning and initial stages of operation. Doing so will assist in the ability to successfully complete the directed mission, all the while maintaining its own safety as well as to those it encounters in the urban environment.

Additionally, awareness, consideration, and planning for these issues will further help mitigate potential unwanted consequences and reduce negative second and third-order effects from its actions; ideally leading to a positive outcome without the expense of new and worse negative effects. Despite the best of intentions, consideration of these issues will assist in mitigation of the security situation

itself, as well as the prevention of potentially negatively impacting the other stability factors that collectively provide overall Urban Stability.

Of course, the military aspect is not the only security factor present for this environment, and even when relying on the military for personnel and resources, its purpose and role may fall closer to a traditional support role for civil services and law and order versus that of conventional military operations. To account for this and other security factors, this study breaks down Security Stability Factors into four different criteria, specifically: Military Forces, Non-Military Forces, Violence Potential, and Securing the Urban Environment. Each of these criteria are themselves composed of various metrics that call attention to some of the numerous determinants and data points that collectively assist in clarifying the role of each particular criteria.

As each Security criteria is itself worthy of detailed study in its own right, this report does not attempt to address any one exhaustively or in great detail; that would be an impossible undertaking. Rather, it attempts to balance highlighting those wave-top issues that demand mention due to their criticality across cities and those unique issues that often go overlooked or under-examined across other resiliency frameworks and military analysis doctrine when assessing the urban environment. Security as a component of Urban Stability is a noteworthy omission from many previous urban resilience studies; highlighting it independently both illuminates new revelations as well as new complications.

Ultimately, though, each Security Factor criteria assists in constructing a relative weight of concern in regards to its overall Security Stability Factor. See Figure 12.1 for a graphical representation of this modeling.

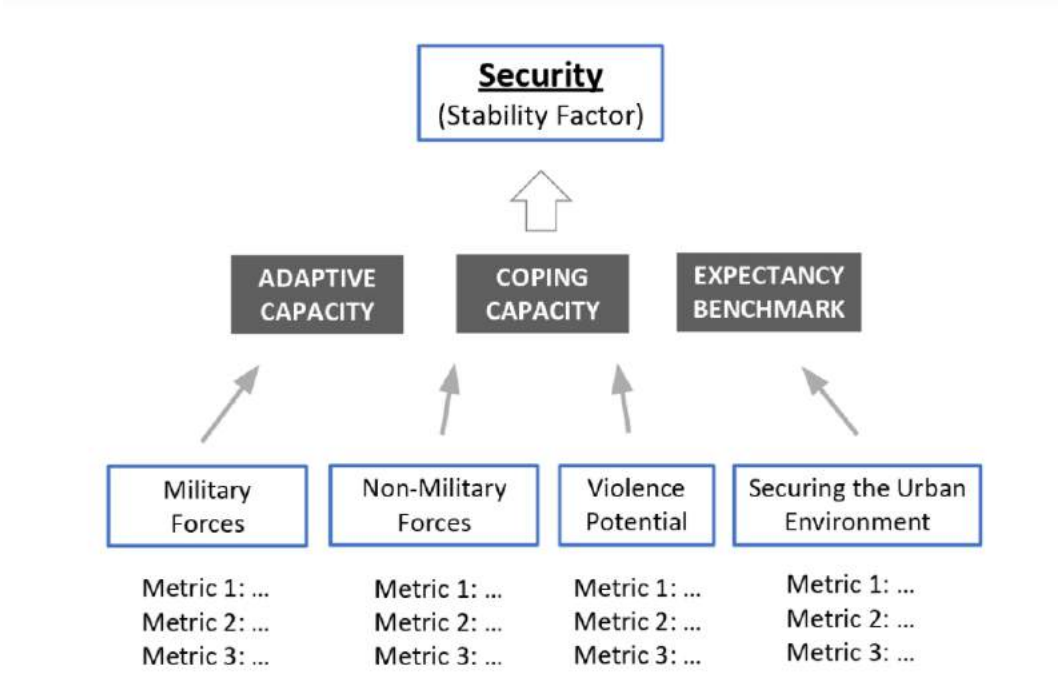

Fig. 12.1 Evaluating Security as a Stability Factor overview

Security Assessment

Military Forces

CRITERIA		METRIC
ADAPTIVE CAPACITY	Threats and Strategy	Capability of adversaries, National military strategy, Operational demands
	Doctrine, Training and Organization	DTO relative to operation demands, DTO relative to services
	Civil-Military Relations	Access to national leadership, External control over Military Reserves and plans, Power of military relative to other organizations
	Capacity for Innovation	Environment, aims and constraints, Previous failure, Product champions
	Foreign Mil-Mil Relations	Military representation & training abroad, Combined programs & exercises
	Defense Budget	Total size and % of GNP
COPING CAPACITY	Manpower	Absolute size of pool, Educational and technical proficiency by rank
	Military Infrastructure	Total number of facilities, Distribution by category and service need
	Combat RDT&E Institutions	Number and distribution by type and service, Quality relative to peers
	Defense Industrial Base	Total number of facilities, Sufficiency relative to service need
	Inventory and Support	Size and structure of inventory, Holdings of highleverage systems, Sufficiency of logistics
EXPECTANCY BENCHMARK	Civilian-Domestic-Mil-Views	General populations views on domestic military forces and use within an urban environment
	Civilian-Foreign-Mil Views	(Similar to domestic military, however applied to foreign military forces)
	Historical Military Presence	Is a military presence a common occurrence in this city, past precidents and grievances, etc

Fig. 12.2 Determining Military Force criteria

Defining the significance, capability, and effectiveness of a military force is a concept that has plagued academics and practitioners for some time. Roughly speaking, there is no agreed-upon framework that definitively captures the strengths and weaknesses of a military, nor a way to effectively correlate the near-infinite number of factors and criteria that can begin to describe it.

For the purposes of this study, this limitation is compounded by the inherent ability of the U.S. military to determine its own relative military concerns, which itself varies amongst the services and as a joint force, to ascribe weight to its most significant and concerning factors when operating internationally. For example, while the Air Force may lean heavily on issues concerning foreign adversarial airpower, Integrated Air Defense (IADs) capabilities, and ground support requirements, the Army may instead be more concerned with ground force ratios, general armaments of civilian populations, and the tactical aspects of terrain and man-made obstacles. Certainly, there is no universal way to capture such issues perfectly in every context, but this section attempts to give it an overall framework that is flexible enough to accommodate exogenous variables that concern the urban environment as well as the overarching Urban Stability concept.

In order to evaluate the Military Force's impact on stability relative to other sections present within the Security Stability Factor itself, some measure of determination must be applied for the entire project to proceed and have meaningful insight. From this perspective, and acknowledging the highly subjective nature of the technique, this study ascribed to a previous RAND Corporation framework on national power to evaluate as a heuristic approach to attempt to determine a rough Military Force capability assessment initially. [3] Although this approach uses a well-researched thesis as a foundation to cover many of the aspects of assessing a military's capability, it also comes tied with the baggage of much academic dissention on the merits of such approaches, and the potential overreliance on quantitative metrics that only tell one piece of a very complex problem. Also, continuing this approach for each section within Security would quickly devolve the study into an accounting exercise approaching a checklist of features. That is not the intent of this study – therefore, while it is used for Military Forces, this approach will not be used for the remaining Security sections.

Within this model, a military force is broken into two distinct portions, strategic forces (the force itself and tangible components) and conversion capability (the forces ability to operate effectively and intangible components). Practically speaking, these decisions sync well with Coping Capacity and Adaptive Capacity respectively, wherein the former represents relatively static components of the military and the latter lends to those features that allow it to be more or less flexible, including its ability to adapt to whatever situation is currently at hand. Though this adjustment is imperfect, this study again has chosen to reject an exhaustive and granular approach to assessing military capability – instead it attempts to highlight some broad and important components of it so that they may be assessed for a different purpose. Militia forces may be a worthwhile addition to this section, depending on their nature and organization, versus evaluating them as a Non-Military Force or a consideration within Violence Potential. A strong, reliable militia can contribute positively or negatively to coping capacity, depending on the nature of the situation; and the same can be said for the expectation.

Culminating the Military Forces section, the additional Expectancy Benchmark component is added to account for the human interaction within security considerations and the unique component of this study. This portion too is not exhaustive, nor is it overly granular, but it draws the analyst and planner into the mindset to apply some deliberation to the idea and then assess how applicable the city and situation are to this concept, and how variations in perception and expectations can have dramatic effects on the a city's security resiliency. Military forces in particular often come with significant pre-conceived notions in the minds of officials and civilians alike, whether positive or negative. Additionally, varying groups from within the overall city population may harbor wide variations regarding these expectations, where some see military intervention positively and others see it as markedly negative. This potential variance amongst expectations demands attention and repeated scrutiny amongst the other security criteria expectancy benchmark sections.

Examining Table 12.2 in more detail, the several factors and their expanded metrics are paired as a means to assist in assessment. These specific metrics should serve as starting points rather than

as an exhaustive list, but the significance becomes clearer when applied to the idea of a threshold question; specifically, a threshold that asks will this city's Adaptive Capacity, Coping Capacity, or Expectancy Benchmark be positively, neutrally, or negatively affected by this factor. Two examples of this relationship follow:

Example 1: In the event of a Humanitarian Assistance/Disaster Relief (HA/DR) crisis in City A, will the Host-Nation's unusually large military budget affect the overall city's stability? In this simplistic instance, the extra funds may contribute to additional resources being applied, positively affecting all three components such that this factor warrants a 'positive' response.

Example 2: A conflict in Country X, City B, as a strategically significant location, requires U.S. forces to enter. If the Host-Nation's military forces are overwhelmingly large but are unable or unwilling to effectively operate in or around City B and otherwise hinder U.S. military operations there, this factor may receive a 'positive' response as the risk to U.S. forces in this city are minimal in the short-term, or even a 'negative' if the anticipated U.S. presence there is expected to be long-term and the Host-Nation has the potential to alter its ability to affect the city in the future.

Worth noting in the first example is that the response to the unusually large defense budget was applied to all three Stability components – Adaptive Capacity, Coping Capacity, and Expectancy Benchmark – although Budget Defense is aligned specifically with Coping Capacity in the figure. This serves to highlight an ongoing mechanism that bears repeated mention: this method and its sections are not meant to be definitive, exhaustive, or linear. Security and military affairs are studied as both an art and as a science, and as such, while this framework provides a way to sequentially start approaching security as a Stability Factor, the method is meant to allow the flexibility to make adjustments as needed. What is most important is that the decision-maker evaluate Security against the other Stability Factors and determine its role in the city's stability or lack thereof. Should Security ultimately be highlighted as a major instability of the city as a result, then the planner must revisit the Security criteria and determine the cause of the instability. In the case of the first example, if Security was negatively contributing to City A's stability, the analyst would review the subordinate components and could identify Budget Defense as disproportionately affecting the City's ability to fund other efforts.

Non-Military Forces

Non-military forces include such a wide range of potential security components that attempting to list them all would be futile. However, some critical types that are common include components such as police forces, coast guards (as applicable), fire services, militia forces, and other government services. Regionally and culturally these various forces may take on a wide range of names, appearances, and even effectiveness, but accounting for their role in aiding Urban Stability is critical for decision-makers to understand. In order to evaluate each one respectively, this section will again use the familiar question will this city's Adaptive Capacity, Coping Capacity, or Expectancy Benchmark be positively, neutrally, or negatively affected for each successive component.

Determining the city under consideration's Non-Military Security Forces factors will be the chief initial requirement for evaluating this section. Though this list may be short and concise, some localities may have a myriad of potential factors to include. Chief among these forces, regardless of the location, are Police Forces. In times of disruption, police elements are likely some of the first to respond and the most prolific forward-facing element of a city's formal response to crisis. And just as conventional Military Forces have had ample academic rigor applied to determining their effectiveness and contributions to city stability, so too have police forces. But also just like the temptation exists within Military Force evaluation to skew towards overly quantified and exhaustive lists and metrics, Police Force evaluation can quickly turn towards a path of crime rates, recidivism rates, and others. Though these metrics assist in painting a picture on the effectiveness and capability of a force, this study instead focuses more narrowly on the threshold question regarding the force's impact on Urban Stability. Fire services closely follow many of the same potentially quantifiable avenues to examine, and although they may be less applicable as a security element in some cities and under some types of disruption, they do often work alongside or in conjunction with their police

counterparts in many crisis situations, such that examining them concurrently alongside other security forces is warranted.

Other additional groups that may fall within the Non-Military Forces criteria include civilian organizations, such as protestors and counter-protestors, or hired security elements such as private security companies. Some care has to be taken in regards to the potential to overlap between riots, protests, and more formal civilian organizations that affect security considerations. Groups that adhere to some level of code and under formal leadership are more appropriately accounted for in this section as opposed to that of Violence Potential, which would include less organized protests that act informally as a mob and a threat to security stability.

To assess the answer to this question, the factors initially accumulated must be compared to the situation and the requirements at hand, and the analyst must use the information available and wisdom from past experience to determine whether each is a positive, negative, or neutral contributor to each of the Stability Factor components.

Violence Potential

Just as military and non-military forces are meant to capture the essential elements that maintain an acceptable level of security, Violence Potential is meant to capture those elements which would oppose such security, or otherwise hinder its impact. Some care must be taken, however, to not resort to redundant measures of elements captured elsewhere, for example highlighting criminal organizations that are otherwise represented within the overall police force effectiveness determination. Though there will exist some overlap, as in other sections, the intent of this section is to focus on unique aspects that are the least represented by the aforementioned security sections, and also that are entirely omitted.

Depending on the region in which the city of concern is located, terrorism may play a significant role, or little at all. It cannot, however, be ignored entirely as even cities that have henceforth not shown any signs of terrorism have the ever-present potential of terrorism occurring. Additionally, the consequences of a terrorist organization taking root during a large disruption in a dense urban environment may quickly spiral and degrade other Stability Factors, potentially to a point that terrorism itself overwhelms the original issue. It is also noteworthy to observe that larger cities may pose a more attractive target to terrorist attacks simply for their own existence – an attack on a major metropolitan center is more likely to garner the attention many individuals and organizations desire for their cause. This unique characteristic may be further exacerbated by the existence of whatever type of disaster or disruption that is presently occurring and requiring intervention, such that much of the international news media may have its attention focused heavily on the city and thus promote an even more inviting opportunity to terrorists. And this too may be further compounded by the involvement or presence of U.S. military resources or personnel in that location, in that it provides a target that is both potentially distracted by the task at hand as well as guaranteed world-wide attention.

Evaluating terrorism, or a lack thereof, might prove a difficult task for some cities. Though seemingly useful to list a partially exhaustive tally of terrorism factors as in other sections, the intent here is to ask the same question regarding its potential impact on Urban Stability. For example, when assessing the applicability of terrorism on a city's Coping Capacity, just what is being assessed? Terrorism has no silver-bullet metric, but it is instead a function of many other Stability Factors, i.e. Social/Cultural, Governance, etc. As such, using the findings from these other Stability Factors may prove useful is determining the likelihood or extent of terrorism as a violence potential. In general, though, the analyst must consider the historical prevalence of terrorism in that city as well as the surrounding areas, in addition to the country itself. This, along with other factors such as controversial policies or politics within the city, will help determine how prepared and flexible the city is in regards to its terrorism preparedness and mitigation efforts, and also what the general populace may expect. In that sense, the historical prevalence of terrorism lends somewhat towards the city's Coping Capacity whereas its policies and politics lend more towards its Adaptive Capacity - though in many instances it may not fit so neatly into either. In some instances, the city may have given little thought in regards to terrorism as it has never

been an issue, and in others there may be a list of previous occurrences from which the city and its government have been able to overcome and adapt.

Gun-ownership varies wildly from region to region and city to city. For example, Canada has tight restrictions on gun ownership relative to the United States, much as Nevada has very different laws relative to New York City. The same is true globally, where gun ownership in a city may fall within a wide spectrum of possibilities, from completely banned (but possibly still present in varying numbers), to fairly unrestricted but not overly common. In any case, this consideration plays an important component of overall security stability, where gun ownership (or lack thereof) could contribute differently to the various Stability Factor components depending on the nature of the situation, whether positive, negative, or not at all.

Gangs, mobs, and organized crime, the existence and history of riots, the existence and types of prisons or jails, and even whether the city is in the midst of a wartime or peacetime disruption all play critical factors in contributing to the overall security scores, but especially towards Violence Potential. Like the other security criteria, how they contribute will vary and must be carefully considered by the analyst. Previous riots can indicate future riots are likely, just as the lack of riots may indicate there is a simmering violence potential awaiting the opportunity to manifest itself. Regardless, the analyst must take special care when approaching the overall violence potential of a city, identifying the unique circumstances of the city, and then apply this to the overall score to inform decision-makers and planners on where their priorities and attention are best served.

Securing the Urban Environment

CRITERIA	METRIC
Superstructure Scale and Density (SSD1)	Average building height/floor count, total number of tall/ supertall structures, number of tall/dense superstructure 'clusters', etc
Subterranean Scale and Depth (SSD2)	Average structure depth, number of subterranean 'layers', age of structures, clarity of structure mapping, etc
Urban Maneuverability	Highways, Roadways, Alleys accessible for MBT and below passage
Construction Type	Are buildings largely concrete/blast resistant, varied, glass-laden, thin-walled/temporary construction, etc

Fig. 12.3 Factors and metrics associating Securing the Urban Environment and Urban Stability

Modern, densely constructed and populated environments pose uniquely challenging dynamics that significantly hinder the ability of a security force to maintain its own safety, as well as conducting stability and offensive operations. Though urban sprawl in less-developed and modern cities themselves pose significant challenges, such as the potential difficulties of operating in a friendly urban slum, let alone a hostile one, more prosperous cities like New York City, Singapore, and Tokyo provide a plethora of additional factors. This section attempts to capture some of the most pressing and significant considerations when assessing a city's ability to respond to shocks and the ability of U.S. Army forces to effectively contribute to stabilizing the city, as well as how various factors contribute to the overall Security Stability Factor, focusing on some of the unique characteristics that arise from both extremely large populations in underdeveloped cities as well as those the aspects unique to the largest modern cities.

Like all of the previous Stability Factors, and even many of the Security criteria as well, there is significant overlap in considering the effects of the Securing the Urban Environment factors with other Stability Factors. For example, when considering the effects of the type of structures that compose a modern, dense city, the analyst should incorporate factors such as the average building height, Infrastructure and Energy requirements (electrical requirements, water and sanitation, etc.) as well as Social and Cultural factors (population homogeneity, social closeness, etc.) and Natural Environment determinants for urban form. However, from the security perspective, the same tall buildings provide a potential breeding ground for hostile actors, insurgent forces, or just generally non-compliant and unaffiliated individuals determined to remain on upper floors that become exceptionally difficult for host-nation and U.S. Forces to assist, dislodge, or confront.

Given the requirements in manpower and materiel to provide assistance to a distressed population in a single large tower (potentially having to rely on stairways in the event of power-outage – see Figure 12.3, the requirements are so large so as to incapacitate meaningful assistance or capabilities. This same consideration, multiplied by a block of such structures in a cluster, then multiplied yet again by block after block of such clusters, and the scale of the requirement begins to come into perspective. From a resiliency perspective, these towers, blocks, and clusters become high security risks, such that beyond a certain level of instability within the city, the ability to maintain, re-take, or otherwise deal with such structures becomes exponentially more difficult. Even the specific requirements for each building will vary with some modern supertall structures utilizing thin-skinned interior construction techniques (drywall over metal frames, for example) with open layouts and cavernous internal voids, whereas other older buildings may contain load-bearing walls, low ceilings, and confusing compartmentalized layouts. Both represent significant challenges in their own right, and when a city contains numerous large, supertall structures combined with older-style yet still large structures, the complexity of securing even a block of terrain may prove insurmountable.

Additionally, the tactics, techniques, and procedures on how best to provide security in individual super-stall structures, or clusters of them, may vary wildly, depending on the location, the disruption, and the given mission of the forces. The potential scale of this problem in terms of the structures themselves has already been illuminated, however, the manpower and time requirements warrant some additional consideration. For example, one hypothetical situation may require forces to enter and search this type of structure, and a quick consideration of the time required for a single platoon – a standard small infantry element of approximately 40 personnel for conducting many operations – to safely enter, explore, respond to incidents and interact with the local population, and communicate amongst themselves for a single floor in a large building could easily surpass several dozen minutes to even hours. This timeline quickly grows as additional floors are added, further compounded by the growing fatigue of doing their respective jobs, carrying necessary equipment, and then having to climb floor after floor – it quickly becomes clear that the unit would be overwhelmed by even a moderate structure of a few dozen floors. In a worst-case environment, the superstructure is crammed with hostile personnel and many dozens of floors high, and suddenly it becomes an impossible task. Though tempting to imagine a scenario where it may be appropriate to isolate such a building to deal with at a later time, to lay siege to it in hopes of forcing the occupants to surrender or otherwise vacate, or to even target the building for a kinetic strike, the limits emplaced on modern warfare by domestic Rules of Engagement (ROE), international norms and ethics, or even the

logistics of dealing with any of these tactics, makes each of them unattractive long-term options in all but the most dire of situations – if at all. Even the most seemingly simple option of isolating a modern supertall structure would require a large amount of forces even before taking into consideration the potential ramifications of the adversary holding the high ground in a 360-degree perimeter.

Beyond even these risks, if such a structure contained even a portion of its normal occupants, let alone its normal or full capacity, security forces would be handicapped in their ability to respond to hostile occupants for fear of significant collateral damage. Choosing to isolate the building and wait out the occupants may quickly become a humanitarian crisis as hundreds or thousands of non-combatants become trapped inside as well. Imagining a scenario where non-combats were able to exit such a structure under these conditions, once free they may still be vulnerable to hostile attempts at their lives. In addition, security forces would now be responsible for their well-being, to include large logistical requirements (food, water, medical) and a place to house them in both the near and long-term. Though it may be easy once again to imagine this as a feasible option, compounded by clusters of such buildings, the scale of the requirement becomes untenable.

Mini-Case: The Slums of Makoko, Nigeria[5]

Lagos, Nigeria provides a glimpse into some of the future considerations for security in fast-growing, dense urban environment. Although estimates of its population vary, the Nigerian government claim of upwards of 21 million put it on the list with all but the very largest cities in the world. Within this vast metropolis there exists a wide spectrum of conditions – from the oil-rich ultra-wealthy few, living in modern and sleek sections of the city, to the vast urban slums that sprawl outward over land and water, where estimates of up to two out of three Nigerians live.

On the Southern edge of Lagos is Makokos, an area made of some of the poorest slums in Nigeria, where population estimates vary from 40,000 to 300,000. Dramatic population growth combined with a lack of property rights and rampant government corruption have resulted in Makokos becoming a largely ungoverned village within the larger Lagos metropolitan. Famously known for one portion of its sprawl built largely on stilts above water, the area overall receives little or no electricity, water, or waste management services, outside black market and informal services. On a day-to-day basis, security either does not exist or is otherwise provided by varying degrees of paid cartels, sometimes hired youth, or roving gangs of miscreants that prey upon their neighbors. When formal security forces do visit, they typically bring with them orders to vacate, forced exodus, and sometimes violence.

The overall result of villages like Makokos – one of many slums throughout Lagos – could quickly become a security quagmire. The lack of property rights and government oversight has led to incredibly densely packed structures with little or no standards. Though the vast majority of structures are thin-skinned, single-story abodes made from scrap wood, tin roofing, or other refuse, some are even less robust and amount to little more than canoes with a wooden shack placed on top. Even more solidly constructed buildings are known to collapse within a few years of construction. Combined with extremely narrow alleys, unpaved roadways or open water canals (that serve as a place for refuse, sewage, and fishing income), no central planning, rampant disease, these slums provide a population that is impossible to ignore and impossible to reach. Entering Makokos, for example, would require significant resources to manage between water or land routes, huge numbers of personnel, and extensive resources to handle squalid conditions and a potentially hostile population with nothing to lose. In the event of hostilities, the flimsy and temporary nature of much the construction would likely give rise to significant numbers of collateral damage, and the distinct possibility of rampant fire spread, as has occurred during previous police incursions.

Fig 12.5 Floating slums in Makoko, Nigeria

How such a situation specifically contributes to the overall Securing the Urban Environment score is difficult to say universally. In a situation where U.S. forces are welcomed into the city for assisting in Humanitarian Assistance and Disaster Relief (HA/DR), a preponderance of supertall clusters may contribute positively towards security coping capacity in that the city is able to largely avoid irreparable damage from hostile elements being able to seamlessly navigate through the population at will – these elements may have some ability to flow to a small degree within a single tower, but even this is mitigated. Conversely, in a hostile environment, these same towers may contribute negatively towards coping capacity by becoming targets for armed combat, thus making avoidance of irreparable damage, and the following cascading effects, impossible. The same is true for adaptive capacity and the expectancy benchmark; that is, it depends on the nature of the situation.

Similar to above-ground (surface and supersurface) construction considerations, many modern citiesalspossess sprawling underground facilities and structures, including subway systems, extensions of superstructures, infrastructure facilities, and others. Much like superstructure requirements, security in these locations becomes intensely demanding. Although on a volume-by-volume comparison with their superstructure brethren they may fall short, they do add other factors such as a lack of light for maneuvering, significantly diminished communication abilities, unpredictable and confusing layouts, degraded air circulation, health and hygiene concerns, and numerous pockets for non-compliant or hostile forces to hide or even lay in ambush. At present, the overall number and size of these considerations in large cities is less overwhelming than their superstructure counterparts, though many urban planners, cities, and futurists are anticipating increasingly large and complex future underground complexes as means to continue expansion for future growth, likely increasing the emphasis of this

Fig 12.6 An approximation of the time taken to climb to the tops of two notable skyscrapers, either by stairs or by elevator. This example exemplifies the differences between two supertall structures and the different time and effort requirements to navigate to upper floors under ideal conditions.

consideration in future operations.[6]

Ground-level considerations also pose their own unique challenges. In a larger urban environment, the ability to navigate as well as provide logistical support en masse is a critical component of security, whether it be to provide aid to a population vulnerable towards turning violent due to desperation, or to conduct offensive operations to an already hostile group – both require the ability to move manpower and materiel to the appropriate location. Using São Paulo Brazil as an example, the tight nature of many of the favelas may preclude the ability to move vehicles in a meaningful way in the vicinity of much of the densest population areas, but the lack of significant superstructures may facilitate the use of rotary-winged support. Conversely, a densely packed city such as Singapore has ample space along road-ways to maneuver nearly any kind of vehicle, military or commercial, but significant superstructure density may limit rotary-winged support. To further compound these types of issues, most of the largest cities are neither homogenous in their geography or their layout such that a combination of either of these extremes may be present; or even additional types, where the same city may possess areas of extreme slopes and minimal construction and others with flat, open roads and dense supertall structures. If this were to occur, this analysis would need to be applied to each section as well as the city collective to determine if any particular subset warranted an oversized weighting when determining its contribution to the Security Factor, or conversely if none were significant enough to warrant individual attention relative to other issues that may be of more concern. Regardless, various types of large cities demand special attention to these features, especially the magnitude of their limitations is further exaggerated by the scale of the issue and the significance of the requirements.

For these reasons and more, Securing the Urban Environment provides many challenges to the overall stability factors in cities. Figure 12.4 (previous spread) indicates the four primary considerations, highlighting many of the factors previously discussed, and provides a tool for assessing this unique section of the overall Security Stability Factor. Like the other sections within Security, this list is not meant to be exhaustive or all-inclusive, but rather a list of primary considerations when approaching this topic and looking at a new urban environment. Also allowing for unique variables and special considerations, the planners, decision-makers, and Commanders will have the ability to raise or lower the threshold level based on their own determination of factors and experience, thus allowing some flexibility into the evaluation.

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FIGURE CREDITS

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Security Conclusion

Security as a stability factor is unique amongst others within this framework for its ability to be incredibly significant, complicated, and relevant when conflict and war threaten the lives of not only the city's occupants, but also of the city's future itself. Unlike other Stability Factors, security issues directly threaten the city and its people, rather than an indirect consequence of other disasters. Said another way, war directly relates to people, death, and destruction whereas a natural disaster or economic downturn is not targeting people themselves. Despite this, in many other instances security components may be absent and largely irrelevant to the overall evaluation. Though various aspects of security issues will likely be involved in all major cities, as explored in this evaluation overview, how they are most appropriately applied and weighted depends largely on asking the right questions and tailoring them to the city and issue at hand.

If used correctly, the security framework outlined here will help separate the most important considerations in such a way that they can be reasonably evaluated, but also separated into manageable portions that may require different approaches to address, such as the different perspective needed to plan for a large hostile military force versus that of a city requiring special attention on how to provide non-military security assistance under challenging circumstances. The listed security criteria are not exhaustive but instead are meant to inform a critical assessment of each component to help inform decision-makers and drive intervention strategies through the use of ACE components that lend to the overall GENETICS framework.

Generally, this approach will be applicable for most scenarios and situations encountered, however, in the most extreme situations, such as that of a post-nuclear detonation, much of the techniques suggested for large populations and larger cities may be significantly weakened as the environment has changed so dramatically, and thus another evaluation framework may be more appropriate for more generalized urban areas.

Chapter 13
CASE STUDY: Hurricane Sandy in New York City

Case Study Introduction

Superstorm Sandy struck on the evening of October 29, 2012. Massive storms, coupled with heavy winds and high tides, inundated NYC's waterfront areas, including the Rockaways, Coney Island, South Street Seaport, Battery Park, Midland Beach, or accounted for 520 miles of waterfront. Thousands of residents were ordered to evacuate. [1,2]

A combination of an unusual weather phenomenon and New York City's high population density resulted in an extreme amount of damage. Many properties were destroyed in the city and many residences lost power. The estimated cost of Hurricane Sandy was $70.2 billion, resulting in a federal aid bill that totalled over $50 billion. In addition to material costs, there were at least 43 Sandy-related deaths as well.[3,4] Impacts were felt in a variety of sectors, including environmental, economic, and infrastructure damage. New Yorkers are still experiencing the lasting effects of the Superstorm, including transit system damage still to be repaired.

There are two main reasons why we chose to analyze the Hurricane Sandy case. We primarily chose Hurricane Sandy, and the associated damage wrought upon New York City, as an example of one of the financial, political, and cultural centers of the world going through crisis. We wanted to see how such a city utilized assets and capabilities to maintain stability in the face of a serious natural disaster. We also wanted to observe potential failures in response to Hurricane Sandy in order to better analyze how highly developed urban environments can still lack resilience.

For this case study, we will apply the GENETICS framework analysis to a disaster shock created by Hurricane Sandy. In each stability factor, we will provide the impacts on urban stability based on adaptive capacity, coping capacity, and expectation benchmarks. We show how the GENETICS framework helps understand and analyze the vulnerabilities and risk that threaten New York's urban stability, and how the GENETICS tool can analyze past events to give insight into future vulnerabilities to stresses and shocks.

Governance

While the nature of the crisis in New York City during Hurricane Sandy was an environmental shock rather than a crisis in government, the criteria of the governance stability factor nevertheless play an important role in the management of the disaster. This was especially apparent in the different responses in the municipal, state and national governments, each of which had distinct effects on the local stability and mitigating some of the worse effects of the disaster.

Municipal Governance

Adaptive Capacity

In preparation for Hurricane Sandy, the New York City government was able to close a number of public venues such as parks, beaches and boardwalks, and enforce this closure until after the storm had dissipated and repairs could be made. Based on coming forecasts and assessment of the affected areas the government was also able to close local schools and convert secure spaces into public shelters for vulnerable populations. For populations ordered to evacuate, there was no noted resistance and people complied with local government instructions.[133] This showcases a beneficial level of authority from the city government for the purpose of adaptive capacity, allowing it to respond to the circumstances of the emergency.

The experience of Hurricane Irene in 2011 had prepared the Bloomberg government with preparations for evacuation and a flexibility to follow recommended mandates previously prepared. Hurricane Irene, similar to Hurricane Sandy, severely affected Coney Island and caused a shutdown in transportation and flooding in Lower Manhattan. Similarly, the 11 years of governing experience of the Bloomberg government, provided a positive effect to adaptive capacity. The New York Government had an increased adaptiveness as a result of closer ties to its local institutions, allowing the city to respond to Hurricane Sandy more quickly and efficiently than a less experienced government. On October 28, officials activated the city's coastal emergency plan, with subway closings and the evacuation of residents in areas hit during Hurricane Irene in August 2011. More than 76 evacuation shelters were open around the city in advance of the worst of the damage to mitigate loss of life.[134]

The local New York City government was also able to work in advance with both State and Federal authorities. This allowed a comprehensive response and measures to evacuate people most at risk, which allowed for a cumulative positive affect on stability.

Coping Capacity

The authority of the New York City government proved to be an advantage to coping capacity. Mayor Bloomberg and the New York City government were able to direct the extensive local emergency services to respond to threats during and immediately after the hurricane. Policy decisions were followed and a clear line of authority to the government was maintained. There was no point in which the city government was at risk of collapse, nor of losing control of its agents.Policy decisions were followed and a clear line of authority to the government was maintained. There was no point in which the city government was at risk of collapse of losing control of its agents. This allowed NYC to maintain basic city functions and emergency services. The government was also able to quickly act to replace and repair damaged pieces of infrastructure to return function to damaged sections of the city.[135,136]

In addition to the benefits to adaptive capacity, the experience with Hurricane Irene, as well as the institutional knowledge of the NYC Government, improved response time and the speed with which emergency services could act and repairs could begin. Parks were beginning

GOVERNANCE - Municipal	
DIMENSIONS	EVALUATION
Adaptive Capacity	POSITIVE
Coping Capacity	POSITIVE
Expectancy Benchmark	NEUTRAL

to open by November 3rd, and water was being pumped from damaged infrastructure.

Expectancy Benchmark

The existing autonomy of the City of New York met local expectations. While New York did require State and Federal assistance, this was expected by New Yorkers, and there were no noted complaints about municipal autonomy. While New York City experienced some protracted disruptions to daily life following Hurricane Sandy, the ability of the city government to utilize local authority to maintain municipal functions and key infrastructure was generally met positively.

State Governance

Adaptive Capacity

Though lacking in several key emergencies powers of the Federal government, the state of New York has considerable autonomy. The federalized system of government within the United Sates offers a degree of independence from the Federal government, and the control of the state budget allows local management of state resources.[137] Fortunately, like the relationship between all three levels of governance enjoyed positive cooperation. As a result there were no significant competing interests and New York State autonomy did not negatively contribute to adaptive capacity.

On October 28, New York Governor Andrew Cuomo declared a state of emergency for every county in the state. He was further able to act effectively by opening shelters in local schools and community centres and shutting down the MTA within New York City. This allowed the government to manage state-wide resources and shutdown vulnerable services to mitigate the risk of death and injury. All of this acted as a positive benefit to adaptive capacity in advance of the impact of the storm.[138] While the experience of Hurricane Irene in 2011 had prepared the New York State government with the measures of assessing a natural disaster and organizing emergency preparations, there was no assessed benefit from the governing experience within the New York State government on adaptive capacity.

Coping Capacity

The New York State government was able to effectively increase the coping capacity of New York City in preparation for the worst of the damage. Governor Cuomo halted the MTA transit system within New York and issued stay at home orders for those in and around the affected areas.[139] The fact that this was accepted and quickly implemented on a short timeframe speaks well for the effectiveness and practical authority of the New York Government. 200 National Guard members from the New York National Guard were deployed to assist with evaluations and rescue efforts. These national guardsmen also provided services such as door-to-door meal and supply delivery for elderly New Yorkers. $100 million fund was created to support those hit hardest. These types of provisions successfully worked to reduce the risk of failure and substantial loss of life. While it was unlikely that the City of New York would experience a collapse of government without State support, the supply of support did work to improve the stability of the city overall, and the general health and wellbeing of its people.

GOVERNANCE - State	
DIMENSIONS	EVALUATION
Adaptive Capacity	POSITIVE
Coping Capacity	POSITIVE
Expectancy Benchmark	NEUTRAL

Expectancy Benchmark

The existing autonomy of the State of New York met local expectations. While New York did require Federal assistance, this was expected by New Yorkers, and there were no significant complaints about State autonomy being infringed. While New York State experienced some protracted disruptions to daily life following Hurricane Sandy, the ability of the city government to utilize local authority to maintain municipal functions and key infrastructure was generally met positively.

Federal Governance

Adaptive Capacity

While much of the direct work in preparing for Hurricane Sandy was done by the City and State Governments, the Federal Government did offer notable support. On October 28th, President Obama signed an emergency declaration for the state of New York.[140] While emergency preparations were already being enacted at the local level, the federal declaration supported their actions and helped create a collaborative support structure in preparation for the hurricane. The Federal Government also declared a health emergency on October 31st, in New York this provided a number of ambulances and other crucial health supplies from across the country which were greatly needed by New York.[141]

Fig 13.1 President Obama monitoring Sandy relief efforts with FEMA staffers.

GOVERNANCE - National	
DIMENSIONS	EVALUATION
Adaptive Capacity	POSITIVE
Coping Capacity	POSITIVE
Expectancy Benchmark	POSITIVE

Coping Capacity

The Federal government continued to offer medical aid as well as directing 30 teams of workers from FEMA to aid in the recovery of the most damaged areas of New York.[142] Federal funding was also supplied from Congress and the White House to assist in recovery efforts and contribute to the coping capacity within New York, including $2.4 billion from FEMA.[143] Beyond its financial assistance and some medical and disaster recovery aid, the federal government was less of a significant factor than at the city or state level. However, if needed, the Federal government would have been able to provide exponentially more resources if New York City was every at serious risk of collapse.

Expectancy Benchmark

Overall, the response from the Federal government seems to have been received positively, with praise from both political allies and opponents immediately prior to an election. The Obama administration also benefited from the association with Hurricane Katrina, and the perceived failure of the Bush Administration to respond at the Federal level, which improved the public assessment of the Federal response in comparison.

Governance Conclusion

Overall, governance was very positive in affecting the ACE stability dimensions. Part of this had to do with how well equipped and authoritative each level of government was. From the City government to the Federal government, all were able to quickly marshal resources and prepare emergency measures. This helped prepare New York in the days prior to the storm. Additionally, the stability and finances that were provided by municipal, state and federal actors helped the coping capacity during and after the hurricane. Loss of life was reduced as a result of implemented resiliency frameworks and the strength of local institutions. Perhaps most importantly to stability overall however, was that all levels of governance were in near complete cooperation with one another. When there were gaps in authority they were able to be effectively filled in by superseding levels of government, and aid and resources were able to be distributed without unnecessary competition. This culminated in a shock that was appropriately handled on the governance factor.

Economics

The unusual weather caused by Hurricane Sandy is undoubtedly one of the most expensive hurricanes in US history. Despite extensive damage, New York responded effectively in managing economic systems.

In terms of coping capacity, the fundamental economic structure, such as income level is considered positive to a city's stability. The city used both manpower and financial resources to prepare for the upcoming hurricane, including food, sheltering, and fuel support. The federal government released two critical legislations to help the city a month followed the incident: H.R. 41 (Public Law 113-1), which temporarily increased the borrowing authority of the Federal Emergency Management Agency (FEMA) for carrying out the National Flood Insurance Program by almost $10 billion as an emergency requirement; and the Disaster Relief Appropriations Act (Public Law 113-2), which provided $50 billion in funding to help improve and streamline disaster the areas impacted by Hurricane Sandy, and for other purposes.[5]

Nevertheless, economic activity directly got impacted as the hurricane forced the city to shut down, including the subway, restaurants, and most retail. The market connectivity in New York City contributed to stability in both positive and negative fashion. Since the areas that directly received the impact were mostly outside the downtown area, small businesses and residential areas were those who suffered the most. This also reflects the negativity of the low coping capacity of the small formal sector of the city. Small business owners have lesser financial capacity to back up their business or secure the employees' payroll if they did not have insurance. Some people live paycheck by paycheck and did not register in the working security system. Meanwhile, some of the home insurance does not cover the flood damage.

Those residents may not be able to rebuild their houses or stop working without government's support. However, having a diverse economy in a community means that citizens will not suffer from supply shortage from those businesses.[6] The individual financial stability of New York city is considered negative for the individual level to the city's coping capacity. In 2011, around 14.3 percent of residents were unbanked while 22.1 percent were underbanked. This surpassed the national level of 8.2 percent of having no account which indicated that a lot of people still did not reserve their money in their account.[7,8] This means their asset, particularly cash could be destroyed by the flooding and heavy storm.

In terms of adaptive capacity, we can see a path of recovery within various groups in the city. The fundamental economic structure in terms of the city's high income level benefits the city overall. New York City received a significant amount of financial support from the federal government, as well as financial donations from philanthropies and nonprofits to assist in the rebuild. Those funds were used in many projects from physical help to counseling support.[9] In addition, a credible financial market is positive to overall financial stability. New York Stock Exchanges (NYSE), which was directly impacted and forced to close during the storm, was reopened after two days, all while being prepared to trade through the electronic backup system.[10] This showed that NYSE prioritized the reliability of the market since the longer they close, the more volatile it would be.

Thus we saw businesses in NYC going back to work, although some companies like Citigroup had to power their operations with power generators.[11] Meanwhile, the market connectivity of the city was also positively adapted. A diverse community in the city helped deliver support from other parts to the city through local networks, not only scarce supplies but also emergency response and support group coordination.[12] The informal sector of the city also adapted positively under the recovery process. For the employment market, the

restoration process after Sandy offered another job opportunity; Most of the local job market rebounded within a month. In the New York City metropolitan area, the job gain in the December after the storm was more than 53,000 jobs, recovering from a 32,000 job loss in November.[13]

For the expectancy benchmark, given these losses in the fourth quarter, Sandy seemed to have a small impact on the nation's overall economy.[14] The loss of business and wealth caused by the storm eventually ended up being roughly balanced out by money that went into rebuilding and recovery efforts from insurers, the government's aid, and private savings. There are also efforts to make further emergency risk assessment and continue the emergency fund. The expectations from the citizenry ended up helping the city. New Yorkers seem confident in the resiliency of the city's economy and job market. People were confident that the supply chain was well maintained and replenished and that the city was going back to normal. This is evidenced by the creation of new Business Recovery Zones (BRZs) to help provide the needs in the impacted areas including ensuring the stock in grocery stores.[15] The city also did not witness a significant drop in the working population as many soon went back to work after the storm. For example, the HireNYC program was launched to connect low-income individuals to economic development projects and help project developers screening applicants at no cost. Meanwhile, other projects were also promoted to improve and build local community markets.[16] The tourist arrival in NYC also has no significant difference from the same time period of last year, indicating that people from out-of-state and foreigners were confident in the city's resiliency.[17,18]

Even under the storm surge, New York City's high income level and fundamental economic structure showed a strong support to the city's stability. Nonetheless, the limited financial support and lack of monetary inclusion at individual level contribute to a negative score to coping capacity as a whole. Citizens at the local level were not well prepared for the disaster. Meanwhile, the adaptive capacity expresses a positive effect to urban stability as the strong economic components support the market activity to adapt quickly after the shock. A strong confidence led financial sector kept operating business while the investment from the government also helped rebound the job loss. This responsive management from the government and continuing economic activities support the positive expectancy benchmark score for the city as a whole.

ECONOMICS	
DIMENSIONS	EVALUATION
Adaptive Capacity	POSITIVE
Coping Capacity	NEGATIVE
Expectancy Benchmark	POSITIVE

Natural Environment

Hurricane Sandy demonstrated the environmental vulnerability of New York City. Although a modern, first world city, much of the crumbling infrastructure and low-lying structures fell victim to the waves and flooding that resulted in a 4.361 meter storm tide measured at Kings Point.[19] While predictions were able to accurately predict most of the storm's severity[20], including nearly perfectly predicting maximum wind speed and peak wave heights, the severity of the storm still left many New Yorkers surprised and shellshocked. To understand the environmental stability of the city, it is important to first understand why New York is vulnerable to hurricanes.

The adaptability of New York is based upon the awareness, form, and flexibility of the city. New York is certainly aware of the risks hurricanes pose to vulnerable city infrastructure. Hurricanes are not a new event to New York; Hurricane Irene had hit the city just the year before, albeit in a far less destructive fashion. The city did take proactive steps to help protect the population, ordering large-scale evacuations of over 375,000 city residents[21] and prepared 76 hurricane shelters in advance of the storm for refugees.[22] As mentioned earlier, New York benefited from accurate climate modeling as well predicting the worst of the storm surges with a high level of accuracy, thus helping inform many of the decisions made to evacuate and protect the most vulnerable parts of city infrastructure. New York City also benefits from a large, well-funded federal government that coordinated with the state prior to the existence of Hurricane Sandy to begin preparing medical supplies and other key resources necessary to save lives.[23] New York City clearly demonstrated high awareness of the potential environmental risks, and was taking action to blunt future potential impacts of storm systems.

Unfortunately, a highly aware government system of future threats cannot by itself create an adaptive city. Although New York has taken proactive steps especially in recent years, a number of infrastructure and design failures of the past continue to haunt the adaptive capabilities of New York City; the urban form was dangerously unprepared for Sandy in 2012. Although many of these vulnerabilities will be covered in more detail in other parts of the case study, it is important to note that key infrastructure systems such as the New York City subway play a significant role in the environmental adaptability of a city. New York City experienced severe flooding into critical infrastructure such as the subway and multiple major power systems, crippling movement and power generation throughout the city and causing billions of dollars of damage to said infrastructure.

Additionally, in 2012, over 650,000 housing structures were destroyed or damaged throughout New York and New Jersey, and there is little reason to believe the current adaptive form of the city would prevent a significant portion of that damage.[24] New York City has a significant amount of housing located upon coastlines and in high flood risk areas along the Atlantic Ocean, such as the Rockaways, a collection of homes and structures built upon a barrier beach.[25] Over 100,000 individuals live upon a strip of sand that will likely be underwater by 2100, and is exceedingly vulnerable to any major storm events that directly hit the area. Low-lying areas of Brooklyn and Queens remain at risk as well as Sandy clearly evidenced; even with the infrastructure efforts of recent years, many of the neighborhoods along the coastline would experience the same amount of damage they experienced in 2012 if another storm were to strike today.[26] While widespread city destruction is exceedingly unlikely, enough form vulnerabilities exist that result in an only moderately adapted city. Much work and money will need to be invested in future storm protection equipment, as well as some potential strategic abandonment, in order to create a highly adaptive form.

Flexibility as an adaptive capacity factor is not particularly noteworthy in the case of Hurricane Sandy. Without needing to explain in great detail, New York is located in the wealthiest country on Earth, and enjoys a great deal of support from state and federal supply chains and disaster relief efforts. While some city residents were stuck without power for multiple days, there were no major supply line breakdowns or systemic failures within disaster relief efforts. The privilege enjoyed by those living within the United States was clear, and most, if not all, New York citizens who decided to not evacuate the city saw operations begin to resemble normal life within 48 hours of the storm. As is the case with most major first world cities, New York's adaptive flexibility was, and remains, extremely high, barring catastrophic changes to the global order of the world.

New York is a major, first world city that has identified future risks and has begun to pursue strategies to mitigate future damage. The city benefits from a strong and stable state and federal government, and enjoys immense resources to dedicate to mitigating future climate harm. However, the basic urban structure of the city does pose undeniable risk to many of the city's residents, as the damage from Hurricane Sandy made abundantly clear. Many low income and minority populations especially remain at risk to future storms, and key infrastructure such as storm barriers are not currently installed. While New York has the potential to be an extremely adaptive urban environment, geographic factors and outdated / lacking infrastructure continue to create vulnerability.

The environmental coping factor, as discussed earlier, is predicated upon the natural vulnerabilities a city faces in both the short and the long term. While New York has a variety of environmental vulnerabilities, most obviously vulnerabilities to sea level rise, it faces significantly more hurricane risk that one might originally predict. Although New York is not in a climate traditionally associated with hurricane risk – tropical, warm weather, etc. – unique geographic features create an unusual coastline that results in severe hurricane risk. The right angle made by Long Island and New Jersey create a natural system that results in abnormally high storm surge levels, as easterly winds drive water westward directly into New York City.[27] While storms often do avoid New York, and may avoid New York even more often in the future as the warming climate effects hurricane patterns, the propensity for intense storm surges due to natural geographic conditions will continually make New York only moderately able to cope with future storm events.[28] Additionally, warming water will lead to more intense storm events with increased rainfall and flooding consequences.[29] If Hurricane Sandy was considered destructive, future storms being born in warmer waters with higher sea levels could be potentially catastrophically damaging to the coastal areas of New York City.

While environmental factors surrounding New York create an environment not particularly suited to hurricane creation, unique geographic features have resulted in a city with only a moderate coping capability in both the short and long term to ocean based environmental risks such as hurricanes and sea level rise.

Expectation benchmarks in environmental factors focuses on the capability of planning and response by formal structures, and the citizenry response and expectations of those decisions. While no major unrest was experienced during Hurricane Sandy, response has remained critical from some of those most affected.[30] In terms of prior expectations, many took warnings from the government seriously, and evacuated some of the hardest hit areas. New Yorkers seemed to be aware of the risk the hurricane presented, and attempted to take proactive action to mitigate harm to their own existence. However, some expectations regarding the threats posed by hurricanes were misunderstood in some

Fig 13.2 Damage to Staten Island caused by Hurricane Sandy

communities. For example, many residents who lived within one block of water felt that wind was a larger risk than water levels. This indicates that some expectations were not well managed by state resources. In terms of citizen response and acceptance of government actions and failures, however, there is indication that in nearby New Jersey, at least, a majority of Sandy victims were dissatisfied with local storm recovery efforts.[31] While this has not contributed to any sort of instability in these urban environments, it is important to note that public reception of recovery efforts were not overwhelmingly positive, although not heavily negative either. In all, it is tough to state a conclusive impact of expectations upon hurricane preparedness and response. No population will ever be fully prepared for a super storm, but the population of New York City took at least some important steps to increase self-preservation, and the state and federal response was adequate, if not perfect.

Warnings were taken seriously. While some did stay behind, many evacuated the most dangerous areas, and loss of life was minimized. Additionally, the expectation of recovery has been at least somewhat met. While some discontent exists, there is not widespread resentment or distrust spreading through the community.

NATURAL ENVIRONMENT	
DIMENSIONS	EVALUATION
Adaptive Capacity	**POSITIVE**
Coping Capacity	**NEUTRAL**
Expectancy Benchmark	**POSITIVE**

Energy

The energy system in New York City failed as a result of Hurricane Sandy's impact. In assessing the coping capacity of the energy system, a number of evaluated criteria negatively contributed to the city's stability, while adaptive capacity criteria were mostly neutral leading up to and during the shock. Expectation thresholds appeared to be highly dynamic in response to both the shock and the policy responses during the recovery, which provided responding authorities the flexibility needed to tackle emerging challenges with a fairly understanding and cooperative society, so we consider this a neutral effect. Following the shock, wholesale changes to the energy system at the City and State level have been implemented, resulting in the energy system's coping and adaptive capacities to be positive contributors to the city's current stability, with urban expectations maintaining a neutral contribution.

New York City's energy system's adaptive capacity was a neutral contributor to overall stability prior to Hurricane Sandy's landfall. Similar to coping capacity considerations we discuss below, New York City's adaptive capacity criteria were essentially overcome by the shock of Hurricane Sandy. Demand Responsiveness was essentially inconsequential to New York City's stability, while Supply Modernization efforts did not begin until New York City began recovery efforts.

Network Flexibility was the most strained adaptive capacity criterion, particularly regarding the degree of the coordination between the key energy system players. This criterion is considered to have a positive effect on New York City's stability, with highly coordinated efforts between all of the major energy system actors - policy makers, suppliers, distributors, and emergency preparedness/response teams were all very active in preparing for and responding to the various strains Hurricane Sandy placed on New York City's energy system.[32] Even with this in mind, we conclude that the energy system's adaptive capacity had a neutral impact on the stability of New York City.

The most significant negative contribution to NYC's coping capacity was the negative effect of the Supply Robustness criteria, which demonstrated critical failures in all four metrics. With critical electricity substations flooding and no way to replace these central nodes, large swaths of the city remained without electricity for days.[33] Concurrently, the fuel resupply network was crippled as a result of port damage and deteriorated road conditions, resulting in critical fuel shortages for first responders and locals during both evacuation and immediate response.[34] Without any local reserve capacity, there was no way to respond to the immediate shortage of fuel, until administrators were able to institute emergency refueling sites days after the initial storm struck.[35]

New York City's Supply Diversity also negatively contributed to the stability of the city, predominantly due to limited variety and a skewed balance, especially when considering the different sectors the energy systems served. Electricity generation relied on traditional generation plants, and without the variation of alternative generation systems, whether those be simple diesel/gas generators or more advanced distributed energy generation sources like microturbines, fuel cells, or photovoltaics.[36] Additionally, electricity generation is predominately consumed by buildings, and did not serve much of the transportation needs for civilians or first responders, who relied on traditional internal combustion engine vehicles. Meanwhile, oil and gas products were primarily directed to transportation needs (although of course contributed to various building heating requirements), again demonstrating a lack of supply variety and a skewed supply balance.

The final active category in the current context is Network Protection and Maintenance, which also negatively contributed to New York City's

stability, although to a lesser degree than the prior categories. The restoration plan was designed almost entirely in reaction to the shock and took days to restore power, where a more deliberate plan that was well-rehearsed prior to the storm could have resulted in a positive contribution. The restoration was so plagued with challenges and delays that Governor Cuomo announced an investigation into the state's utilities, with some areas of Long Island without power for 16 days.[37] As it stands, the reactionary process and difficulties in accessing and restoring key energy nodes negatively contributed to New York City's coping capacity. Supply Responsiveness is very difficult to evaluate in the context of Hurricane Sandy due to the crippling effects of the storm elsewhere in the system. With failing transmission lines and generation nodes, the electricity system was virtually incapable of meeting any demand in certain areas of New York City for days. Oil and gas supply, particularly at the consumer level - both for first responders and for civilians still in the area - struggled to fulfill demand until emergency refuel stations were established for first responders, while the Mayor established a rationing system to limit the long lines at gas stations for remaining residents.[38,39,40] Given the magnitude of the shock, Supply Responsiveness can at best be categorized as having a neutral effect on New York City's stability.

Similar to Supply Responsiveness, Demand Efficiency had a fairly limited bearing on the energy system's ability to cope with a shock at the scale of Hurricane Sandy. Building and vehicle efficiencies and the penetration of public transportation (for more energy efficient mobility) are nearly irrelevant in the circumstances of this sort of shock and the cascading effects in the other coping categories. As such, Demand Efficiency is similarly rated as having a neutral-at-best effect on New York City's coping capacity.

Given the intensity of the shock and the cascading effects throughout the energy system, local New Yorkers adjusted their expectancy benchmarks on a near-daily basis. Whether it was pre-storm, post-storm, or during the storm surge, the expected service thresholds for electricity, gas, and oil changed dramatically, as a function of the physical effects of the storm, in response to the policy actions of government administrators, or as part of the maintenance and restoration plans of the utilities.[41,42,43] The long lines for gas and extensive outages drove significant responses from government and industry.

Two specific incidences help to highlight expectancy benchmarks not being met and corresponding policy responses. During the recovery, lines to get gas were so long that the Mayor needed to institute a rationing policy. The panic-buying and hoarding of gas, along with the long lines, reflect that the expectations for a reliable supply were very low. Following the implementation of the rationing policy and the absence of critical voices against the policy, we can infer that the rationing policy was accepted - a policy that would not be accepted during more normal circumstances. The second example reintroduces the earlier note about the Governor's investigation of the delays in restoring power. We infer from this that there was a dissatisfaction at the local level with the restoration process. While there was an acceptance that some outages would occur, the extended outages fell below the expectation threshold despite the recognized challenges of responding to a disaster, ultimately generating a response from the Governor.

Reviewing the energy system's contribution to New York City's stability, we conclude that coping capacity and expectancy benchmarks negatively impacted stability, while the energy system was a neutral contributor. In the years that followed, New York has undertaken major efforts to increase both their adaptive and coping capacities, and we would like to highlight some of those efforts here as examples of best practices for future analysts considering the stability of their city.

One of the biggest policy efforts was the

Reforming the Energy Vision plan implemented by the Governor. This comprehensive program targets more distributed energy generation and storage, diversification of the energy supply for transportation and buildings, hardening key physical energy infrastructure (generation, transmission, etc), and modernizing the grid, efforts that address almost every criteria in the energy stability factor.[45] Another part of the recovery included the development of the NY Prize Microgrid Competition, which helps spur innovation into community-based microgrids, which should aid network protection and supply robustness.[46] Additional efforts to develop supply robustness occured at both New York State and the US Federal Government, with both developing gas reserves: New York commissioned the Strategic Gas Reserve as part of the Fuel NY initiative in 2013 and the US Department of Energy created the Northeast Gasoline Supply Reserve in 2014.[47,48] Efforts to develop the coping and adaptive capacities of the energy system should put New York City in a better position to remain stable despite emerging stresses or shocks.

ENERGY	
DIMENSIONS	EVALUATION
Adaptive Capacity	NEUTRAL
Coping Capacity	NEGATIVE
Expectancy Benchmark	NEGATIVE

Technology

Technology increased the city's ability to predict and prepare for the hurricane. It also strengthened the recovery capacity by collecting information and facilitating assessment. Social media offered the government new ways to connect with people and deliver information. Meanwhile, the government had to deal with the related problems of misinformation and fake news, as well as the over-reliance on technology.

In terms of adaptive capacity, the government showed efficient management of the disaster with the help of corporations and non-government organizations. The government was able to access maps and crowd-sourced information, and that data helped emergency response professionals by providing situational awareness with regard to weather, key resources and personnel, their location, and other assets. For example, Google Crisis Map provided information for damaged assets, traffic conditions, donation needs, and shelters and recovery centers. The "Hurricane Sandy Communications Map" mapped telephone outages and the locations of public Wi-Fi available in areas hit by Sandy, helping the post-disaster response.[49] There was also a disaster recovery software system on recovers.org that helped communities to organize critical resources such as information, volunteers, and donations. It was reported that there were 150,000 visitors to the websites for the four New York City communities in just the first six days that they were live.[50] Supporting volunteer activities and donation platforms not only alleviated stress for the government, but also built a sense of cooperation within the community. At the same time, the government implemented a national hotline, providing year-round disaster crisis counseling, which was necessary for building up communication with the public.

Social media played an important role in formulating public awareness by providing a relatively new source of data and helping to enhance situational awareness. During the hurricane, people turned to social media platforms to share information, with internet usage increasing by 114%.[51] The platforms offered people ways to take community

actions, make donations, and assist victims. Government officials used social media to share information and respond to public needs, and private companies also provided services through Twitter. When there was an absence of government information or a cohesive approach to collect information in one place for a better approach, social media made it possible for many agencies, nonprofits, and volunteers to develop and combine information and resources, and to publish them in one place. Many government agencies also aggregated and published information through a centralized portal as well. For example, the New York City Mayor's Office provided information via one website (www.nyc.gov) during both response and recovery from the storm. Information was also updated hourly on the on Twitter by New York Office of Emergency Management.[52]

Some websites offered information on volunteer opportunities, where to find prepared food, and the availability of resources including open gas stations, pharmacies, hotels, restaurants, etc. Influential government twitter accounts such as New York State Governor New York City Office of Emergency Management[53](@NotifyNYC, @ nycoem), and the City of New York Mayor's Office (@nycmayorsoffice, @nycgov) also built up communication with the public. Within the public itself, twitter published a #Sandy web page that provided information on several resources. Official channels also included Facebook pages, Flickr, and Google+, etc.[54] It also used social media to initiate and maintain contact with loved ones and friends, show and provide support to the community, solicit donations, and more, with the help of nonprofit organizations managing the information and networks. Facebook pages were built such as the Hurricane Sandy News page, Hurricane Sandy Info – Relief & Recovery page, and Hurricane Sandy Relief Volunteer Group page. Infrastructure providers such as water, power, and transportation agencies shared information on the status and availability of their resources through various social media channels as well.

To deal with fake information, the government proposed a requirement of federal website standardization, including operating standards, and the requirement to cover information such as statistics, safety tips, and situation reports. In addition, several websites, blogs, and spontaneous volunteers published, addressed, and corrected false rumors. For example, snopes.com (which had previously been designed prior to Sandy to correct "urban legends, folklore, myths, rumors, and misinformation") published information on various photos and rumors, as well as response and recovery information. Other examples include websites such as WNYC.org, Hope For New York (www.hfny.org/hurricane), DNAinfo.com, My New York Legal Help and It Is In All of Us.

In terms of coping capacity, the city firstly predicted the impact of the hurricane through its integration into the larger weather services available. Remote sensing satellites played an important role in this regard as the European weather modeling center accurately predicted the hurricane's track and strength, and sounded the alarm five days prior to its landfall. Due to this, the Federal Emergency Management Agency (FEMA) prepositioned commodities and assets, activated response centers, and quickly built up working connections with local governments and other agencies.[55] Prediction and advanced warning reduced the number of deaths and gave the city time to prepare.[56]

In response, the community responded quickly, using a number of technology, communication, and media resources that it had at its disposal, further facilitated by high levels of media penetration throughout the city, allowing the rapid spread of the information. Members of the tech group also started an email list, distributed a list of pressing needs of hurricane victims along with available resources,[57] and nonprofit organizations with local volunteers helped to satisfy needs that were identified in daily meetings and conference calls.[58]

In regards to communication infrastructure, in the year Hurricane Sandy hit, there were 79.3 internet users for every 100 people and 96 mobile cellular phone subscriptions per 100 people, showing a high level of internet access and mobile phone penetration.[59] Although the hurricane destroyed cell towers and caused some suspensions of online communication, which showed the vulnerability of telecom infrastructures, these figures and actions taken showed that the system was still able to cope with many of the demands placed upon it.

In terms of expectation, the fragility of infrastructure is a big concern. The response for disasters, no matter whether it comes from the government or the public, is still largely dependent on utilities.[60] Hurricane Sandy caused power outages, and residents thus suffered internet outages and lost connections.[61] Data center companies ran out of power and had to shut down servers.[62] New-York based business and services were interrupted, with the equipment damaged by water and temperature, and the companies experienced difficulties in recovering data for customers.[63]

Although the public showed good awareness and preparedness for Sandy, the city lacked education on potential emergency responses, especially on how to use new tools to adapt. People still tended to reach for low-tech options in extreme situations instead of taking the time to learn new skills in advance, increasing the difficulty of managing databases efficiently even though they existed. Hackathon-created tools are great for people who feel comfortable with them, but email, printed forms, and even yellow legal pads still ruled on the ground.[64] The most commonly used digital tools in disaster response are still Excel spreadsheets, Word documents, and Access databases. Plus, in any emergency, situational focus can narrow people's views and lead to blind spots and communication issues.

Responding to Hurricane Sandy, NYC officials were not aware of the additional communications channels used by volunteer groups and had almost no visibility into their actions. To make matters worse, national response agencies used the Incident Command System and National Incident Management System to coordinate, but most volunteer groups either didn't know these frameworks existed or didn't know how to integrate with them. As a result, the government still lacked an effective day-to-day way of communicating with volunteer groups and nonprofit organizations. As a result, building up connections and cooperation proved ineffective and wasted time for response after the disaster happened.

In conclusion, technology increased the coping capacity with tools for prediction of the hurricane and sending early warnings to the public. Thus, we consider NYC's technology contribution as a positive effect. Adaptive capacity was raised by the response through social media platforms, and effective one-way and two-way communication between the government and the public. Data collected on websites also helped the government to make decisions and to assess damage. Information sharing and communication also showed positive results on expectation, but the public lacked prior familiarity and could not fully take advantage of these high-tech tools, therefore we consider it as a negative effect.

TECHNOLOGY	
DIMENSIONS	EVALUATION
Adaptive Capacity	POSITIVE
Coping Capacity	POSITIVE
Expectancy Benchmark	NEGATIVE

Infrastructure

Hurricane Sandy struck New York City in 2012, causing localized flood damage to several subway stations which caused major disruption to transportation links. The primary damage to New York City's infrastructure did not come from the hurricane's wind or rainfall, but from the storm surge that flooded the city in the wake of the hurricane.

The largest impact on infrastructure was to the city's subway system. Water leaked in through street-level ventilation grates and entrance stairwells and flooded the underground trackways. In addition to being a barrier to the movement of trains, water soaked the subway's signal system cables and its power systems, and eroded many older wooden rail ties.

Flooding also put some stations completely underwater and impassable. As a result, special pump trains had to be deployed to pull millions of gallons of water out of the tunnels.

The effects of flooding were most pronounced in two areas: Lower Manhattan and the southern shoreline of Brooklyn and Queens, two of the coastal frontages with the most exposure to the storm surge. Of these two, Lower Manhattan had the highest impact on infrastructure because this area of the city has far more infrastructure assets, as well as far more population and employment density.

In particular, many of the tunnels under the East River into Lower Manhattan were the worst hit of the subway lines, because water will naturally pool in a downsloping tunnel.

Because the flooding took place at critical areas in the city center, train service could not be

Fig 13.3 Flooding Damage to a Subway Station in Lower Mannhattan

operated through Lower Manhattan on most lines. In a city where the subway is known as its principal mode of travel, localized damage crippled an entire network.

This is primarily because during the process of railway construction, it is incredibly cost-ineffective to build turnaround points at every station, which is the type of facility necessary for a 600-foot long subway train to safely reverse direction and avoid a flooded or otherwise restricted area.

Many urban railways only feature turnbacks at the ends of each line. In this case, this meant that a series of localized floods crippled New York City's subway since miles' worth of subway lines were unusable due to several impassable and flooded areas.

Rail divertability is shown to be an issue in the recovery to Sandy. Naturally, many of the first transit services to return were buses, which have much more flexibility to operate on roads and rights-of-way which are not flooded. In some places, bus routes replaced some segments of the subway system which remained closed for several weeks after Sandy's landfall in order to make necessary repairs.

Another significant infrastructural challenge was wastewater. Most of New York City's water treatment plants are located on the shores of the Hudson and East Rivers, and eight of them experienced failure in the aftermath of Sandy since wastewater flow was three times the average. While this failure did occur, a highly nimble bureaucracy was able to repair all the facilities and ensure full service within 96 hours.

However, Hurricane Sandy has pushed New York's MTA to design solutions that might prevent another such crisis, demonstrating their institutional adaptation and a positive governance environment. In November 2019, the MTA designed a flood-proof gate solution for its subway entrance stairwells, the principal means for floodwater entry during Sandy, and tested this solution by installing it at a station and then artificially flooding the stairwell. This solution demonstrated an effective use of technology which is aimed to be deployed to critical locations throughout the city which are at risk of flooding during a storm surge.

While New York City depended significantly on the subway, it was not the only part of life that was disrupted by Hurricane Sandy. The city's schools were closed, mandatory evacuations initiated in coastal areas, and nearly all citywide events and businesses shut down. The city was clearly anticipating a major disruption, and as a result basic travel needs (such as going to work, school, or running errands) were also eliminated or severely altered. Shelter-in-place policies were also implemented, forcing residents to stay home. As a result, New Yorkers' benchmarked expectations for normal life were already thrown out the window. While this might be a driver of overall instability, it is a markedly different situation than one in which citizens still had sustained needs for mobility and were not required to stay in.

INFRASTRUCTURE	
DIMENSIONS	EVALUATION
Adaptive Capacity	NEGATIVE
Coping Capacity	NEGATIVE
Expectancy Benchmark	NEUTRAL

Culture

In terms of social and cultural factors, Hurricane Sandy primarily impacted three criteria: community support, education and health care. Identity and culture were not a major part of the crisis, either from the stage of preparing for the storm prevention or the period of recovery. Therefore, it will not be included in the consideration.

From the public education perspective, New Yorkers have limited knowledge of the hazards of hurricanes and little knowledge of what can be done to avoid them. At the time of hurricane Sandy, New York City had no official organization like the Citizen Preparedness Corps to provide useful disaster prevention knowledge to the public. The group was founded in 2014 to provide courses and lectures on disaster preparedness. Similar civic education was lacking during Sandy.

When Sandy hit New York, people with disabilities became more vulnerable due to mobility issues; disabled individuals have unique requirements in times of crisis. First, people with disabilities living in tall buildings need assistance evacuating. Second, when faced with power failure, they need to get additional help. Third, they need information about which evacuation sites are handicap accessible. New York City's major disaster response plan ignored the disabled community and did not take into account their unique needs. According to Susan Dooha, Executive Director of the Center for the Independence of the Disabled, New York (CIDNY): "For over a decade we have warned the City about its failure to adequately plan for people with disabilities in emergencies and the harm that failure brings. Today's decision means that all New Yorkers, with or without disabilities, can look to their City to plan for their needs for accessibility during disasters and emergencies."[65] To be far, prior to Sandy, there was a focus on how to help people with disabilities survive major disasters, but efforts were not enough. Representatives of the disabled even sued the government for violating the Americans With Disabilities Act.[66] As a result, the city's lack of emergency plans made the disabled more vulnerable to disasters, and negatively impacted urban stability.

Elderly people faced similar conditions in Hurricane Sandy to people with disabilities. Elderly people with limited mobility may have difficulties in obtaining supplies. Elderly people who use elevators to access upper floors faced similar mobility issues after the power failure. Additionally, some elderly people with diseases need constant care. Many nursing homes were hit by the hurricane and shut down services, putting the lives of the elderly at risk. During hurricane Sandy, 17.2 percent of New York City's residents were over 60, according to census data.[67] Most of those killed by the storm were elderly people who drowned in their homes or cars.[68] So New York City's elderly were at great risk from such a disaster. The city had taken some temporary steps, such as providing door-to-door food delivery to nearly 20,000 seniors.[69] But overall, New York City did not have a comprehensive plan for how seniors would fare in a major disaster during Sandy.

During Sandy, New York City's health system faced two challenges. First, people injured by the hurricane needed the medical system to treat them. Second, the hospitals hit by the hurricane needed to take care of the existing patients and continue to carry out daily medical services. In terms of overall health resources, the impact of the New York City health system is positive. New York City had 62 hospitals with 26,451 beds during Sandy, one of the largest numbers of hospitals in the country.[70] New York City also has top-tier medical resources. In a 2013 list ranking hospitals, three of the seventeen hospitals ranked in the top six or more specialties were in New York.[71] The health system's resources made New York City more resilient to Sandy.

With only 43 deaths, Sandy's impact on the health system did not generate victims at a high enough rate to overwhelm emergency health systems. In the face of the hurricane, New York City's hospitals were more impacted by interruptions in the care of existing patients. Hurricane Sandy caused widespread power outages in New York City, and outages were among the worst problems hospitals faced during the storm. Power outages forced hospitals to use backup generators, which were often damaged by ensuing flooding, forcing some hospitals or medical facilities to shut down services. More than 18 percent of hospitals were hit by power cuts[72], 20 percent of their beds were at risk and five major hospitals had to be evacuated.[73] In addition, New York City hospitals and various government agencies evacuated about 6,300 patients from 37 other health facilities. There was initial optimism that no major hospitals would need to be evacuated, but this obviously failed to materialize.[74] From an emergency preparedness perspective, New York City's hospitals are poorly prepared, especially for power shortages and flooding. In a 2019 article, authors reviewed the course of hurricane Sandy, explaining how, after the storm, hospitals realized the importance of changing the physical structure of buildings, adjusting their electrical supplies, and improving their emergency evacuation plans.[75]

CULTURE AND SOCIETY	
DIMENSIONS	EVALUATION
Adaptive Capacity	NEGATIVE
Coping Capacity	NEGATIVE
Expectancy Benchmark	NEUTRAL

Security

Overview

Superstorm Sandy proved to be a major stressor on many aspects of security within NYC, such as with the police force acting as a solution to issues normally well beyond the scope of their regular duties. Despite significant augmentation from outside security partners, the storm and its aftermath provided ample opportunity for criminal activity; however, the city escaped the aftermath relatively unscathed from a security perspective, remaining strong, vigilant, and well-protected throughout.

Military Forces

Adaptive Capacity

The DoD began its response to the storm and staging resources prior to Sandy making landfall.[76] Although the DoD prides itself on its ability to adapt to any circumstance or requirement, the response to Sandy was especially unique as it marked the first instance of a dual-hatted Title 10/Title 32 commander overseeing both the National Guard and Federal forces, resulting in an unprecedented coordination of municipal, state, and federal resources.[77] For the duration of the crisis, the DoD was able to continuously showcase its conversion capability by adjusting to the requirements as they presented themselves, including such things as providing fuel to local level security and services as well as conducting clean ups. The DoD also immediately responded to requests for assistance and adjusted administrative requirements and procedures in order to most effectively deliver services to those in need, indicating a positive influence on the Military Forces Adaptive Capacity during the crisis. [78]

Coping Capacity

The United States enjoys a very large and well-funded active and reserve military at the national-level, complimented by National Guard forces at the state-level. In Fiscal Year 2012 (FY12), the U.S. Congress appropriated $645.7 billion to the Department of Defense, of which $530.6 billion was available for funding regular military pay, training, equipment, and readiness. As of September 2012, just prior to Superstorm Sandy, the total active-duty manpower was just under 1.2 million personnel.[79] As the U.S. military is charged with "supporting a response to an attack or natural disaster at home" in addition to its conventional military obligations, New York City was a recipient of federal military assistance during this crisis.[80] During Superstorm Sandy, nearly 61,000 service members were collectively mobilized and ready to respond, although only a fraction of this total was allocated to assist NYC directly.[81]

New York State's Division of Military and Naval Affairs (DMNA) is the executive agency responsible to the Governor for managing New York's Military Forces, consisting of the New York Army National Guard, New York Air National Guard, the New York Naval Militia and the New York Guard.[82] With a FY10 budget of approximately $860 million, and beginning in 2011 (a 2012 annual report was not publicly released), the New York National Guard had around 12,000 servicemembers, of which the NY Army National Guard maintained its full strength with 10,500 soldiers.[83] Although New York City is home to only a modest number of small National Guard bases and no major active-duty installations, the greater North Eastern portion of the U.S. enjoys numerous military installations that are available to support any required response which are further augmented by a larger, robust U.S. network of installations and Defense Industrial Base infrastructure. Overall, the extensive U.S., New York, and New York City network of Military Forces amounted to a showcasing of the ability for strategic forces to effectively organize in order to respond to the storm. Most significantly, the DoD was able to augment much-need services and resources through the Defense Logistics Agency (DLA), U.S. Transportation Command (TRANSCOM), and the U.S. Army Corps of Engineers (USACE), such as by providing approximately 9.3 million gallons of fuel for first responders[84] and other urgently needed services[85], as well as the assisting with much-needed pumping to extricate water from flooded critical public transit assets in the greater New York City metropolitan area.[86,87] Collectively, these factors aggregate towards a significantly positive Coping Capacity, whereby the great New York City metropolitan area is well supported by military forces and resources to handle large and diverse crises and disruptions.

Expectancy Benchmark

The general U.S. population, including that of New York City, have a largely favorable view of federal and state military forces. Despite significant activation of forces and resources, including multiple Navy ships just off the coast and military forces placed selectively in and around the city, there was little reporting, complaints, or mention of concern regarding infringement of citizen's rights, potential for violence, or negative sentiments towards the government or military. Additionally, there were little-to-no reported events or media coverage of protests or resistance from civilians demanding

SECURITY - Military Forces	
DIMENSIONS	EVALUATION
Adaptive Capacity	POSITIVE
Coping Capacity	POSITIVE
Expectancy Benchmark	POSITIVE

military forces move, vacate, or otherwise adjust how they provided assistance to the city. Confidence in military forces was such that little concern was expressed over the dual-hatting of the Task Force Commander and the significant amount of authority the position afforded, nor was there concern over relinquishing the responsibility at the appropriate time.[88]

For its part, and less well-known to the general public, the DoD and other levels of government were keenly aware of the potential for overstepping authorities and perceptions. In one telling instance on November 4th, an element of the Marine Corps came ashore on Staten Island temporarily under unclear guidance. Although there was some question as to the origin and intent of the order, and whether this represented a breach of state sovereignty, by all accounts local residents welcomed the Marine Corps presence while local and national media outlets provided extensive coverage of the response activities. Although immediately recalled to their ship, they soon returned to assist with debris clearance.[89]

Interestingly, expectations regarding the outsized role that the DoD would play led to some confusion regarding limitations of resources that it could provide, such as reports of some minor complaints over the significant gas shortages and the DoD's policy to limit its logistical support to only emergency responders and critical services.[90] These inconsistencies in understanding DoD's authority provide an example where positive expectations of the abilities of Military Forces exceeded actual capability.

Non-Military Forces

Adaptive Capacity

Overall, the NYC Non-Military Forces ability to cope with the circumstances and demands of Sandy were extensive, but still many adjustments were made to adapt to the evolving priorities and needs. To this end, the New York Police Department (NYPD) reinforced its regular patrols with officers normally assigned to organized crime units as well as plain-clothes detectives in order to further enhance police presence in potentially dangerous blacked-out neighborhoods.[91] The NYPD also brought in more staff and lengthened tours to cover the additional requirements, worked with the Federal Emergency Management Agency (FEMA), and New York State Emergency Services to provide over 500 light towers in blacked-out neighborhoods, and even mobilized 1,200 Police Academy recruits to assist with traffic control at some of the more than 3,500 intersections without power.[92]

Before the storm, NYC Non-Military Forces also conducted home visits, advised residents of the city's evacuation order, notified residents of the availability of various shelters, and distributed pre-packaged food and supply kits. New York Fire Department (FDNY) EMS, along with mutual aid ambulance resources, coordinated evacuations of several hundred patients from Coney Island Hospital, Bellevue Hospital, and NYU Hospital, including patients in critical condition and more than 15 infants in neonatal intensive care. Once the storm subsided, FDNY and NYPD conducted grid searches of more than 31,000 homes and businesses to locate and assist people in severely affected areas.[93]

During the storm, the FDNY pumped water out of more than 2,700 flooded homes and businesses, removed trees and cleared debris from roadways, fought multi-alarm fires, supported and evacuated healthcare facilities, and provided medical aid, all resulting in nearly three times the normal number of operations.[94] The NYPD, for its part, assisted and cooperated with other city departments, such as Housing and Transportation, by providing language capabilities, assisting with announcements, providing real-time updates to utility providers, enforcing temporary rules[95], and providing logistical support.[96,97]

After the storm, NYPD officers were used

beyond their normal crime control capabilities to distribute food and supplies, conduct wellness checks for vulnerable, staff evacuation shelters to ensure public safety, assist evacuees in obtaining donated food and supplies, assist in filing for FEMA assistance, and addressing other basic needs, and distributing fire safety pamphlets.[98]

Federal resources adapted by utilizing the new U.S. Department of Homeland Security's Surge Capacity Force, a group of volunteers from various Homeland Security departments that rapidly deployed to the city, that brought together agencies including the Transportation Security Administration, Immigration and Customs Enforcement, the Coast Guard and others.[99]

Organization levels ranging from municipal through federal non-military forces were able to quickly adjust and adapt to the needed requirements, resulting in a strong Adaptive Capacity overall.

Coping Capacity

New York enjoys the largest and one of the oldest municipal police departments in the United States, with approximately 35,000 officers and 19,000 civilian employees in 2012.[100] The NYPD is responsible for policing over 8 million people by performing a wide variety of public safety, law enforcement, traffic management, counterterrorism, and emergency response roles. As of 2020, NYC had the lowest overall major crime rate of the 25 largest cities in the country. The NYPD is responsible for regular patrols throughout the city, including the subway system and its millions of daily riders, patrolling the city's public housing developments of more than 400,000 residents, and serving as traffic safety agents and school safety agents.[101]

The NYPD was able to handle its traditional roles during the storm despite the elevated levels of urgency and requirements. During and immediately following the storm, both NYPD absenteeism and the city crime rate were down dramatically, with the latter down 27 percent compared with the same period in 2011. There were more than 130 storm-related arrests, including a small bump to 85 total burglary and other property crimes, and 52 at gas lines for disorderly conduct and other offenses; however, there were no reported murders for several days after the storm.[102]

In addition to regular day-to-day policing, emergency responders conducted boat and helicopter rescues, manned bridge checkpoints, patrolled blacked out neighborhoods, directed traffic through hundreds of intersections, collected and delivered food donations, staffed 911 call centers, guarded terrorism targets and patrolled long gas station lines. Although 911 calls increased to over 20,000 calls per hour (the highest hour call volume ever)[103], there was negligible degradation to overall services and an ability to keep the peace.[104] Although not perfectly suited to the task, general NYPD boats and special operation inflatable boats used by the nearly 15,000 strong FDNY were sufficient to conduct rescues of nearly 2,200 victims.[105] Realizing the potential scale of disruption prior to Sandy's landfall, city agencies were able to prepare for potential fuel disruptions by fueling vehicles and generators in advance, and the NYPD's independent fuel supply allowed other municipal agencies to fuel vehicles in the days following. The FDNY also activated its Incident Management Team (IMT), a team of 50-60 FDNY staff trained in logistics, finance, planning, and command to manage large-scale, complex incidents in New York City and around the country to coordinate the evacuations.[106]

FEMA also worked extensively with NYC services and the DoD, including supplying 1.9 million meals and 1.3 million liters of water within just three days of the storm[107], further contributing to NYC's already positive non-military security force Coping Capacity.

SECURITY - Non-Military Forces	
DIMENSIONS	EVALUATION
Adaptive Capacity	POSITIVE
Coping Capacity	POSITIVE
Expectancy Benchmark	POSITIVE

Expectancy Benchmark

New York City has a high expectation for its non-military forces, especially since the overwhelming increase in support following the terrorist attacks on September 11th, 2001. Even in the years prior to 9/11, overall civilian perception of the NYPD had been gradually improving as crime in the city continued to fall year-over-year. [108]

Just as the population rallied around the NYPD/FDNY after 9/11[109], expectations during Superstorm Sandy were high, regardless of which agency was providing services and resources. An actual reduction in crime immediately following the storm speaks to expectation that security forces would be sufficiently able to maintain order and respond to crime, violence, or emergencies, despite the calamity, and was perhaps even further augmented by civilian assistance. In one poll, nearly 80% of those surveyed indicated they would be willing to organize to try to do something to keep a local fire station open if, because of budget cuts, the fire station was going to be closed down by the city. This mindset generally speaks to the overall expectation that fire services – like all security services in the city - are always available and always capable of performing the required tasks.[110]

Violence Potential

New York City's unique stature as the largest American city, its densely packed boroughs, and its long and complicated history make its potential for violence much higher than most U.S. cities. And as one of the most recognizable and iconic international cities in the world, New York City has long been a target for terrorism. The 1960s attacks from left-wing militants, Puerto Rican activists, and Islamists, the Al-Qaeda truck bombing of the World Trade Center in 1993, the attempted truck bombing of Times Square in 2010, and of course the 9/11 attacks killing nearly 3,000 people are just a few of the violent events that have taken place in the city. Yet despite its size, complexity, and the constant vigilance required, no attack has successfully been able to bring the city to its knees, or deter the city's progress.[111] This ongoing threat, combined with the immense urban population, enormous disparities of wealth amongst its residents, and various cultural enclaves around the city certainly provide for ample potential for violence; yet despite these factors and others, NYC possesses many adaptive and coping mechanisms that help ensure its continued resilience when stressed.

Adaptive Capacity

In response to the numerous and likely still-high presence of would-be terrorists in the city, security and citizen's behavior have adapted over time to prepare for and mitigate the potential damage. Ubiquitous subway and transit security presence, constant public surveillance, and a collective mentality of citizenry to remain vigilant and to collectivize when needed are all evidence of the city's adaptive capacity.

High-profile terrorism and other violent crimes were not the only issues that NYC security forces had to account for in this period. During and after the storm, some would-be scammers attempted to exploit the situation by price-gouging, soliciting fake charitable donations, falsely completing assistance forms, and even cyber scams. Though much of the city was desperate for various types of assistance, the city was able to effectively combat these scams

Fig 13.4 Lines for Gas on Staten Island following Hurricane Sandy

by providing information to help inform the populace of scams and by informing them of the proper means from which to receive their respective recovery needs. These efforts, combined with a generally collective NYC mindset to be wary of such scams, reduced the impact of the storm. Had such measures not been in place, the initial shock of the storm could have been compounded by increasingly desperate citizens as they experienced further hardship and anguish, potentially increasing the likelihood that they themselves would resort to protest, blaming, anger, and even crime or violence in response.[112]

Coping Capacity

Overall, New York State has a gun ownership rate of 10.3 percent[113], although this figure is much lower within the city itself. This is largely due to laws and regulations mandating that although anyone 21 or older, American or those with Alien Registration Cards, are eligible to purchase a gun, many types are prohibited for purchase and any gun requires a permit from city authorities. In addition, obtaining a concealed carry license is difficult, and open-carrying is not allowed, reducing the likelihood of a preponderance of firearms being carried throughout the city, aside from lawful security forces themselves.[114] Although crimes involving guns are not uncommon, with roughly 450 homicides in 2012 alone[115], over half of deaths due to guns in the city are suicides[116], and the city's firearm death rate is less than half the national rate (10.0 per 100,000).[117] This level of gun ownership and crime both contributes and detracts from the city's Coping Capacity, where additional gun ownership may reduce crime in some instances, or else provide security from hostile foreign actors, it may also contribute increased crime and security concerns for domestic security elements.

NYC had around 12,000 prisoners at the time of Sandy[118], but did not have any more instances of loss of control, riots, or other issues that affected the safety of the overall population. What's more, some citizens seemed more concerned with the safety of the prisoners themselves as opposed to their ability to escape or contribute to post Sandy-crime.[119]

Expectancy Benchmark

Somewhat unsurprisingly due to the environmental nature of Sandy's impact on the city, surveys indicated that the most common reasons for evacuating were because of the threat of possible natural impacts (storm surge, flooding, wind, rain and waves), the forecast calling for bad conditions, or being told, recommended, or convinced to leave. The main reasons reported for not evacuating are thinking

that the impacts would not be bad in their area, feeling prepared or safe, and thinking they could handle the impacts, indicating that crime as a response to reduced security or opportunity exploitation were not major factors.[120]

Although this may seem like an intuitive concept, in many cities throughout the world, disasters often create cascading effects in criminal activity in their aftermath. Modern U.S. cities are not immune, including NYC itself. On July 13, 1977, a major blackout hit the city during an economic decline. Power losses, coupled with rising crime rates and the panic-provoking (and paranoia-inducing) Son of Sam murders, resulted in arsonists setting more than 1,000 fires and looters ransacking 1,600 stores."[121]

However, the overall crime rate around the time of Sandy supported expectations based on previous recent NYC encounters with disasters, with only a small bump in major felony offenses in an otherwise declining crime rate since at least 2000.[122] Some crime as a result did occur, such as some looting and assaults around Coney Island (and other areas), but they remained limited in scope and a general exception to the norm[123], while citywide murders dropped 86% immediately after the storm.[124] A source of otherwise social discontent, the Occupy Wall Street movement, though weakened at the time after disruption the year prior, rallied to assist.[125]

The main emphasis of emergency and disaster planning by government agencies was to pay attention to news and announcements, know key resources and numbers, and have a plan and supplies, but oriented towards disasters such fires, floods, and weather-related events – not crime or violence.[126] NYC residents were generally more concerned regarding their expectations to have gasoline immediately rather than wait it out[127], and although some small fights broke out over low supplies, they too were easily handled by regular NYPD and did not have the opportunity to escalate.[128]

Securing the Urban Environment

New York City represents the single largest U.S. metropolitan area by population size, as well as one of the largest and densest city centers in Manhattan. Due to its limited geographic footprint, the city has been forced to grow upwards at a faster and more prolonged rate than most other major U.S. cities, resulting in a very dense aggregation of medium, tall, and supertall superstructures, all atop a network of decades-old subterranean expansion.

The city is host to over 6,000 buildings higher than 10 stories, with hundreds more under construction at any given time. On average, these buildings are approximately 19 stories tall, with considerable outliers encompassing some of the tallest buildings in the world. Collectively, these buildings represent over 115,000 floors that would potentially require security forces to work through. To make matters worse, the tallest 2,000 buildings contain half of all the floors, and the very tallest 10 percent of buildings contain more than a fifth of the floors.[129] The scale of these structures alone is such that any of the world's security forces, military or otherwise, would struggle to properly reach or assist the entire city and its population simultaneously, let alone attempting to provide security on and around this scale of development with anything short of its entire force. he logic or justification of attempting such an undertaking is questionable,

SECURITY - Violence Potential	
DIMENSIONS	EVALUATION
Adaptive Capacity	POSITIVE
Coping Capacity	NEUTRAL
Expectancy Benchmark	POSITIVE

to be sure. This claim is not meant to suggest it is entirely impossible, that a phased approach may not be reasonable, or even to suggest any level of tactical, operational, or strategic advice – it is simply meant to convey the enormity that such a built of city represents, and how it is a unique characteristic of NYC that is not necessarily applicable to other cities.

In such an environment, the loss of control or rule of law would amount to a dire security situation, whereby large portions of the city would be potentially lost to security forces due to their inaccessibility and inherent danger. Subterranean features present additional obstacles, such as NYC's deepest subway station a staggering 180 feet below street-level.[130]

The city also possesses an extensive network of older construction with its own challenges. Due to inconsistent adherence to previous zoning laws, in addition to the very mature age of many buildings, construction practices, building layouts, materials used, and a number of other factors vary wildly. For example, nearly three-quarters of the existing square footage in Manhattan was built between the 1900s and 1930s, much of which include significant obstacles to access for security forces including elevated front entryways, brick walls[131], narrow hallways, extremely steep stairways, thick wooden doors, variations of high to low ceilings, limited natural light access, and thick floors.[132]

Given this footprint, providing expanded security beyond that of normal police and local security forces, especially for the purposes of countering a large outbreak of violence would be incredibly difficult. The permanent construction methods also reduce the ability for the city to adapt, whether for accommodating an influx of people, or changes required to provide access, resources, or services in ways that conflict with the intended original construction. Due to this, security forces of all types would be severely restricted in their ability to mold their surroundings to fit their needs, or in a more immediate sense, remove obstacles to their progress.

New York City does have reasonably well laid-out streets, especially in the portions with its infamous grid pattern, such that navigating the city in mostly straight, level, and wide streets would provide multiple avenues for movement. Security may be hampered by the city's geography (multiple islands and waterways) as well as infrastructure and transit choke-points, however the details of these unique city characteristics are expressed more thoroughly in their respective Stability Factor sections.

Most of these considerations did not affect the operation of immediate Sandy assistance, but certainly had the potential to play a larger role had the security environment deteriorated. In the unlikely event Military Forces had to enter Manhattan or some of the more restrictive portions of the boroughs, navigation of larger equipment and the logistics of providing for their personnel and needs could have proved difficult, though not impossible.

Security Conclusion

New York City has overwhelming support and internal security capacities, allowing it an overall positive scoring for its Coping Capacity, in spite of the lower scores for its violence potential and urban environment security. Despite the potential for security situations to deteriorate under extreme circumstances, the overall robustness of military and non-military forces have shown

SECURITY - Securing the Urban Environment	
DIMENSIONS	EVALUATION
Adaptive Capacity	NEGATIVE
Coping Capacity	NEUTRAL
Expectancy Benchmark	NEUTRAL

over time and during Superstorm Sandy they are adequate to address and mitigate many concerns. Like many of the disruptions that the city has faced over its history, Superstorm Sandy stressed the normal procedures of the city's polices forces; however, collectively, alongside assistance from the state, neighboring areas, and the federal government, security forces were able to adapt to the changing situation, adjust as needed, and maintain minimal levels of crime – despite the many opportunities – giving rise to a positive Adaptive Capacity score. Additionally, the city was able to quickly return to a sense of normalcy in the eyes of most of its citizens, emerging even stronger on the other side as the city continued to learn, grow, and progress into the future.

SECURITY - Overall	
DIMENSIONS	EVALUATION
Adaptive Capacity	POSITIVE
Coping Capacity	POSITIVE
Expectancy Benchmark	POSITIVE

Conclusion

Hurricane Sandy was a devastating disaster that challenged New York City on many levels. Our case study assessed the different impact factors by GENETICS analysis and how they tested the adaptive capacity, coping capacity, and the expectancy benchmarks of the city and its people.

The adaptive capacity outcome showed positive effects to urban stability. These are mainly contributed to by governance, economics, natural environment, technology, and security factors. A strong authority and experienced crisis management helped the government react responsively and maintain fundamental activities during the storm. Government and community support quickly filled the supply and energy shortage. Technology, particularly the use of social networks, was widely used to facilitate real-time response, build citizens' awareness, and provide partnership throughout the crisis.

Still, our framework points out the negative impacts of the constraint of public infrastructures, which could not be easily adapted. Meanwhile, the public's knowledge regarding emergency response was limited to certain populations. The coping capacity outcome of the city showed both negative and positive effects, while some factors demonstrated neutral impacts. The governance, technology, and the security factors positively impacted the city's stability. The government utilized advanced technology to predict the upcoming event and prepared for the most affected area. Meanwhile, extensive military networks in and around New York City significantly helped the city handle the crisis, particularly in emergency response. On the other hand, economic, energy, infrastructure, and cultural factors were negative to the city.

Despite being a high level of income city, small businesses and informal sector at the individual levels were the most impacted from the storm. The city's infrastructure could not cope efficiently, as exemplified by the subway system's multi-day stoppage, while the energy system experienced numerous shortages and strains. Minority groups, the disabled, and the elderly, were left out for the response plan. Environmental factors in general posed a neutral impact to the city as the geographic features of the city contribute to a moderate coping capability in both the short and long term to ocean based environmental risks such as hurricanes and sea level rise.

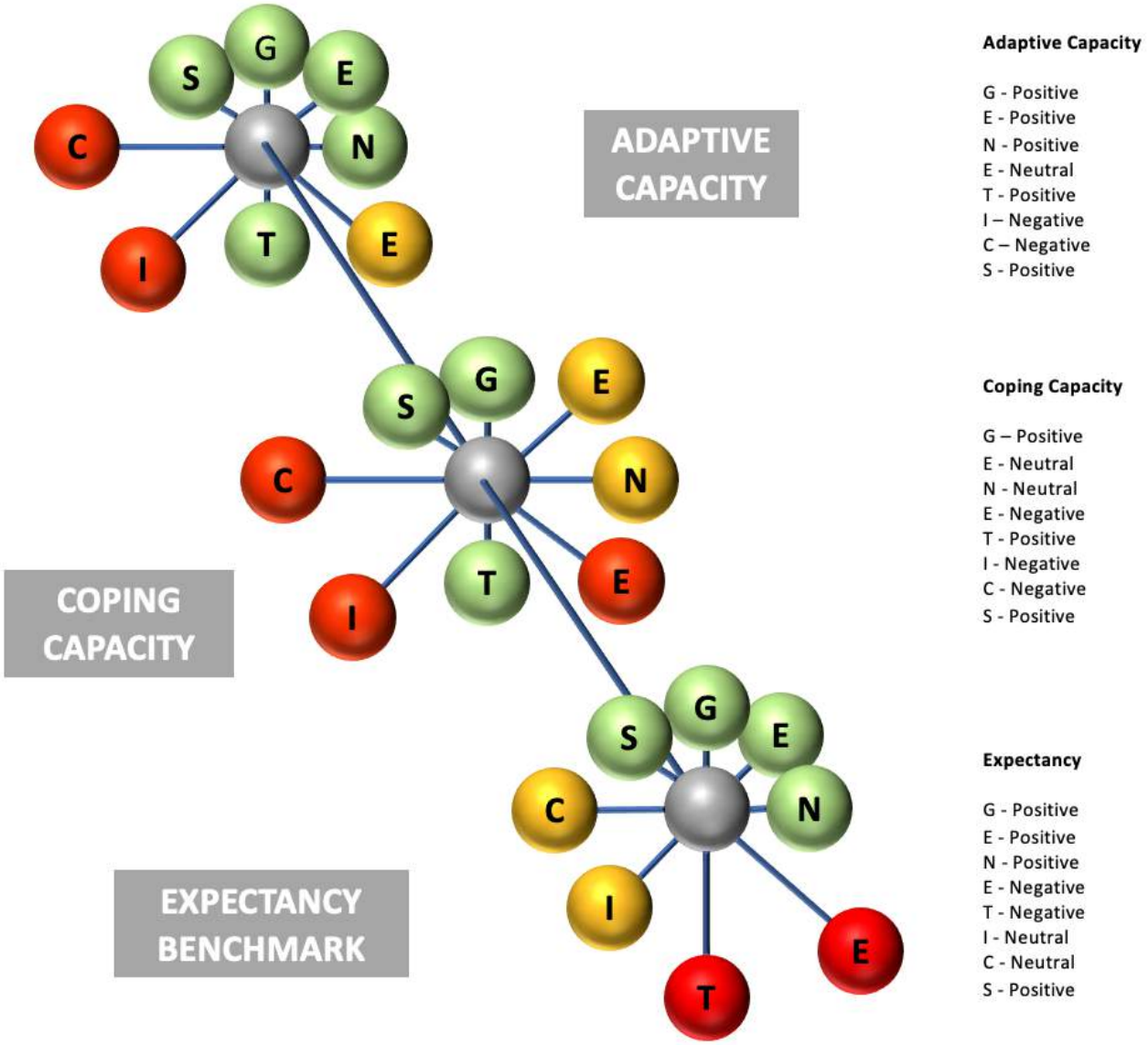

Fig 13.5 GENETICS Model for Hurricane Sandy Case Study

The expectancy benchmarks also express different effects for each factor. The governance, economics, natural environment, and security factors demonstrate the positive impacts. Meanwhile, the energy, technology, and infrastructure factors show the negative impacts. The government could utilize its autonomy in both administrative office and field work from the military effectively. This helped achieve people's expectations during emergency time and helped economic activity process accordingly. On the other hand, the city's low capability of infrastructure management of energy and transportation showed a very slow recovery pace.

What we find interesting under the Sandy case study is that all of the factors are relevant and impact the city's stability. Some factors, such as governance and security, show positive impacts to coping capacity, adaptive capacity, and expectancy benchmarks while others show mixed impacts. Infrastructure is the only factor that poses negative impact. This shows that having a responsive government to emergencies may not be enough as the study shows that the current fragility in infrastructure is a threat to the city's ability to cope and adapt to disaster. The contradictory impacts from each factor reflect the different levels of resilience of the city in several perspectives which we need to evaluate carefully.

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FIGURE CREDITS

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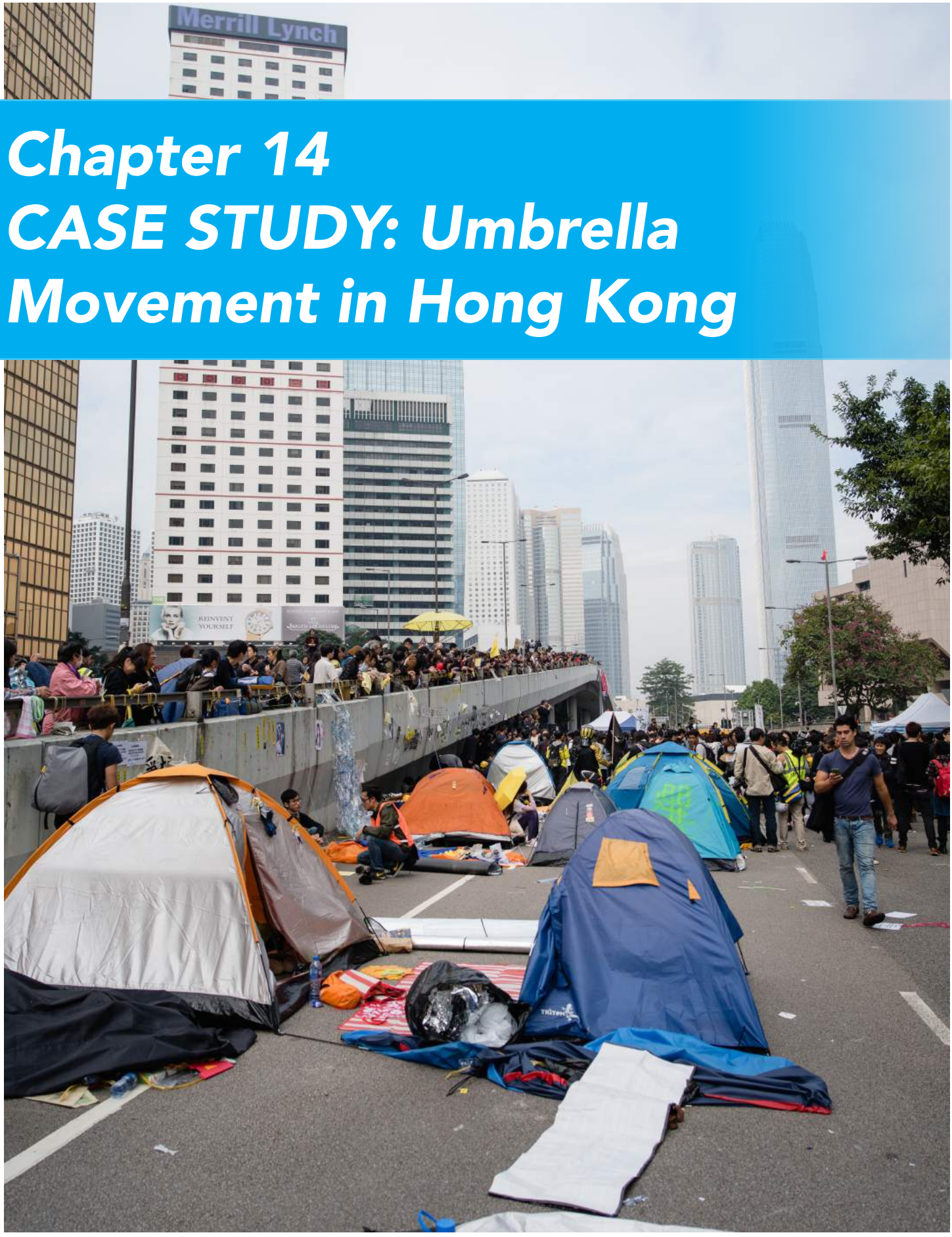
Chapter 14
CASE STUDY: Umbrella Movement in Hong Kong



Case Study Introduction

The Hong Kong Umbrella Revolution, also known as the Umbrella Movement or Occupy Movement, refers to a series of civil movements for universal suffrage that took place in Hong Kong from September 26 to December 15, 2014. The protesters spontaneously occupied several main traffic roads for sit-ins and marches. Their main demands were to fight for the right to nominate citizens for the election of the Chief Executive and to abolish the functional groups of the Legislative Council. The main symbol of the movement is yellow umbrellas, which originated from demonstrators who used umbrellas to disperse when the police dispersed pepper spray. Thus, the media dubbed the demonstrations the"Umbrella Movement" or "Umbrella Revolution." The protest is one of the largest civil demonstrations in Hong Kong's history. The demonstration began with student movements in several universities and gradually evolved into a comprehensive social movement involving citizens of all classes in Hong Kong. In the early stage of the movement, peaceful demonstrations were the primary form of protest.

In the later stage of the movement, violent conflicts occurred frequently, including clashes with the police and other citizens. In the end, the demands of the demonstrators were rejected and the movement ended in disappointment. There are two main reasons why we are using the Hong Kong Umbrella Movement as a case study.

First, the Umbrella Movement gradually evolved from a peaceful gathering to a large-scale violent event, hindering the normal operation of the city and challenging basic order. This transformation created a situation useful as an example of one of the many social movements which have turned into serious urban disruptions. Secondly, unlike Hurricane Sandy, the umbrella revolution in Hong Kong didn't happen spontaneously; tensions had been gradually fermenting for months until conflict finally broke out. Crises faced by cities globally are not solely from sudden disasters, but also from potential instability within cities due to political, natural, and social developments. This kind of "spontaneous" social crisis often builds for a long time before it breaks out, as demonstrated by the Umbrella Revolution.

The methodology we used in this case is the same as that of Hurricane Sandy which will not be repeated here. It should be emphasized that due to the different types of crises, each factor may use different metrics for specific evaluation.

Governance

Metrics related to the Governance Stability Factor played a crucial role in the development of the 2014 Hong Kong protest. To understand the impact of government on the urban stability of Hong Kong, the details of the protest can be applied to the previously outlined criteria and metrics of the governance factor to examine the effect on adaptive capacity, coping capacity, and expectation threshold during this period of time. Due to the unique political statue of Hong Kong, this case study only requires the examination of three governance criteria, municipal governance, national governance and international presence. Hong Kong has no overseeing provincial authority.

Municipal Governance

Adaptive Capacity

A consensus among many Hong Kong protestors were that the proposed changes to Hong Kong elections were a reduction in local autonomy. The changes were seen as an ongoing trend of increased control by the National government and thus a reduction in the self-determination of Hong Kong citizens. The view that the National government was slowly reducing the autonomy of Hong Kong and increasing national control was persistent before and after the 2014 protests, and has a ongoing negative affect on the ability to respond adaptively to threats. This was exacerbated by ongoing socio-economic problems that increased tension especially among Hong Kong students and youth.[1]

The reduction in Hong Kong's autonomy heightened the flashpoint of local concerns over national level control and exacerbated fears over the cultural and political divide between Hong Kong and the mainland. As a result of the large degree of autonomy Hong Kong had enjoyed since 1997, including a unique political system and separate currency, many Hong Kongers preferred maintaining a status quo of high autonomy. The new legislation jeopardized this.[2]

There was a positive effect on the adaptive capacity of Hong Kong due to a relatively recent history of popular protests, including the 2013 dock strike, the 2012 Qingdong incident, the 2011-2012 Occupy Central protest and the 2010 and 2005 democracy marches. While these protests varied in scope and size, they contributed to relevant experience for local authorities in managing civil discontent and preventing the outbreak of violence, as well as in preventing the breakdown of municipal control.

Coping Capacity

One of the strongest assets to the coping capacity of Hong Kong at this time was an effective system of policy implementation and local authority. The Hong Kong government maintained an efficient bureaucracy and enforcement mechanism, with a local police force responsive to the Hong Kong government. The Hong Kong government maintained an effective degree of control over the local authorities and basic policy enforcement and authority. This allowed the city government to adapt to the changing environment of the protests while maintaining government services.

During this period of stress, the ability of the Hong Kong government to utilize its own local enforcement mechanism, and retain an effective implementation structure, allowed for the protests to be contained locally. While protestors were still met with a harsh response from police, including the use of tear gas, lethal force was never deployed. This prevented a widespread use of national government forces, which given the history of protests in the region, likely would have exacerbated the protests greatly.

The Hong Kong government at the time of the protests was led by Leung Chun-ying, who had only been in power for two years. However, given the high level of continuity in political leadership and influence throughout the government,

GOVERNANCE - Municipal	
DIMENSIONS	EVALUATION
Adaptive Capacity	NEGATIVE
Coping Capacity	POSITIVE
Expectancy Benchmark	NEGATIVE

the collective efforts of the government were informed by a significant amount of experience. Most government services and performances seem to have met general expectations.

Expectancy Benchmark

The perception of the Hong Kong government, especially among younger Hong Kongers and students became increasingly negative over the duration of the protests. The Chief Executive saw a drop in recorded approval ratings to 39.7%, and discontent with the state of Hong Kong politics remained.[3] The perception of the police and police behaviour similarly became increasingly critical, especially as a result of the overly aggressive actions of the police during the protests against those suspected of involvement. The perceived loss in autonomy was also one of the driving factors of the protests, and was a clear failure of the expectancy benchmark, given the loss in democratic and local oversight that many in Hong Kong had come to expect.

State Governance

Adaptive Capacity

Scored by Freedom House on metrics of democratic freedom, including civil and political liberty, China scores a 10/100, squarely in the "Not Free" category.[4] This assessment is generally agreed with by other international watchdog organizations which have evaluated the People's Republic of China as an authoritarian single-party state. This specific form of government negatively affected the stability of Hong Kong in this situation. Adaptive capacity was reduced as China did not have national-level democratic forums to respond to protestor complaints though legitimate political processes.

The high level of authority of the national government has also negatively impacted Hong Kong's adaptive stability. This is due to the detrimental effects this authority has on local Hong Kong autonomy. As a result of Hong Kong's recent history of significant autonomy and liberal style governance, the rise of authority from the national Chinese government is primarily perceived as a threat to the autonomy of Hong Kong.

Additionally, the representation within the ruling executive and legislature of the Chinese government and Chinese Communist Party lacks the ethnic and linguistic diversity necessary to represent the differences felt by many in Hong Kong to the mainland. Although this diversity adequately maintains stable adaptive and coping capacity through much of mainland China by meeting local expectancy benchmarks, this is not true of Hong Kong. Many of the perceived fears of the Hong Kong protesters were identified as a loss of their unique identity and culture to an unrepresentative national government. As such this contributed negatively to Hong Kong's stability.

Coping Capacity

The authoritarian nature of the Chinese Communist Government also worked to reduce their Coping Capacity. The fears of high national government authority and reduced municipal autonomy would not have been as pronounced if the government was trusted to be a representative of the people. However, the non-democratic nature of the CCP contributed to its vilification by protestors and helped promote their message among pro-democracy and liberal activists.

GOVERNANCE - National	
DIMENSIONS	EVALUATION
Adaptive Capacity	NEGATIVE
Coping Capacity	POSITIVE
Expectancy Benchmark	NEUTRAL

The strong authority of the Chinese national government, while detrimental to adaptive capacity concerning Hong Kong, is nevertheless a source of strong coping capacity. The high authority, seen in the ability for the national government to impose specific policies on the Hong Kong government and direct national security forces into Hong Kong if required, make the requirements for a collapse of stability exceedingly high. Due to China being able to effectively direct policy and utilize security forces from outside of Hong Kong if necessary, authorities can quickly intervene if local Hong Kong authorities seem to be struggling in order to preserve a CCP-friendly government.

Expectancy Benchmark

The expectation threshold among a vocal segment of the Hong Kong population has been to keep authority of the national government low within the territory of Hong Kong and to maintain a degree of independence. As a result of increasing national authority, the government has set the condition for increasing unrest. However, especially among the groups protesting, the attempted increase of authority and the negative expectations of the Beijing government are not unusual. It is instead the failure of the expectancy benchmark in the Hong Kong government that has raised people's ire. As a result, the national government does not have a strong impact on the expectancy benchmark.

International Presence

While not as significant as the municipal or national government criteria, the international presence within Hong Kong as relevant to the 2014 protests still bears mentioning, notably in the metrics of occupation and recognition.

Fig 14.1 The skyline of Central Hong Kong

GOVERNANCE - International	
FACTORS	EVALUATION
Adaptive Capacity	NEGATIVE
Coping Capacity	NEGATIVE
Expectancy Benchmark	NEUTRAL

Adaptive Capacity

Hong Kong had been a British Colony for 156 years until the transfer to the Chinese National Government on July 1st, 1997. This long period of foreign occupation significantly changed the nature of Hong Kong, as residents see the territory uniquely as a British colony, with Western, liberal economic and political institutions entrenched in the city. This unique history is largely responsible for Hong Kong's autonomy becoming so valued by many living in Hong Kong, and fear of a suppression of their unique status is common. While not the norm, there are even some still remaining in Hong Kong who identify more strongly with Britain than the Chinese Communist Government
Adaptive Capacity

Hong Kong had been a British Colony for 156 years, until the transfer to the Chinese National Government on 1 July 1997. This long period of foreign occupation significantly changed the nature of Hong Kong, seeing the territory uniquely develop as a British colony, with Western, liberal economic and political institutions becoming entrenched. It is in large part of this reason that Hong Kong's autonomy has become so valued by many living in Hong Kong, and a fear of a suppression of their unique status is feared. While not the norm, there are even some still remaining in Hong Kong who identify more strongly with Britain than the Chinese Communist Government.

Coping Capacity

While Hong Kong has enjoyed a special status since 1997 under the One Country, Two Systems, Chinese policy, Hong Kong still lacks any international recognition as an independent state actor. Unlike Taiwan, which has some limited recognition, Hong Kong is universally accepted to be a subsidiary state to China. As a result, there is no capacity for direct international intervention against national government suppression. Any protest activities the people of Hong Kong engage in are as a dissident population, rather than an independent recognized national actor.

Expectancy Benchmark

There is no notable effect on the Expectancy Benchmark as a result of metrics related to international presence.

Governance Conclusion

Overall the contributing governance factors have a negative impact on stability. As measured by ACE, both the Hong Kong and Chinese national governments have set conditions which are actively detrimental to adaptive capacity, and prevent either government from resolving the underlying issues responsible for these protests. This is likely the cause of the several protests Hong Kong has experienced in recent years and will likely continue to experience into the future. However, while the adaptive capacity and expectancy benchmark are weaknesses, coping capacity is a strength. This is due to the fact that as much as the Hong Kong protestors criticize the brutality of the local police, the fact that local Hong Kong police used non-lethal weapons did much to mitigate much of the worst of the potential public uproar. However, even in such a case that local police were unable to maintain control, the strength of the national government means that the chances of Hong Kong protestors being able to separate from national control without international intervention were slim to

Economics

As the center of international commerce, Hong Kong ranks as one of the wealthiest cities in the world. The fundamental economic structure showed positive effects on economic stability. Given the ongoing protesting situation, high-income cities such as Hong Kong are considered to have the financial firepower to boost its economy by fiscal and monetary policy. We can also say that the Chinese government has the ability to afford the economic loss from a widespread protest by students and the general public during those three months.[6]

Hong Kong has four fundamental strengths: healthy foreign currency reserves, prudent fiscal policies, a sound financial system and a flexible and responsive economy. Nonetheless, the market connectivity showed a negative effect on the city's coping capacity. As the city is a center of the financial market, a lot of money comes from international investors, specifically from mainland China. This specific reason can also apply for the financial stability which inclines to a negative effect. The continuing protest increased the difficulty of remaining investor confidence. A high level of informality also posts a negative effect on a city's resiliency. Marked as one of the most unequal incomes in the world, a number of citizens are suffering from economic loss. The high cost of living in the city, especially in rental prices, makes it more difficult for certain groups to cope with the financial burden from protesting.

Hong Kong experienced various protests in the past. However, the umbrella movement is directly towards the Chinese government. The fundamental economic structure showed the positive effect on the city's adaptive capacity. Hong Kong's economy is governed by free market principles, so the markets respond quickly to interest rate changes and other variables, making the economy resilient in absorbing external shocks and capable of adjusting efficiently to validate the linked exchange rate. As observed, the Hang Seng Index value fell just 6 percent during the 2014 protests, lower than the predicted decrease of 15 or 20 percent from some market watchers. Meanwhile, the market connectivity showed a positive effect. Surprisingly, there were less effects on the overall economy than what people expected. This may be the reason why the protests did not reach their goal. Despite a slowing GDP growth in the fourth quarter of 2014[7], and the fact that the protest location was located in the central retail areas of Hong Kong, retail sales actually increased compared to the previous year over the same period. Simultaneously, total trade from a conglomeration of exports and imports showed an improvement. Particularly, the export of services from tourism went up which reflected on over 90 percent fully-booked hotel rooms during the movement.

This showed high confidence from visitors despite the existence of the protest.[8,9] The financial stability also showed a negative effect. Although the government can boost the economy by public policy, the high level of wealth disparity within society can put more fuel to the future demonstration. A deterioration of the sociopolitical situations and delays in addressing structural challenges of insufficient housing supply and high-income inequality could further weaken economic activity and negatively affect the city's competitiveness in the long term. This protest is also a reflection of the high level of informality in the city. The poverty rate even after the recurrent cash policy was 14.3 percent, or accounting for 962.1 thousand people living with poverty.[10] Under this umbrella movement, not only they were protesting for fully democratic election, protesters were also aiming for taking the land redevelopment, housing, and income redistribution.[11]

Hong Kong failed to achieve its own citizens' expectations. One thing to keep in mind is that even if the macroeconomic indicators demonstrate a favorable growth, it may be not important if some people in the society still suffer

from public policy. City may seem to recover from this stress. However, from the local point of view, the movement shows an unmeasurable political power, raising the civil awareness of the future generations. Meanwhile, internationally, the movement could gain media attention and gathers support globally.[12]

Hong Kong, as a center of financial and commercial city, showed the high ability to cope and adapt with economic loss in terms of fundamental economic structure. However, the unequal economy and low financial inclusion dominate the coping capacity to be negative for the city's resiliency. The overall adaptive capacity received a moderate or neutral effect since the high confidence in Hong Kong significantly helped remain high market activity. One vital factor cannot be neglected under this protest is the expectation of citizens towards their own government. Hong Kongians are not satisfied with the election policy and the current living condition provided by mainland China and aim for possible future protest. Therefore, we can conclude that the economic expectation is negative for the city's stability as a whole.

ECONOMICS	
DIMENSIONS	EVALUATION
Adaptive Capacity	NEUTRAL
Coping Capacity	NEGATIVE
Expectancy Benchmark	NEGATIVE

Natural Environment

The Umbrella Movement of 2014 took place in a city that experienced no significant environmental disruptions that led to the rebellion against authoritarian policies of the Chinese Government. In this specific case study, it is not important to cite various environmental causes that can lead to urban instability and revolution as it was not relevant during the protests. Hong Kong enjoys a fairly temperate climate, with an average temperature of 73 degrees Fahrenheit. During the protests ranging from September to December, Hong Kong is extremely temperate, and not in a rainy season. No major natural disasters occurred, and no level of adaptation was necessary to mitigate the effects of the movement and provide urban stability. While Hong Kong is by no means immune to environmental harm such as typhoons and sea level rise, these factors did not create the disruptions of the pro-democracy movement. It is important to note that future environmental impacts could create civil unrest that could compound upon previous rebellious efforts by the population, and should be considered when analyzing future potential instability events.

Adaptive capacity in our model refers to the awareness, flexibility, and form of an urban environment to prepare and respond to environmental threats and hazards. Hong Kong is a highly aware city, with ambitious climate goals laid out in their Climate Action Plan 2030+ including carbon reduction goals of 70% by 2030.[13] While this is certainly beneficial for mitigating future environmental risks to urban stability, this had no meaningful impact upon the Umbrella Movement. Hong Kong is highly flexible as well, with some of the most advanced flood mitigation and hurricane mitigation systems in any city[14], and has access to effectively unlimited natural resources, food, and water through its connections to mainland China. In a socio-political conflict such as the Umbrella Movement, there is little reason to believe that

environmental adaptability led to, or prevented, any type of event or response. As the adaptive capacity in this case was inconsequential, we rate the adaptive capacity as neutral.

The coping factor of Hong Kong, or the natural vulnerabilities a city faces, affected the Umbrella Movement not through any type of environmental event, but through the natural geography Hong Kong resides within. Hong Kong is located on an island only slightly bigger than Manhattan[15], and is highly mountainous, making difficult both protest and response. Protests in Hong Kong were diffused throughout the city due to lack of a natural gathering space, and response by the Chinese Government was difficult due to lack of access points to the island.[16] The natural geography of Hong Kong, as well as the British history of Hong Kong, created an environment that may have led to some of the rebellious events that occurred in 2014. A culture segregated by geography will tend to have separatist impulses[17]; certainly some of the rebellious activities against the government were driven by these nationalistic, isolationist attitudes. Additionally, the weather, as stated previously, was friendly to the protestors, as no major climate events took place during the months of protests. While it cannot be said that nice weather creates instability, it does provide an environment for it to take place; protestors are far less willing to venture out in a blizzard. As stated before, it is difficult to attach much significance to the natural environment as a source or cause of instability in 2014; however, there is some reason to believe that the geography may have helped contribute to an unstable environment. In this case, due to a lack of environmental hazards, we rate the coping ability of Hong Kong as neutral.

In a similar vein to adaptive capacity, the thresholds of the population, while certainly tested by many factors, were not pushed by environmental factors. We did not identify any forces that impacted the environmental thresholds that could have defined the conflict or led to instability. As expectation thresholds were also inconsequential, the thresholds are also considered neutral.

NATURAL ENVIRONMENT	
DIMENSIONS	EVALUATION
Adaptive Capacity	**NEUTRAL**
Coping Capacity	**NEUTRAL**
Expectancy Benchmark	**NEUTRAL**

Energy

The energy system of Hong Kong was a neutral contributor to the stability of Hong Kong throughout the Umbrella Movement. The Umbrella Movement stressor was not motivated by an energy concern, and the energy system was able to consistently match supply and demand throughout the protest. As outlined below, there were underlying factors in the energy system that could have resulted in serious instability, particularly regarding the system's coping capacity, but ultimately, these criteria were not stressed, and the energy system maintained a neutral effect on Hong Kong's stability.

Notwithstanding the limited impact on the city's stability, energy systems maintained their importance for the execution of daily city activities as well as in support of the protest and responses to the protest. As the protestors increased the size of their operations, they established a study area equipped with free mobile chargers, lamps, and wifi, powered with the support of local generators and wind turbines, or plugged in to recharge devices in the homes of sympathetic residents nearby.[18,19,20] For the broader society, energy demand and supply trends remained generally unimpacted in 2014, with both total energy consumption and electricity consumption maintaining normal trends, as shown in Figure 14.2 below.

The adaptive capacity of Hong Kong's energy system was a neutral contributor to Hong Kong's stability during the Umbrella Movement. None of the three subordinate criteria were stressed during the event, as none played a significant role in preparing the city for the emerging challenges of the Umbrella Movement. Most of the efforts to modernize and increase flexibility and responsiveness across the energy system of Hong Kong only began after the movement concluded. For example, the two primary electric companies only initiated their primary smart grid initiatives between 2016 and 2018, well after the Umbrella Movement.[21] With no changes to the energy system's modernization, flexibility, or responsiveness, we evaluate the energy system's adaptive capacity as having a neutral impact on Hong Kong's stability during the Umbrella Movement.

The biggest concern for Hong Kong's energy system's coping capacity is Supply Diversity. Hong Kong only produces 77% of their domestic electricity needs, relying on generation plants on mainland China to fulfill the gap.[22] Electricity generation comes primarily from coal, but also includes nuclear and natural gas generation.[23] Almost all of the coal used in Hong Kong is

Fig 14.2 Hong Kong Total Energy Consumption by Sector[24]

imported from Indonesia, all nuclear power is generated at the Daya Bay Nuclear Facility in Guangdong, while natural gas is transported from gas fields owned by China. The rest of Hong Kong's energy needs are met by oil and gas, with Singapore dominating the oil supply into Hong Kong.[25] While this was not an issue during the Umbrella Movement, Supply Diversity concerns could have been a factor in destabilizing Hong Kong and there would have been very little opportunity to cope with any stress to this supply system.

Supply Robustness serves as another potential concern for the energy system's coping capacity, primarily due to node centrality concerns that could have been leveraged by either protestors or the Chinese central government. As noted, there are two power distribution companies that monopolize Hong Kong: CLP Power Hong Kong Limited and Hongkong Electric Company (HEK).[26] Combined, they operate five total electricity generation facilities, while CLP manages the Daya Bay Nuclear Facility contract and operates a pumped-hydro storage facility.[27] Coal and oil imports occur at only two facilities: Tap Shek Kok on CLP's Castle Peak Power Station and Po Lo Tsui on HEK's Lamma Island Power Station.[28] Were the protestors to target any of these generation facilities or ports, or if the Chinese central government were to restrict transmission out of the Daya Bay Nuclear Facility (or blockade the ports), the energy system could have deteriorated and had a significant negative impact on the stability of Hong Kong.

While there was the potential for major issues, the coping capacity criteria ultimately had almost no impact on Hong Kong's stability during the Umbrella Movement. Supply consistently met demand signals across the energy system, the transmission, storage, and generation capacities were never overwhelmed, demand efficiencies were neither improved nor diminished, and no maintenance actions were required across the system to warrant a more in-depth analysis of this criteria.

As the Umbrella Movement did not overly stress Hong Kong's energy system, there is no data

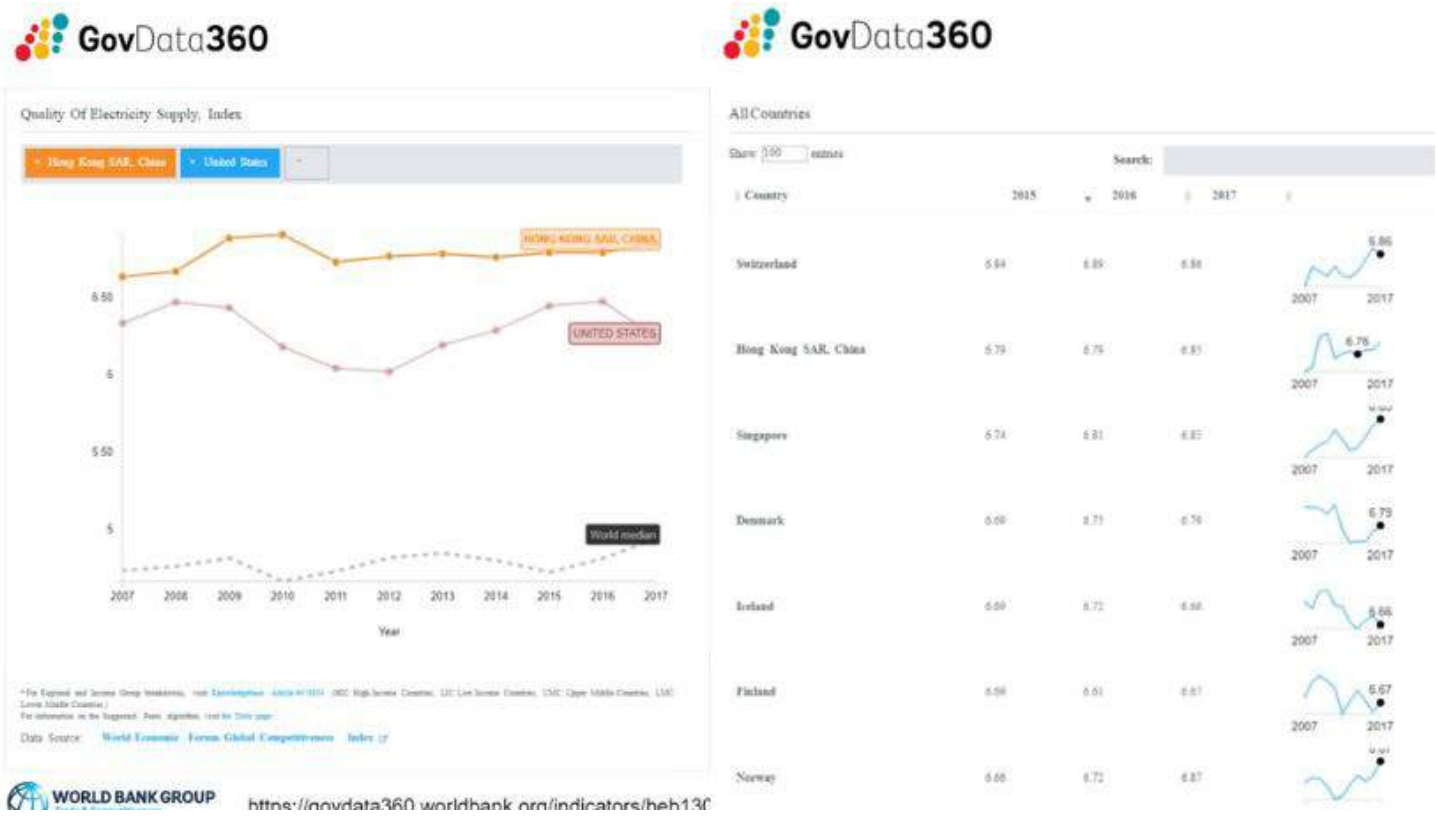


Fig 14.3 Hong Kong Electricity Ratings[30]

available to assess how the citizens perceived the energy system's capabilities or what concerns they may have had regarding service delivery, prices, etc. Worth noting, however, is that there was likely a very high benchmark, with both CLP and HEK registering average system availability ratings over 99.99%.[29] Per the World Bank's World Economic Forum Global Competitiveness Index, Hong Kong's electric supply quality is among the top rated systems in the world. Hong Kong registered a score of 6.76 on a scale of 7 in 2014, and in 2015 was the second ranked system in the world, with both shown in Figure 14.3 (previous spread). Considering this data, we conclude that there was a very high energy system expectancy benchmark in Hong Kong. Any service interruptions, such as those discussed in the coping capacity section, would likely have fallen below the expectancy benchmark and exacerbated instability in the city. All considered, the best conclusion is that the expectancy benchmark was, at a minimum, met, as evidenced by the lack of protests about the energy system, and therefore it had a neutral impact on Hong Kong's stability.

While there was a potential for the energy system to become a negative contributor to Hong Kong's stability during the Umbrella Movement, the energy system was ultimately a neutral contributor. Coping and adaptive capacities, as well as the expectations benchmark, maintained sufficient levels to ensure that the energy system was not overwhelmed by the stresses of the protests and did not become motivation or cause for additional unrest. As noted in previous sections, despite the energy system not being a focal point of the Umbrella Movement, Hong Kong has actively pursued grid modernization and supply diversification to continue to build their coping and adaptive capacities for the energy stability factor.

ENERGY	
DIMENSIONS	EVALUATION
Adaptive Capacity	NEUTRAL
Coping Capacity	NEUTRAL
Expectancy Benchmark	NEUTRAL

Technology

The Umbrella Movement had many characteristics of a modern social movement with the participants thinking of themselves as autonomous individuals connected through consensus. Such movements involve high participation of youths facilitated by the use of highly personalized digital networks.[30] This particular movement had a significant degree of spontaneity and large amounts of participation, with a rapid scaling-up process that showed the power of technology and media in the formation of a new type of movement.

Social awareness was improved during the movement. Media helped facilitate the collective actions and "digital narratives" of the Umbrella Movement, showcasing the rise of more personalized politics, especially among young people, who are more interested in values such as economic justice, environmental protection, and workers and human rights.[31] Those topics became easier to address and discuss as the penetration of personalized media increased[32], particularly media found on mobile phones, websites, and social media, creating new platforms for alternative views and collective action. During the protests, Facebook, Hong Kong Golden Forum, Discuss.com.hk, Tumblr, and WhatsApp were among the major platforms for information distribution and opinion sharing[33]

During the movement, social media served as an insurgent public sphere (IPS) for protestors to mobilize and act against the state by increasing support for the movement while reducing satisfaction with the regional and central government as well as trust in the Hong Kong police.[34] Social media thus became the primary tool for facilitating political communications and self-organizing activities such as protests[35] damaging stability at some levels. Meanwhile, the "high-choice media environment" led to opinion polarization amongst the public, and these heightened political attitudes were connected with the political communication during the movement. This showed the disruptive ability of social media at a time of great controversy by enabling the autonomous construction of social networks controlled and guided by their users, and the "filtering" effect of the individual network.[36]

Government prediction, preparation, and response were negatively influenced by the spread of media in regard to coping capacity. First of all, Beijing depended on the information collected by the Hong Kong Liaison Office, and could not predict nor immediately make responses to online dissatisfaction.[37] Secondly, official media platforms distributed different understanding about the goals, motivations, and requests of the protestors. Meanwhile, the protestors relied on their own media platforms to distribute their own information. Combined, the effect of this selective reporting was to exacerbate misunderstandings between parties and further instability. Additionally, hackers from Hong Kong and abroad attacked government websites, with university students conducting more than 11,500 attacks on the police website.[38] On the other hand, the media did increase community response with the discussions in forums, and helped them to stress the importance of rules and law.[39]

At the same time, the users would choose the contents based on their interests and concerns. Therefore, it is hard for the government to limit the sources of information through one channel and unify the opinions. Mobile phones also served as a powerful tool to record the moment and reach global audiences,[40] encouraging discussion and the spread of information and thoughts. Social media enhances political participation, encourages interpersonal discussion on various topics including controversial public issues, and enables expression and information sharing. This reforms citizens' expectation in future involvement of events and the methods of expressing opinions.[41]

We conclude that technology had a neutral impact on adaptive and coping capacities, with a positive impact on the expectancy benchmark. Social media played a positive role in raising public awareness and supported discussions of the issues, but also negatively impacted stability by serving as a platform for further polarization and protest organization. Disinformation and misinformation also reduced the effectiveness of the government's response. Social media had a positive effect on expectations by facilitating participation in social issues and building closer connections to the world. We conclude that technology and communications were both a facilitator of instability but also a tool to mitigate continued protesting, while setting conditions for increased stability in the future. Given these divergent indicators, we evaluate this factor as having a neutral impact for adaptive and coping capacity, and a positive impact on expectancy benchmarks.

TECHNOLOGY	
DIMENSIONS	EVALUATION
Adaptive Capacity	NEUTRAL
Coping Capacity	NEUTRAL
Expectancy Benchmark	POSITIVE

Infrastructure

With a very high level of development, Hong Kong is a city with a significant amount of infrastructure for its citizens. Broadly speaking, most citizens have access to well-functioning water, sewer, and power, as well as a high-quality network of roads and public transportation.

The protests were largely centered on the occupation of open-air public spaces, such as plazas, squares, streets, and boulevards. This was seen by the organizers as the most effective way of calling attention to their cause, ensuring the visibility of the movement, as well as maximizing the impact it would have on the city's operations and urban expectation benchmarks.

Critically, Hong Kong is an island city. The city's central business district (CBD) is located on Hong Kong Island, facing Kowloon, part of the Chinese mainland, across Victoria Harbor. Much of the city is located on two other principal islands in the harbor, Lantau and Tsing Yi. As a result, most of the city's crucial infrastructure links are bridges and tunnels connecting the various islands, carrying cars, trucks, buses and trains. The city is also one of the densest in the world, as the north side of Hong Kong Island boasts over 91,000 residents per square mile.

One of the centerpieces of the protest movement was the "Occupy Central" mass protest which aimed to immobilize the CBD by blocking crucial road rights-of-way, in an attempt to grind the city to a halt. This was largely successful. The goal of the protesters was to close critical links, which was in theory an excellent strategy to cripple a city whose mobility is dominated by a small handful of bridges and tunnels.

In Hong Kong, the subway system is privately owned and operated by the MTR corporation, a state-owned enterprise; as a result, many forms of public gathering or protest on the MTR's subways can be considered trespass on private property. Additionally, while crowding into a subway station might be an effective way of shutting down some travel, it might not achieve the same level of visible, open-air presence that filling public plazas could, nor could it attract the same number of protesters.

However, by focusing on occupying above-ground public spaces, the underground subway system was not affected. In fact, the subway became a lifeline for the functioning of the city, showing an average 20% increase in ridership during this time[42]; an even more significant increase when considering the fact that many businesses in the CBD were closed as a result of the protests. During this time, most bus and tram services on the street level were suspended for safety and to avoid getting "stuck" in the protest areas, meaning that the MTR became one of the only functioning providers of mobility in the city at the time.

This is emblematic of the city of Hong Kong's infrastructure system having a high level of coping capacity by having multiple infrastructure facilities that remained functional in the midst of a crisis, as well as a high level of infrastructure flexibility with different modes of travel that creates adaptive capacity for citizens.

What is especially noteworthy is who took advantage of the additional coping capacity and adaptive capacity. During the protests, the subway allowed many previous aspects of the city, such as places of business, schools, and government institutions—to continue functioning unimpeded by the crisis. However, the functioning subway also allowed many individuals to join the protest movement from around Hong Kong.

Closing down the MTR system could've been an effective containment measure on the government's part, in order to limit participation in the protest movement. However, the effectiveness of the system in the face of this crisis and the important role it held in keeping

the remainder of Hong Kong running meant that it was not used for containment and was left running.

INFRASTRUCTURE	
DIMENSIONS	EVALUATION
Adaptive Capacity	NEUTRAL
Coping Capacity	NEUTRAL
Expectancy Benchmark	POSITIVE

Culture

In terms of social and cultural factors, the umbrella movement mainly involved two criterias identity/culture and education. Among them, the identity and culture criteria is the most important. As far as the community support criteria is concerned, the umbrella revolution did not arise from resource allocation problems in the community or caused significant damage to the vulnerable groups. As far as the medical criteria is concerned, although the support of the medical system is needed for the injuries of some civilians and policemen in the conflict, the direction of the movement had little to do with the medical system in general. Therefore, the contents of these two will not be applicable to the analysis of this case.

The education level of Hong Kong citizens is inconsistent. In 2014, among the population aged 15 and above, the university education level reached 22.1%, the secondary level or preparatory level accounted for 50.5%, and the primary level or below accounted for 19.7%.[43] In other words, the number of citizens who have received university education is comparable to those who have only received the most basic education. By contrast, statistics from 2011 show that 30.1 percent of the Beijing's population had received university education or above, and 94.07 percent had received primary school education or above in Beijing.[2] In fact, the data on the education level of Hong Kong residents shows that Hong Kong has higher education rates much lower than cities of similar size.

In the early days of the umbrella revolution, university students in Hong Kong were the main participants. They took the expression of their demands as the content and the peaceful demonstration as the main means. Even as they entered the occupy central phase period, the students remained committed to the cause of peace. However, with the escalation and expansion of the movement and the wide participation of different classes of citizens, the means of the movement began to change and violent conflicts began to appear. Low education rate, therefore, has a negative impact on the movement.

The umbrella revolution in Hong Kong began with a student movement and gradually evolved into a social movement after more than a month. Going back to the source of the incident, on August 31, 2014, the standing committee of the National People's Congress of China formally adopted the decision on the issue of universal suffrage for the chief executive of the Hong Kong special administrative region and the method for selecting the legislative council in 2016, setting a framework for the method of universal suffrage for the chief executive in 2017.The nomination committee is composed of 1,200 members in accordance with the provisions of the election committee for the 4th chief executive and 2 to 3 chief executive candidates. Each candidate must be nominated by a majority of the nomination committee before he or she can become a formal candidate.

At the same time, the resolution of the NPC standing committee also stipulated that the 2016 legislative council election method of Hong Kong is not allowed to be amended, and must follow the 2012 legislative council election model.[45] That decision angered Hong Kong citizens who were supporting universal suffrage, because they believed that under this system, all candidates who did not win the preference of the central government would be "screened out" by a nomination committee composed of a small circle of elites and politicians. This process would create a system where only pro-establishment candidates would be allowed to be voted for. Therefore, they believed that the general election of the chief executive under the "8.31 framework" was far from being the "true general election" they advocated for. Essentially, disagreements over the way the elections were held sparked the whole affair.[46]

This shows not only the political differences between Hong Kong and the central government, but also the difference in core values between the central government and Hong Kong's younger generation. During the British colonial period, Hong Kong citizens had no right to participate in the election of the governor, who was directly appointed by the British government. Since its return to the mainland, Hong Kong has maintained a relatively independent administrative system as a special administrative region of China, emphasizing democratic elections and citizens' right to participate in elections at all levels. There is a clear difference between generations in their understanding of the right to vote.

The older generation, having lived through the colonial period, has a more positive attitude towards the current electoral system because of their own experience with authoritarianism. But many of the young people who took part in the umbrella revolution grew up after the handover, and therefore were less willing to support non-democratic systems simply because they were less restrictive than previous systems. To some extent, democracy is one of the core values of the younger generation and a logical starting point for them to view government policies. The central government has maintained a consistent attitude: although Hong Kong is a special administrative region with an independent system of government, as a Chinese territory, the central government cannot lose, nor is it willing to lose, political influence. This attitude also reflects the mainland Chinese's mainstream core value which is the desire for national unity. The movement was prompted by a clash of core values between the two.

If the umbrella revolution was just a normal peaceful demonstration, it would not be in the scope of our discussion, because a normal demonstration is a daily behavior of citizens and a normal activity of the city. It is precisely because the umbrella revolution broke away from the mode of peace and gradually evolved into a more unstable protest movement that tested Hong Kong. One of the important reasons for violence is the cultural understanding of conflict between different groups. The new and old generations have different understandings and expectations of democracy.

For example, a November 23, 2014, poll on the impact of the occupy movement found that more people under the age of 18 and those aged 18-29 said they had had an argument with family or friends because of the movement (42% and 43%). The survey showed that younger citizens tended to support the occupation, while older respondents were significantly more likely to oppose it. Moreover, only 32 percent of those under 18 said they were against the occupation, while 76 percent of those over 60 said they were against it.[47] In addition, the two generations have different views on the legal system itself. Among the under-18 and 18-29 age groups, 38% and 32%, respectively, disagreed that breaching the injunction would have an impact on the rule of law in Hong Kong.

Up to 90 per cent of those aged 60 or over, however, thought that breaking an injunction would undermine the rule of law.[48] The conflict

makes the mutual criticism on the Internet turn into the fighting in reality by virtue of the umbrella revolution. It was not the cause of the umbrella revolution, but it was the auxiliary condition that later turned violent.

Hong Kong citizens have long had a unique cultural identity compared to mainland China, which is due to the City's history. City identity and national identity are closely linked and the confusion of national identity will gradually affect city identity. During the British colonial period, the citizens of Hong Kong wandered between British and Chinese national identities. On the one hand, as a British colony, the British political system and educational system are used, with English as the main language. However, Hong Kongers are not accepted as true Englishmen. On the other hand, traditional Chinese culture still plays a great role. In fact, as an immigrant city, many of its residents have ancestors from the mainland. After its return to China, Hong Kong citizens have been torn between Chinese and Hong Kongers. Normally, there is no conflict between Chinese and Hong Kongers. But since Hong Kong was granted a great deal of independence after the handover, independence has also prompted some young people to feel confused about the identity that Hong Kong people are not Chinese. Young respondents aged 18 to 29 have seen their sense of Chinese identity plumb to its lowest level since 1997, according to a poll. When asked to identify themselves, 42 per cent of respondents chose Hong Kong and 18 per cent Chinese. In the previous survey, 40 percent chose Hong Kongers and 20 percent of Chinese. Respondents were more likely to identify themselves as Hong Konger and less likely to identify themselves as Chinese.[48] This kind of identity deviation is one of the main reasons for the occurrence and evolution of the umbrella revolution. When Hong Kong's citizens reject Chinese identity, the revision of the electoral law could spark a wider revolt. It can be imagined that if there were no difference in the identity of Hong Kong people towards Chinese people, then this movement would have stayed on the Internet or at least it would not have grown to the scale witnessed.

The umbrella revolution is not just an expression of Hong Kong citizens' views on voting rights. It is also a way for young people to vent their dissatisfaction with life. Although Hong Kong has always been an international financial city, famous for its prosperity and modernity, many young people in Hong Kong have been facing huge pressure and difficult living conditions for a long time. Among them, the most important problem they face is the housing problem, including the high housing price, the crowded living conditions. This kind of dissatisfaction with life causes subjective emotional loss and mental stress. "Today's young students in Hong Kong are taking to the streets. To be honest, with today's housing prices in Hong Kong, most young people will never be able to afford their own houses in their lifetime. The high housing prices have led young people to despair about the future."[49] one expert said. An editorial in Hong Kong's Ming Pao newspaper also said that the large number of young people who recently took to the streets to take part in the occupy movement and fight for democratic universal suffrage was an obvious trigger point, and that their dissatisfaction with the status quo and despair over home ownership were believed to be contributing factors.[50] The revision of the electoral law offers a perfect opportunity to vent that despair. At the same time, this sense of despair has helped the movement move from peace to violence.

CULTURE	
DIMENSIONS	EVALUATION
Adaptive Capacity	NEGATIVE
Coping Capacity	NEUTRAL
Expectancy Benchmark	NEGATIVE

Security

Overview

Beijing views unrest in Hong Kong as a national security issue, partially due to its "One Country, Two Systems" policy, and partially due to Hong Kong being seen as a precursor to a potential reunification route with Taiwan – a core issue for the Chinese Communist Party.[51] As such, its overall security situation exists in a precarious state, balancing national security considerations with those of its own internal well-being. Despite this, Hong Kong enjoys a robust security apparatus, capable of accommodating mass protests as well as some acts of destruction, all the while avoiding escalation towards either significant security crackdowns or a complete loss of safety and control.

Military Forces

In 2014, China's military, the People's Liberation Army (PLA), maintained a standing force of approximately 2.3 million personnel spread throughout its Army, Navy, Air Force, and Second Artillery Force. Although it faces shortcomings from outdated command structures, personnel quality, professionalism, and corruption, as well as weakness in conducting large-scale integrated and joint combat operations, after years of double-digit growth in funding and organizational improvements, it remains a significant and overwhelming force relative to the population of Hong Kong.[52] In addition to the PLA's overall declared forces, its close ties with other government organizations, as well as the lack of transparency with its capabilities and operations makes distinguishing its association with some actions regarding the Hong Kong protests unclear. As the PLA operates as the military force of the Chinese Communist Party (CCP) and not directly on behalf of the country, and given that the CCP is somewhat at odds with Hong Kong's semi-autonomous government and ideology, the PLA represents both a protector of Chinese sovereignty (with Hong Kong within that sphere) as well as a potential threat to Hong Kong's security stability.

Adaptive Capacity

Under Basic Law, the PLA may be directed to intervene within Hong Kong; however, given the sensitivities of such a move, Beijing's ability to use this option is limited to all but the most critical of situations. Shy of such events, Hong Kong and its people are actually somewhat resistant to changes regarding the presence of military forces in the city. For example, the PLA received some pushback while trying to expand its presence in Hong Kong in the months prior to the Umbrella Movement, specifically when attempting to construct a PLA-specific harbor along the waterfront. The response from locals included immediate protests and several break-ins to the PLA garrison, to which PLA spokespeople responded that it may be a sign for the need for increased PLA involvement in the Special Administrative Region.[53]

In the months prior to the outbreak of the full movement, the PLA attempted to influence the city by driving armored vehicles with guns mounted in turrets throughout the city in the early hours of the mornings, which locals saw as a sign of warning regarding further protests. The change in tactics regarding PLA presence within the city showed an attempt by officials to flex their authority while operating within the tight constraints of the law and status-quo non-interference, and as an example of the PLA's conversion capability as well. However, its limits were tightly bound by associations of PLA armor and civilian protests from 1989. [54]

During the Umbrella Movement protests themselves, mainland official state media criticized the protestors, warning of consequences if it continued, implying the potential involvement of PLA forces.[55] There was also some evidence of increased activity within the Hong Kong PLA garrisons, as well as increased presence of unmarked military-

license plate bearing SUVs throughout the city. Both of these actions were representations of military forces adapting to the evolving protest situation.[56] Additionally, there has been some evidence of mainland China intimidating protest participants before, during, and even after the protests, including threats on their life, hacking, and stalking of protestors and their families. [57]

Coping Capacity

Hong Kong PLA Forces: Formerly known as the Prince of Wales barracks under British rule, the Hong Kong Garrison now serves as the headquarters for approximately 6,000-10,000 PLA troops, which we are considering the manifestation of China's structural forces that concern this study, located not far from some of the main protests. There also exist numerous smaller PLA-associated facilities located strategically throughout the territory that are home to naval and air force personnel.[58] None of the PLA personnel stationed within the garrison are recruited from locals, nor are they allowed to interact with the population outside of the garrison, including in their free time.[59] Many of the forces are actually positioned just outside of the territory in Shenzhen, however their total numbers in Shenzhen are also unknown.

Hong Kong Basic Law Article 14 says that the PLA troops stationed in Hong Kong are there "for defense" and "shall not interfere in the local affairs of the Region." Though the law allows the Hong Kong government to "ask for assistance from the garrison in the maintenance of public order and in disaster relief," it also states that on such occasions the PLA must adhere to Hong Kong law. Article 18 clarifies further that most Chinese laws do not apply in Hong Kong, with the exception of the National People's Congress Standing Committee deciding "to declare a state of war or, by reason of turmoil within the Hong Kong Special Administrative Region which endangers national unity or security and is beyond the control of the Region, decides that the Region is in a state of emergency, [then] the Central People's Government may issue an order applying the relevant national laws in the Region."[60,61]

Expectancy Benchmark

There are some contradictions existing with the general perception of military forces by the people of Hong Kong. On one hand, there is the nationalistic pride of having a strong military force for China overall, as well as the relative security that Hong Kong people feel about their city. On the other, despite attempts at downplaying the often heavy-handedness of PLA forces on domestic affairs, the looming memories of China's previous 1989 Tiananmen Square protest and the violent Beijing response remain; giving some concern over the potential for a repeated response to democracy protests in Hong Kong. More recent events further support some concern for PLA heavy-handedness, such as actions taken in Tibet in 2012 when unarmed protestors were killed.[62]

Rumors regarding PLA involvement persisted throughout the duration of the movement, from the protestors worrying over their involvement, either from the PLA garrison on the island, or from the mainland itself. Hong Kong officials pushed back on those rumors, however, stating there was little likelihood of this occurring.[63] Beijing, for its part, was also concerned about "the sight of Chinese troops confronting Hong

SECURITY - Military Forces	
DIMENSIONS	EVALUATION
Adaptive Capacity	NEUTRAL
Coping Capacity	POSITIVE
Expectancy Benchmark	NEUTRAL

Kong protesters, particularly students," and the likely international response in return. As a result, Beijing put its faith in local Hong Kong non-military security forces to handle the unrest.[64] These security forces then explicitly stated they did not believe that PLA involvement was likely, further attempting to relax heightened tensions and disrupt the typical non-involvement status-quo that Hong Kong civilians expected.[65]

Regardless of these efforts, some citizens remained concerned of PLA involvement, with many in Hong Kong acknowledging that if military forces were to get involved, it would likely lead to the end of Hong Kong as it currently stood.[66] Despite this, the tensions did not give rise to any major events that resulted in Beijing calling up, using, or otherwise directly interacting with the protestors. Even during the middle of the protests, public opinion of the PLA garrison remained steady with an approval rating of 63.1%. [67] In fact, in one instance, a fire broke out at the PLA Central Barracks in early December near some protestors. Though the protestors took the opportunity to heckle nearby Hong Kong police regarding their assistance to the fire, the protestors also assisted local firefighters responding to the smoke by directing them down the right roads to access the PLA compound. Had there existed more tension amongst protestors, local Hong Kong security forces, and mainland PLA forces, such an event likely would have had a different outcome. [68]

Non-Military Forces

Distinct and separate from the PLA, the People's Armed Police (PAP) are a paramilitary security element in mainland China. Little is known publicly about the composition of PAP forces in Hong Kong, but they are suspected to consist of a contingent placed within the PLA facility within the island garrison. Acting essentially as a specialized riot-control paramilitary group, they were expanded and improved upon after the Tiananmen Square incident in 1989 as an alternate force hovering between regular police forces and that of the PLA. [59] Though not necessarily part of Hong Kong's independent security forces, under Beijing's authority or Hong Kong's request, they can be used in some circumstances to quiet unrest – as was suggested briefly in one of Beijing's mouthpiece publications the Global Times, suggesting that if protests continued, elements of the PAP may in fact be called upon.[70]

Adaptive Capacity

Hong Kong security forces had planned and trained for a small, centrally-located protest, but instead found themselves facing a much larger movement simultaneously operating at three different locations. When initially confronted by some of the early protestors on September 28th, police escalated their response by first using pepper spray and eventually tear-gas.[71] In response, the protestors adopted the use of umbrellas to block the pepper spray and tear gas canisters, while at the same time not adopting a posture or using anything that might be confused by security forces as threatening or escalatory. The more threatening response to the police escalations, however, was the addition of tens of thousands of additional protestors joining the movement.

Police attempted to clear camps nightly, however the protestors continued to return and the standoffs led to further tension and escalated responses. Police use of tear gas continued, and some protestors were pushed back with batons, dragged away, and arrested or shuttled away in ambulances. However, much of the back-and-forth between protestors and police was resigned to taunts, chants, and peaceful acts of disobedience.[72] In total, nearly 1,000 protestors were ultimately arrested, and there were few serious casualties on either side.[73,74]

Although they reacted relatively early with a heavy hand – confronting the protestors and using tear gas and pepper spray – they ultimately adopted a policy to wait out the protestors[75] as well as to chip away at the edges of their encampments to further reduce their occupied

footprints.[76] Protestors then took to trying "flash occupations" of new sites, organized over the Internet, to disable police efforts to anticipate the groups next movements[77], while security forces began to detain and search affiliates of the protests as they attempted to depart or arrive at the airport, or otherwise declare them as national security risks.[78]

Although security forces were able to adapt and flex resources to match the protestors and keep the movement from becoming too unruly, the city's security forces were stretched thin. Due to the nature of Hong Kong's separation from the mainland, the city was unable to call in outside or national forces to augment its own, leading to growing fatigue amongst those involved with the protests.[79] This was further compounded by the requirement of security forces to alternate between protecting the Umbrella Movement protestors from counter protestors, only to turn around and begin to push back on the Umbrella Movement protestors once again.[80] When violence and the use of non-lethal weapons eventually became too much, some protest leaders called for the movement to disperse and try alternate means of continued protest, effectively ending the movement.[81]

Coping Capacity

Hong Kong's Police Force maintains between 28,000 and 37,000 members amongst its ranks[82,83], and includes the Hong Kong Auxiliary Police Force (called upon during times of emergencies) and other specialized units, including a marine element capable of policing the islands and waterways around Hong Kong's immediate area. The police force operates independently from mainland security forces and maintains its own responsibility for recruiting and training its forces internally.[84] Both regular patrolling officers and auxiliary officers generally carry a sidearm, a baton, and pepper spray on their persons, but specialized positions may also carry heavier weapons.[85] In addition, the Police Force includes a wide variety of vehicles for patrols, including heavier armored vehicles, and is well equipped with riot gear when required.[86] Hong Kong's Fire Services Department has nearly 10,000 uniformed members with hundreds of civilian members as well. It operates its own independent fire response service from the mainland, including the operation of ambulance services, and enjoys modern equipment, fast response times, and extremely high favorability ratings amongst the general population. Hovering around or above 90% since at least 2012,[87,88] these ratings far exceed the bottom ranked police and PLA forces.
Though the numerous protest[89]ing groups did not represent security forces themselves, some did in fact train and hire marshaling elements for their own safety, as well as to manage the overall protests so that disruptions and confusion did not occur.[90] Overall, these marshalling groups remained relatively small, operating in small teams and likely numbering only a few dozen in total.[91]

Expectancy Benchmark

The expectation of the populace towards the Hong Kong security forces has remained high due to its history of professionalism but also the low instances of violent crimes in the city. In fact, it has held a position as one of Asia's most well-regarded police forces, even as it faced Hong Kong's greatest social crisis in recent memory.[92] Though some corruption has existed in Hong Kong's police force previously, it was more-so under British rule and decades prior, and now the force enjoys the perception of a professional and well-trained force overall.[93]

Due to this reputation, the protestors largely believed the protests would remain relatively peaceful, going so far as to publish and disseminate a manual to codify their actions which explicitly required non-violence - especially in the face of arrest or police interactions.[94] Teams of volunteer protestors came to pick up rubbish and litter and sort it for recycling, and obediently parted ways for ambulances and emergency vehicles on blocked roads.[95] They also believed they had the upper hand in the

SECURITY - Non-Military Forces	
DIMENSIONS	EVALUATION
Adaptive Capacity	POSITIVE
Coping Capacity	POSITIVE
Expectancy Benchmark	POSITIVE

early stages, stating that the "police don't have enough officers to close down the districts where there are protests."[96] Although the protestors knew the situation might escalate, and include hostility from police, they did not anticipate overwhelming force or brutality, but rather that both sides would tire over time[97] and that the student protestors would ultimately have the opportunity to travel to Beijing to negotiate.[98]

These expectations evolved over time, especially as the police began to use tear gas for the first time since 2005[99], and also after the attempts at clearing the Mong Kok encampments. Although they soon complained about police brutality, this also highlighted the high expectations most of the populace held of the police force – specifically that it would remain non-violent despite the increasing size and scale of the protests.[100] Yet despite the expectation that city police and security would adhere to rule of law, there was also some expectation that should Beijing get involved, rule of law would no longer be honored and security forces would operate more in the shadows.[101] A few even worried that security forces might become the Gong An, a reference to China's feared Public Security Bureau, which enjoys virtually unfettered powers on the mainland.[102]

Towards the latter stages of the protests police were being accused of using pepper spray without warning, issuing increasing beatings, and seemingly choosing when and where to enforce law, and both sides' emotions remained high.[103,104] Ultimately, several of the Occupy movement founders advised students and protestors to retreat for fear of continued violence, effectively ending the movement.[105] By the end of the movement, Hong Kong security forces saw a negligible dip in approval, maintaining a relatively steady 61-62% approval rating.[106] Some residents were also aware of PAP forces within Hong Kong, but little was known regarding the specifics of their presence. However, as recently as 2011 in nearby Wukan, PAP forces were used to quell protests, so their capability was not unknown.[107]

Violence Potential

Adaptive Capacity

During the course of the protests, security forces, the protestors themselves, and other elements of the city adjusted and changed to fit the situation. Security forces alternated between passively observing and aggressive confrontation with protestors, only to return to protecting the protestors from counter protestors. Despite this, there remained some level of complicity[108,109] between security forces and proven triad members[110], despite injuries to some of their own personnel.[111] Protestors shouted and jeered security forces in some instances, while in others assisted them and engaged them in a friendly manner. Yet others, unhappy with the progress of the movement[112], advocated for more aggressive and destructive approaches but also shied away from violence and chaos.[113] Potential sources of extreme violence like the triads ventured from the shadows in force, possibly under state direction, albeit not necessarily identifying themselves directly, and confronted groups of protestors, journalists, and students.[114] Yet despite the various changes amongst the groups, overall security was maintained without rising into chaos, nor was there promoting of dramatic changes in protestor sizes – outside the initial non-violent escalations – highlighting the high adaptive capacity of the city.

Fig 14.4 Hong Kong Security Forces Protecting Protestors

Coping Capacity

Hong Kong is one of the safest cities in the world, with a crime rate about half that of Los Angeles and New York.[115] Although gun laws are extremely strict and ownership requires registration, there are an estimated 260,000 or so guns in the hands of private citizens.[116] Itdoes, however, have a history of large protests in recent history, including:

Protests in 1992 over anti-subversion law Article 23 and its possible enactment in the Basic Law resulting in tear gas and confrontations that left 21 people dead.[117,118]

A 500,000-strong protest on July 1, 2003 that resulted in the replacement of Hong Kong's leader Tung Chee-hwa, marking the first time since the founding of the People's Republic of China that the Communist Party was forced to back down in the face of popular pressure and remove a senior leader.[119]

A protest on September 8, 2012 when tens of thousands took to the streets to decry Chinese patriotism classes becoming mandatory courses in Hong Kong schools.[120]

On July 1, 2014, upwards of 500,000 took to the streets in support of democracy, while thousands more counter-protestors also took to the streets in protestation. Notably, some evidence exists of counter-protestors being paid to attend.[121]

Umbrella Movement protestor totals approached nearly 100,000 on the streets of Hong Kong at their peak, diminishing over time but also swelling temporarily over weekends.[122]

In 2014, Hong Kong did not have a publicly known history of recent instances of terrorism.[123] However, it does have a long history with gangs, known collectively as triads. Though significantly diminished from the 1960s and 1970s when as many as one in six locals was associated with a gang, in 2014 there may have been as many as 100,000 affiliated in the city. Since the return of the city to the mainland, much of the traditional, infamous triad violence and open criminality diminished, either transitioning to secretive black market activities or even more legitimate business endeavors. Regardless, a large number still exist, and have been known to be used as thugs-for-hire.[124,125]

For those that commit crimes and are found guilty, there are 29 correctional facilities in Hong Kong, which can accommodate up to 8,400 people in total, including 24 correctional institutions, three half-way houses and two custodial wards of public hospitals. Medium security prisons are equipped with double

SECURITY - Violence Potential	
DIMENSIONS	EVALUATION
Adaptive Capacity	POSITIVE
Coping Capacity	POSITIVE
Expectancy Benchmark	POSITIVE

fences with restricted areas in between, while minimum security prisons are equipped with one fence. The recidivism rate in Hong Kong was 27.1 per cent as of 2013, marking a significant decrease from 36.5% in 2004.[126] Collectively, the relatively low amount of criminality present in the city, combined with few potentially violent offenders that might escape during widespread disturbances, and the relative security of facilities containing them, the overall violence potential of the prison system is minor.

Expectancy Benchmark

The Umbrella Movement at its peak represented a sizeable population of dissenters, which of course could have easily escalated into yet higher levels of tension, violence, and upward spirals of participation paired with downward spirals of violence, especially in the rare occasions when open violence occurred, such as the beating of one protestor by several police members.[127] Even as more extreme elements of these groups tried to grow the protests with online recruitment, using manga-styled literature to grow its ranks with enthusiastic youths[128], and despite numerous mobs of counter protestors with more aggressive intentions than the democracy protestors themselves, as well as fears that the protests amounted t[129]o the survival of Hong Kong[130], the city and its security forces never seemed to lose their respective sense of selves. In the end, Hong Kong maintained the peaceful image the city has long enjoyed.

Securing the Urban Environment

Hong Kong provides a glimpse into some of the future considerations for security in modern, dense urban environments. With over 7 million people in a 426 square mile area, Hong Kong represents one of the densest urban environments in the world. In addition, it also includes over 1,440 skyscrapers densely packed together to accommodate such a large population in a limited space, nearly doubling the number of skyscrapers of New York City in a smaller geographic footprint.[131] Of these, there are an estimated 7,827 buildings more than 115 feet tall, and 315 buildings taller than 500 feet. Unlike New York, many of these buildings exist in large clusters, or rather represent the majority of the city itself, rather than spread amongst different sections in tight clusters. Also due to density, the distinct lines between areas and features of the city remain blurred, contributing to confusion as to when one building may stop and another may have begun, requiring the use of additional senses and sights to maintain an overall sense of bearing.[132]

Fig 14.5 Hong Kong Protestors Surrounded by Tear Gas

Many of the surviving older buildings are considered "composite buildings" – essentially massive tenement buildings with inconsistent and unregulated internal structures and layouts, often absent of natural light. Much of the oldest

SECURITY - Securing the Urban Environment	
DIMENSIONS	EVALUATION
Adaptive Capacity	NEUTRAL
Coping Capacity	NEUTRAL
Expectancy Benchmark	NEUTRAL

construction in the city has been replaced by new, modern structures, which represent different considerations due to their height.[133] The streets are so congested, the Hong Kong PLA garrison troops reportedly maintain only lighter weapons, including machine guns mounted on smaller armored vehicles, specifically used for their ability to navigate the narrowest and most difficult streets.[134] And like above ground construction, Hong Kong's subterranean construction contains a mix of old World War II tunnels, mines, subway systems, sewage treatment facilities, and even flood plains. As the city continues to expand, increased emphasis has been placed on expanding to underground locations.[135]

One especially notable element of Hong Kong's urban security environment is the former Prince of Wales barracks building, now known as the Central Barracks, which represents a unique structure in terms of its design and defensive nature. Built in 1979 by the British, it resembles a 28-story upside-down bottle, where the bottom portion narrows intentionally for the purpose of increasing the defensive abilities of those inside the building from outside attack. In the event external forces would need to access this building, with any adversarial forces inside, and even under the best of conditions, would face a monumental task beyond simply overcoming the enormity of the building itself.[136] Due to these factors, Hong Kong represents an extreme example of a modern city that would demand unsustainable security resources in the event of a large scale or violent outbreak. Even under peaceful terms, providing meaningful security, assuming the population has devolved into some level of desperation or lawlessness, would require an astonishingly large amount of resources and personnel.

Yet despite major protests, security has been maintained by local security forces without the need to bring in outside military forces. This simultaneously speaks to the positive and negative aspects of Hong Kong's Securing the Urban Environment factors. On one hand, the overall layout and construction have contributed to the failure of geographically dispersed and varied opposition to materialize, which would be exceedingly difficult for local security forces to handle. On the other hand, it is not difficult to see how things might also quickly deteriorate.

For example, with ongoing riots already straining the security resources, significant disruption to other Urban Stability Factors, such as a loss of power from a catastrophic storm or the collapse of the local economy due to a global pandemic, could create a scenario where the same factors that positively affected the security environment might be turned on their head. In this way, a large group of displaced persons (accordingly unable to use or afford their already strained housing situation) are now densely packed throughout the city with limited ability to meaningfully disperse, quickly overwhelming local security and necessitating outside security assistance.

Security Conclusion

Over the course of Hong Kong's history, the city has faced numerous challenges and yet continued to grow and thrive. More recently, its access to a strong body of security forces as well as a well-funded and professional police force has helped it to avoid irreparable damage from which it would be unable to recover. During the

Umbrella Movement, the city was able to cope with a potentially volatile movement without fracturing its security apparatus, speaking to its positive Coping Capacity. Although security resources have been challenged by protests large and small, as well as by changing criminal and world-security events, the city has successfully adjusted its security posture to prepare for and mitigate on-going challenging threats, including elements that sought to expand the democracy movement as well as those that sought to punish it, contributing to a strong positive Adaptive Capacity. Through it all, the city and its people never lost its sense of self, nor did it collapse into a state of martial law or complete chaos, all while the majority of its people accepted the limits of the institutions and laws placed above them. The culmination of these factors contributed an overall positive Expectancy Benchmark.

SECURITY - Overall	
DIMENSIONS	EVALUATION
Adaptive Capacity	POSITIVE
Coping Capacity	POSITIVE
Expectancy Benchmark	POSITIVE

Conclusion

First, we make a simple summary of the three dimensions: adaptive capacity, coping capacity and expectation benchmark. From the perspective of adaptive capacity, the cultural and social factor has found a negative impact while the security factor still had a positive impact. Other factors had a neutral impact on the city's stability. The cultural and social factor points out that the relatively low education rate of Hong kong is one potential reason that the movement went violent ultimately. The security factor indicates that because the overall security of the city was maintained without rising into chaos nor promoting dramatic changes in protestor sizes, the city showed good adaptive capacity in this aspect.

From the perspective of coping capacity, the economic factor clearly noted a negative impact, while the security and the governance factors drew positive conclusions. Other factors again identified neutral stability impacts. The economic factor points out that the unequal economy and low financial inclusion made a negative impact on the coping capacity. From the governance factor's analysis,the city showed positive impact because of efficient policy making bureaucracy and enforcement mechanisms. From the security aspect, the city's access to a strong body of security forces and well-funded and professional police force lead the city to have strong coping capacity.

From the perspective of the expectancy benchmark, the cultural and social factor and governance factor reached a negative conclusion. The security and technology factors assessed positive stability impacts, while the remaining factors were neutral. From the perspective of governance, the gap between maintaining a degree of independence and the increasing national authority makes a negative impact on stability. From the cultural and social factor's analysis, the conflict of core values, the opinion gap among different groups of citizens, the confusion of identity and the low satisfaction of life contribute to a low score of expectancy benchmark. The security factor indicates a strong expectancy benchmark due to the fact that the majority of citizens accept the limits of the institutions and laws placed on them. From the technology factor's opinion, the positive

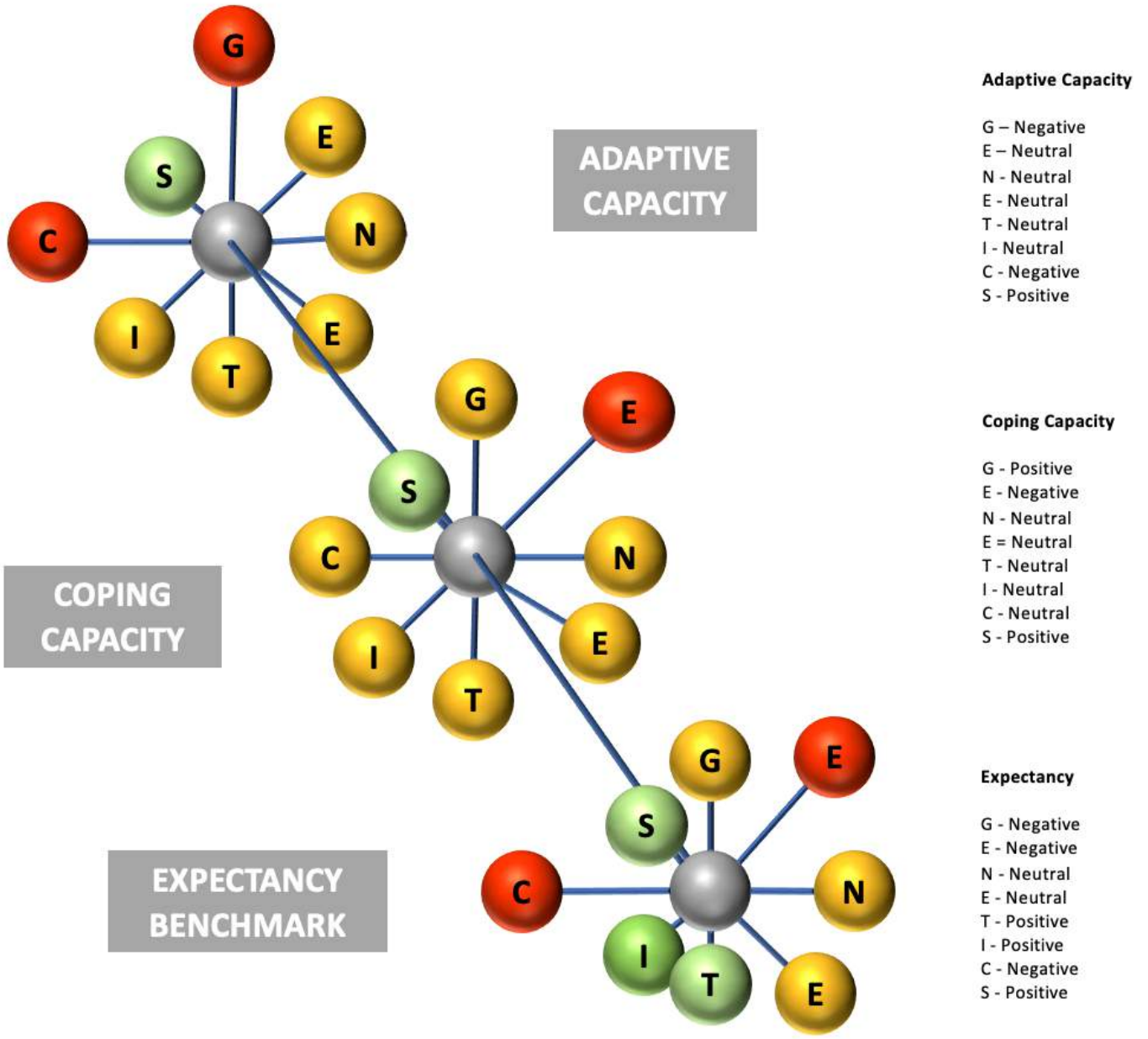


Fig 14.6 GENETICS Model for Umbrella Movement Case Study

result is drawn because social media enhances political participation, encourages interpersonal discussion and enables information sharing.

From the case of Hong Kong, we reached two interesting conclusions for analysts to consider in future cases. First, some stability factors may play a limited (or almost non-existent) role in a given case, based on the context of the city and the stress/shock. For example, Hong Kong's environmental and energy stability factors were nearly irrelevant during the Umbrella Movement context. Second, many factors give an overall neutral impact because metrics in the same criteria indicate opposite conclusions. This phenomenon more reflects the complexity of the crisis faced by the city and is important for policy- and decision-makers to be aware of when studying a particular case or city in the future.

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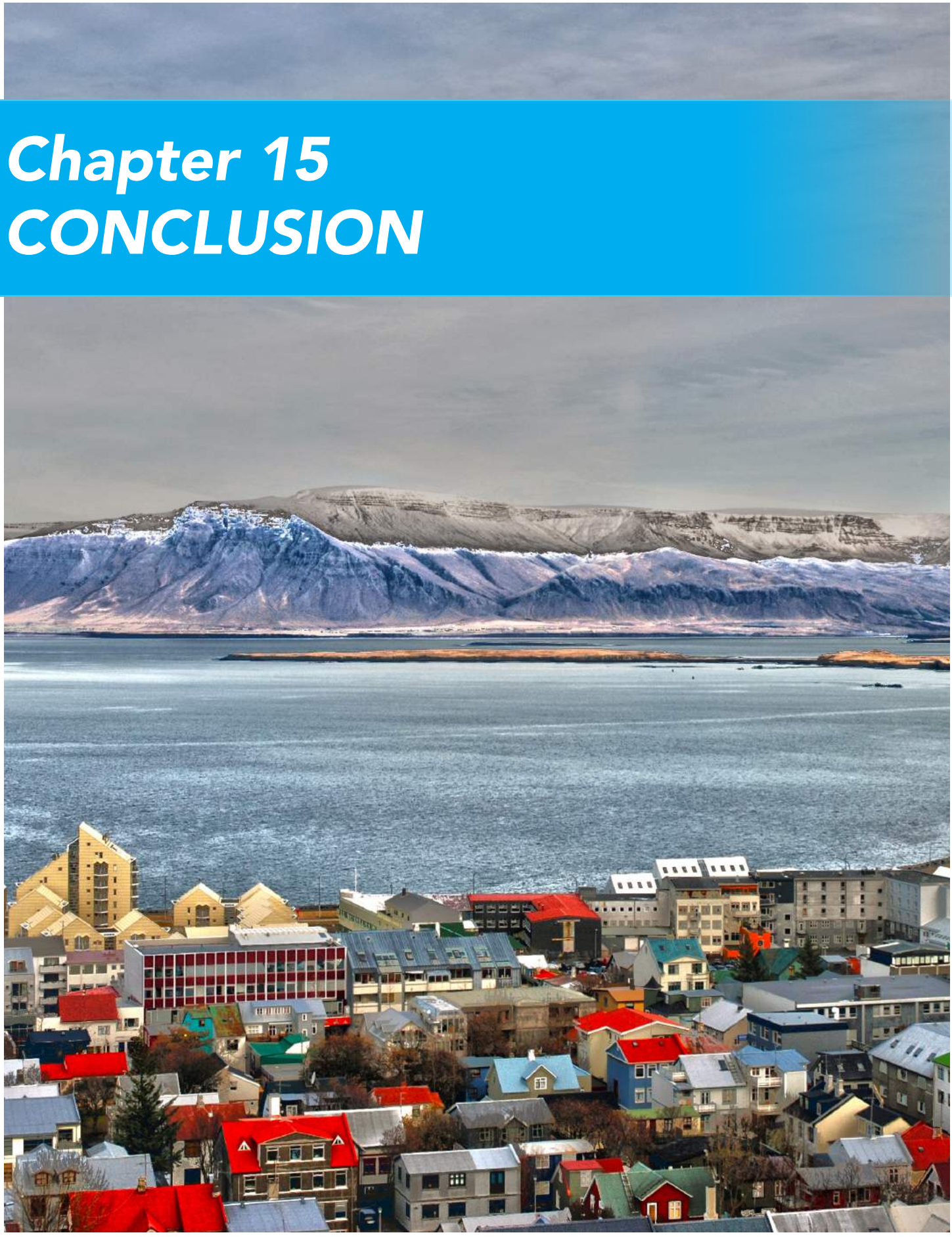
Chapter 15
CONCLUSION



Recognizing that war is an inherently human enterprise, and that more and more of the world's population will live in urban areas, there is a logical conclusion that future conflict will occur in and around major urban environments. In response, it is imperative that the Department of Defense continue to develop an understanding of these environments to ensure they are prepared to address the needs of a future area of operations. This study consolidates some of the available literature regarding urban resilience and develops a new taxonomy around the concept of Urban Stability, which is assessed by the three dimensions of adaptive capacity, coping capacity, and expectancy benchmarks across eight stability factors: Governance, Economic, Natural Environment, Energy, Technology and Communication, Cultural and Social, and Security. Combined, these factors form the GENETICS framework, and through an evaluation of the criteria and metrics outlined in the report, are assigned an ACE score of having a positive, neutral, or negative impact on a city's stability.

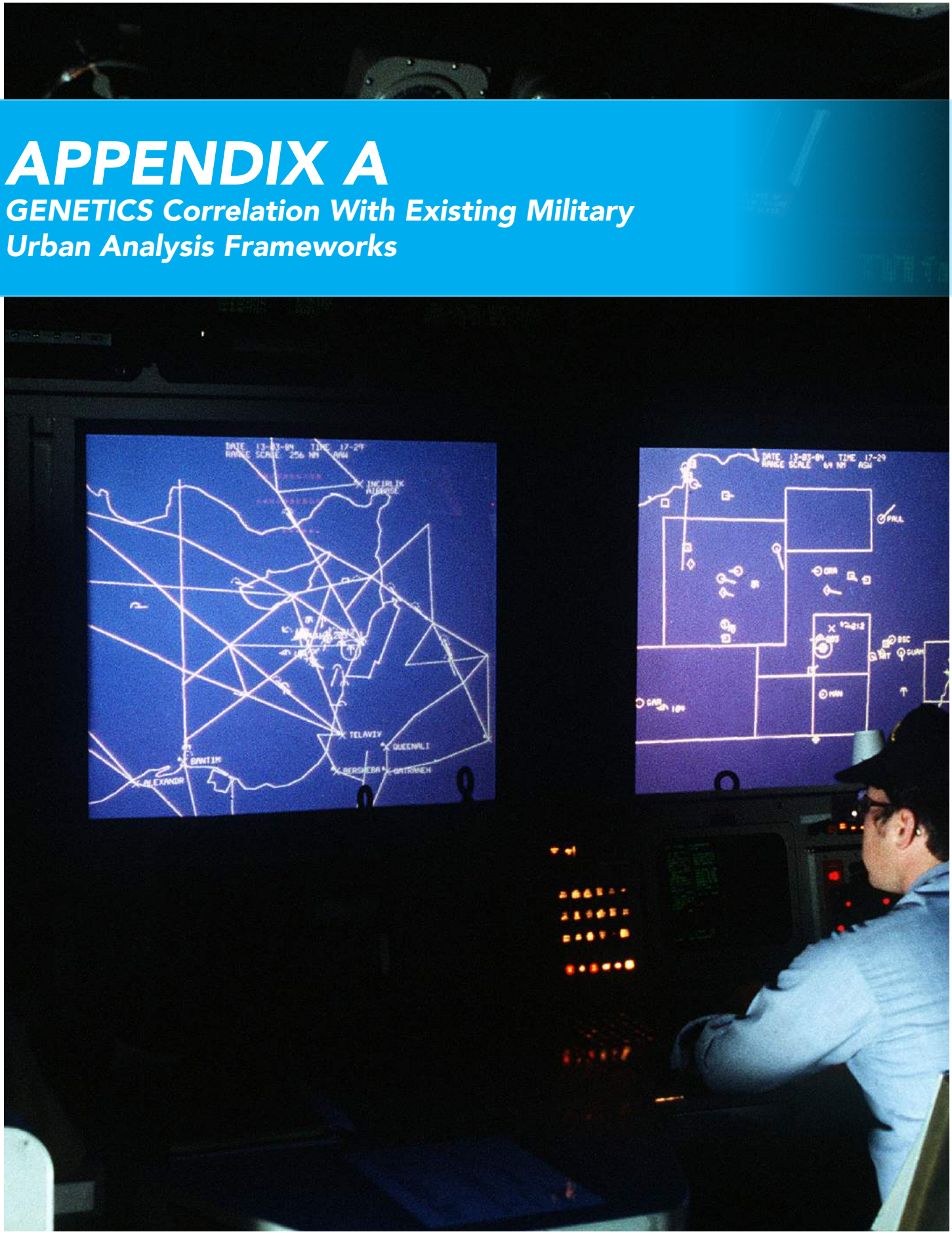
With the GENETICS and ACE concepts defined and explored in detail, we applied our framework to two case studies: the 2014 Umbrella Movement of Hong Kong, a more emergent stress, and New York City's Hurricane Sandy shock in 2012. Both cases demonstrated the opportunities and limits to our current approach, as certain metrics or criteria for each stability factor could indicate nearly opposite conclusions when assigning an ACE score - alternatively, the use of more subjective, qualitative, and interpretive methods enabled our team to reach more dynamic conclusions than a more data-intensive approach may have allowed.

As echoed throughout the report, the criteria and metrics outlined in each of the stability factors are not all inclusive, but are illustrative of the information we think can best inform planners and decision makers as they develop situational awareness about a city in preparation for or in response to an emerging shock or stress. Similarly, as every city and urban environment is different, this tool does not make an attempt to rank or compare cities. While comparisons and ranking of cities in terms of resilience is valuable, many of the previous efforts do not necessarily help understand specific contextual factors that influence stability. Our study instead focuses on rapidly understanding the factors influencing urban stability that have potential to influence the severity of a stress or shock.

Looking forward, there are a number of options to improve and expand the GENETICS framework. Refining the criteria and metrics and developing more robust indices to facilitate more quantitative analysis would enable more rigorous determinations of ACE scores. While the adaptive and coping capacity dimensions are explored in current literature, further efforts to explore and quantify unique contexts of individual cities will help build a more thorough understanding of the novel expectancy benchmark dimension. Applying this framework to additional city cases will also inform and help revise further development of the criteria and metrics, whether they are desk studies like this one or, preferably, site visits that allow a team to work more closely with local experts. As emerging threats like climate change, pandemics, and broader social unrest, there is also a unique opportunity to apply this framework across multiple cities facing a similar threat. (COVID-19 is a timely example of just such a threat that could be explored in future studies. While it is entirely too current for us to have explored in this study, we would be remiss if we did not address how influential this sort of stress is on cities across the globe and the valuable information an analysis of city stability in response to this threat would generate.) We expect that applying our tool to assess the responses and stability of multiple cities facing similar emergent stresses could yield valuable information in order to develop this tool further and better prepare future planners and decision makers in understanding urban operating environments.

APPENDIX A

GENETICS Correlation With Existing Military Urban Analysis Frameworks



The purpose of this Appendix is to directly address some of the similarities and differences between this study's GENETICS framework and those of other military frameworks, especially in regards to those mentioned in the introduction chapter. Although this section does provide an expanded explanation of decisions and thought-processes behind the construction of the GENETICS framework, it does not fully exhaust all of the granular decisions that were made, nor does it fully exhaust external discussions regarding the use of existing frameworks and the vast literature and additional academic writings regarding updates, improvements, or critiques of them. Instead, this section addresses military practitioners and those with some prior knowledge on these subjects with direct acknowledgment to likely concerns, as well as introduce these ideas to those that may be unfamiliar but curious to know more than what is presented in the main body of the study itself.

PMESII-PT, METT-TC, and ASCOPE

The Army is no stranger to conducting in-depth analysis to support intelligence and planning requirements for operations large and small. When given a mission in a defined location, the default course of action is to use the Intelligence Preparation of the Battlefield (IPB) process that results in intelligence products that are used during the Military Decision-Making Process (MDMP) to assist in developing friendly courses of action (COAs) and decision points for the commander.[1] More specifically:

IPB is the systematic process of analyzing the mission variables of enemy, terrain, weather, and civil considerations in an area of interest to determine their effect on operations. IPB allows commanders and staffs to take a holistic approach to analyzing the operational environment (OE). A holistic approach—

- Describes the totality of relevant aspects of the OE that may impact friendly, threat, and neutral forces

- Accounts for all relevant domains that may impact friendly and threat operations

- Identifies windows of opportunity to leverage friendly capabilities against threat forces

- Allows commanders to leverage positions of relative advantage at a time and place most advantageous for mission success with the most accurate information available

The DOD describes this Operational Environment specifically as "a composite of the conditions, circumstances, and influences that affect the employment of capabilities and bear on the decisions of the commander,"[2] and further directs that it be analyzed using operational variables and mission variables. The operational variables consist of political, military, economic, social, information, infrastructure, physical environment, time (known as PMESII-PT), while mission variables consist of mission, enemy, terrain and weather, troops and support available, time available, civil considerations (known as METT-TC). Embedded within Civil Considerations is the ASCOPE tool (areas, structures, capabilities, organizations, people, and events), meant to capture the influence of manmade infrastructure, civilian institutions, and activities of the civilian leaders, populations, and organizations within an area of operations on the conduct of military operations.[3]

ADP 3-0 continues on to state a similar argument as that presented in this study, namely that each operational environment (and city, for the purpose of this study) is unique and using these variables will help Army leaders make informed decisions as part of a larger, unified effort.[4] In fact, some effort is taken within Army doctrinal manuals to attempt to describe the significance of seeing the larger perspective when doing this analysis, realizing there are elements outside of the Commander's control and that all efforts must be synchronized.

When looking at this doctrinal approach we did not see any inherent flaws. In fact, we largely agree with many of its arguments and its approach to such things as the significance of securing populations, protecting infrastructure, and strengthening institutions. However, where we saw room for improvement was not the overall approach, but rather the specific framework used to realize its analytical development.[5]

Current Army methodology directs the collection of existing information and the evaluation of the information and intelligence related to the operational variables, specifically of those applying to the ubiquitous PMESII-PT. Acknowledging the strengths of PMESII-PT, civil considerations are typically blended in using the equally prevalent ASCOPE, resulting in a PMESII/ASCOPE crosswalk configuration (See Figure A.1 for an example of a typical crosswalk configuration).

This process has been refined over successive years and is widely used throughout numerous field manuals and other publications, and, to be clear, this study does not suggest that there is anything inherently wrong with that process. However, useful as this methodology is, it does have limitations that make it less well suited towards the scope of this project, specifically when applied to large and densely populated cities. Although PMESII-PT can and has been applied to national-level analysis as well as that of a small region or city, the broadness of its applicability remains one of its largest weaknesses when compared to the GENETICS framework, which treats cities as distinctly different from generalized geographic spaces. Additionally, PMESII-PT and ASCOPE are generally applied to an adversary or threat, whereas the GENETICS framework applies directly to the urban environment.

Furthermore, while this traditional cross-walking leads to exhaustive research in order to fill in each block with applicable information, it does not inevitably lend to any specific conclusion.

		A	S	C	O	P	E
		Area	Structures	Capabilities	Organizations	People	Events
P	Political						
M	Military						
E	Economic						
S	Social						
I	Information						
I	Infrastructure						
P	Physical Environment						
T	Time						

Fig. A.1 PMESII-PT / ASCOPE Crosswalk

Instead, we sought to do more than simply list various considerations and instead to provide a "So What" component to the analysis in the form of relatively weighted criteria for further consideration, assessment, and potentially for resource allocation. Within the GENETICS framework, the ability to score each criteria as a positive, negative, or neutral element of the larger city considerations, enhanced by the intuitive visualization, immediately guides commanders and decision-makers towards those areas which demand the most attention, and perhaps more importantly, why these areas demand attention.

One of the main goals of the IPB process, and using the cross-walking technique, is to define the Operational Environment, and just as doctrine directs the exploration of variables both inside and outside this defined area, the GENETICS framework also explores the complexity, overlapping nature, and a city's place as part of a larger region, state, and global order.[6] Unlike the methodology described in ADP 2-01.3, we do not set defined limits on a commander's geography at this stage, opting instead to account for the factors outside the defined geographical limitation that may significantly affect the inside of the commander's specific Area of Operations (AO) or Area of Interest (AOI).

Another important distinction of the existing framework is that, by definition, it is meant to prepare a battlefield for follow on opportunities,

and is specifically a component of the MDMP directed at its principal audience of tactical Army commanders and staff.[7] In contrast, the GENETICS framework fills a niche above this level, where the space is not necessarily defined as a battlefield, nor is it assumed that the Army or even wider Joint Forces will be the main effort. Additionally, in contrast to other tools that have different foci, the GENETIC framework is meant to consider all stability factors equally, and may ultimately provide guidance for further refinement using other frameworks.

Not coincidentally, the Stability Factors of GENETICS (Governance, Economics, Natural Environment, Energy, Technology and Communications, Infrastructure, Cultural, and Security) are not dissimilar from those of PMESII-PT. While they were in part selected for their broad applicability towards the larger commonly cited factors we determined from resilience literature review as integral to our methodology, we also consciously attempted to somewhat mirror the style of the PMESII-PT acronym. This had the dual benefit of naming the framework with a clearly distinguishable acronym, as well as to deliberately differentiate it from PMESII-PT while keeping it in a style that would not clash with military culture and thus help promote its use. However, it must also be noted that even when the specific components of PMESII-PT, METT-TC, and ASCOPE are separated out, they are distinctly different than those of GENETICS. Comparing the criteria used in the GENETICS framework on Natural Environment, for example, the convergence of weather, climate, and geography are different from the division of these concepts amongst existing DOD methods.

The GENETICS framework also incorporates some other unique concepts absent from PMESII-PT and ASCOPE, in particular the idea of urban resilience and stability and the inclusion of expectation as a serious factor to consider. The inclusion of resilience and stability changes the approach in that it includes the requirement to view the city as a dynamic situation versus as a static one. In the case of PMESII, listing each individual data point does not lend itself to considering how that data might affect other parts of the city, nor that the entire city is adjusting as a response to some disruption, and as a result, all the information listed is inherently dynamic itself. Adding in the expectancy benchmark concept also layers a new consideration; simply listing facts becomes insufficient as the military will also have to anticipate and react to how the civilian population will be affected by these dynamic events.

One last consideration of note was the idea of using GENETICS as a replacement for PMESII-PT in the crosswalk, thus producing a new GENETICS / ASCOPE model that would be specifically tailored for use on large cities rather than a generalized approach to any area. Although this option presented a somewhat attractive approach for its simplicity and ease of use, we felt that it did not sufficiently evolve the current methodology, nor did it provide significantly improved results, and therefore the idea was largely abandoned. However, should the overall GENETICS framework prove to be too cumbersome, there is potential for using this streamlined approach (likely with some modification) to attempt to capture some of the unique large city characteristics within a new crosswalk approach that may still provide benefits beyond that of GENETICS.

Other Approaches and Notes

DIME-FIL – As diplomatic considerations are not necessarily taken along with Operational Variables, there exists a tool for approaching the instruments of national power that are commonly described with Diplomatic, Informational, Military, and Economic, Financial, Intelligence, and Legal. This acronym differs from that of PMESII in that it is meant to help describe "friendly" forces. As COL McDonnell argues, although there is a relationship between PMESII and DIME, in that we might apply PMESII to a threat force while they might apply it back on us, showing they may in fact be describing the same things, albeit from different perspectives. However, as simply mapping DIMEFIL to PMESII is faced with 42 combinations at the first level of analysis, this new crosswalk approach merely increases the chance of a critical elements being overlooked, or in the case of our study, being approached from the wrong perspective. [8]

SWEAT-MSO and MRsSPEA – Both of these acronyms are alternate or subsets of PMESII-PT itself, with SWEAT-MSO (Sewer, Water, Electricity, Academics, Trash, Medical, Safety, Other Considerations) oriented towards Infrastructure and MRsSPEA (Moral, Religious/Spiritual, Social, Political, Economic, Aesthetical) oriented towards Social. While they provide additional clarification, or at least a focused view, they have many of the same shortcomings as PMESII-PT itself, and incorporating them further only exacerbates the weakness previously described.[9]

OAKOC - Within the Security Stability Factor specifically, there is another similarity between the GENETICS approach and that of existing approaches. Broadly speaking, both Violence Potential and Securing the Urban Environment criteria incorporate some of the aspects of OAKOC - observation and fields of fire, avenues of approach, key terrain, obstacles, and cover and concealment, as an implicit consideration. As GENETICS is less concerned with these tactical considerations, the level of detail diverges, but the connection can be seen looking at the general layout of a city and how its buildings are constructed when comparing to various OAKOC factors.

SOURCE MATERIAL

1. ATP 2-01.3 Intelligence Preparation of the Battlefield. March 2019

2. DOD Dictionary of Military and Associated Terms As of January 2020 https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/dictionary.pdf

3. ADRP 5-0 The Operations Process. May 2012

4. ADP 3-0 Unified Land Operations. October 2017.

5. ADP 3-0 Unified Land Operations. October 2017.

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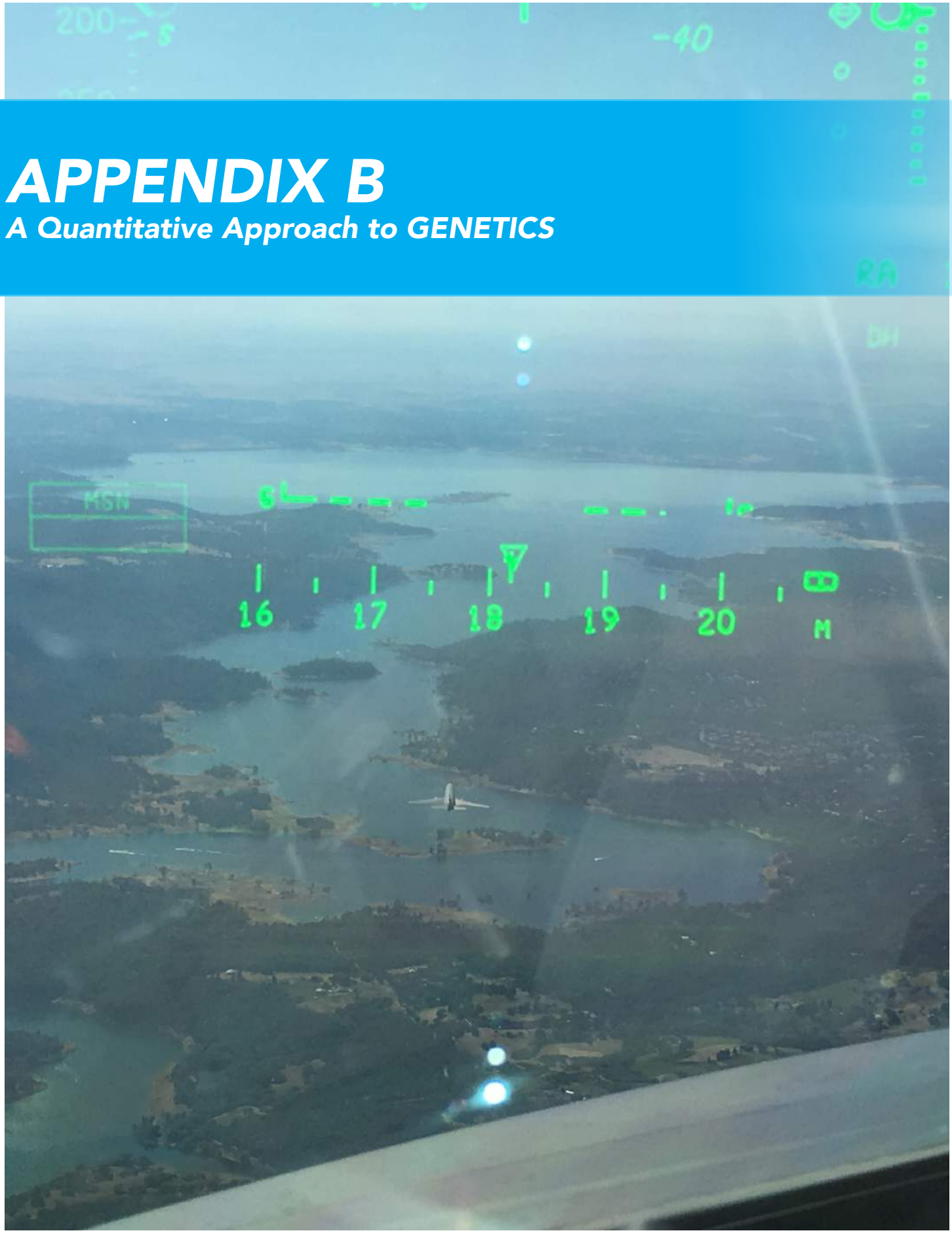
APPENDIX B
A Quantitative Approach to GENETICS



The purpose of this appendix is to describe some of the considerations that were taken in regards to making the GENETICS framework a more quantitatively driven process. Although the idea was proposed and lightly explored, the specifics on its full implementation, benefits, limitations, and future evolution were not fully explored. Therefore, the content of this overview is not meant to explain every step of this potential option, nor to claim that it would have been fully feasible. Some of the ideas may have resulted in eventual dead ends; however, some likely would have led to interesting results as well.

Introduction

As briefly mentioned in the Literature Review chapter, many past resilience studies use methodologies that lead to a numeric score, or feature some type of weighting mechanism in order to make comparisons between cities. Some of these methods are more transparent, while others merely allude to formal and proprietary data processing techniques that gather data, normalize it, and determine a score or ranking for each city evaluated. The benefit of these approaches is not only the ability to compare cities and rankings, but also the more objective nature of using data, as well as a repeatable and verifiable method that reduces the overall subjectivity and causes for interpretation.

Although there are many limitations and shortcomings to a quantitative heavy approach, the fact that other studies and frameworks have successfully utilized it validates it as a viable approach worth considering. Despite this, over the course of our study's development, we ultimately determined that such a technique would prove overly cumbersome, time-intensive, and not contribute adequately to producing meaningfully unique results beyond the framework that was ultimately chosen.

Benefits of a Quantitative Approach

Despite not choosing a quantitative approach overall, many of its other benefits were considered and casually explored. For example, as an expansion of the weighting mechanism of some of the previously completed studies, the group could have implemented, based on several factors, a scheme that allowed certain Stability Factors to carry more or less attention and weight. Although this was mathematically possible, the group did not reach a point on how best to resolve how this weighting mechanism would have ultimately looked, or how impactful its results would have been. Generally speaking, one consideration was to keep every stability factor unweighted during a case study exploration, and then artificially adjust the weighting after the group re-evaluated the quantitative outcome and manipulated it to ensure that a second iteration would result with the group's well-informed but somewhat subjective determination. This too was deemed an inadequate approach as the benefit of a more objective approach would have been counteracted with a somewhat subjective weighting technique, and an objective weighting scheme that adequately addressed this proved elusive initially.

Based on the weighting logic, however, another approach was considered wherein each study could be weighted based on the type of stressor the city experienced (e.g. a hurricane, an earthquake, a riot, etc.). In this way, depending again on how the weighting was determined and applied, the results would be more consistent across different evaluative iterations, and thus

reduce some of the added subjectivity. This idea of applying different criteria or metrics to different stressors was also considered for inclusion into the final GENETICS framework, but the additional complication of another layer of analysis made the framework overly complicated relative to any benefit, if any existed at all. An extension of this would have been the ability to incrementally add new data and stressors into the methodology and tool, such that over time it could refine its output with new relevant details or criteria, but this too includes many limitations that are addressed later in this section.

A numerical outcome would have provided an easier method to determine a final outcome. Regardless of whatever normalization or weighting process used, a quantitative approach would have concluded with a number, and as such a number of additional benefits would have been present, such as the greater specificity possible with a range of scores as opposed to the negative, neutral, positive framework used. For example, in the case of a generic '0-10' scoring technique, a numerical result would have had the ability to communicate a spectrum or severity result, wherein a 5 through 10 score might have meant a positive outcome, but also that a 9 was more positive than a 6. This spectrum would have also allowed the idea of a threshold to be included, such that certain ranges meant different determinations, and that there would be some codified "tipping point" or inflection point that immediately identified a critical change. In this way, a commander could have been notified that a certain score meant that security was a concern, but also past a certain score, security may have collapsed, required additional resources, or some other response.

As the study required a visualization of a final outcome, a numerical scoring system lent well to many data visualization options available. In this way, different scores could have been easily represented in different ways, calling attention to particular scores within certain ranges for added emphasis, or that significant connections between Stability Factors be made to more easily draw attention to them. Not only would this have been a fairly painless addition, different scores could have ascribed to different visualization types quickly that best represented their outcomes the most clearly, and even could have been automated in such a way that little or no user interaction or determinations would have needed to be made. In this way, providing raw data into a simple prompt could have immediately determined results and visualized them using readily available and free-source data analysis software or coding, such as Python, R, and others.

Lastly, the types of data best suited to this approach were discussed but never finalized. One favored approach was to use publicly available data from notable sources such as the United Nations or well-known non-profits. In this way, questions about the authenticity and reliability of the data would be reduced, and the requirement to conduct new studies to gather and aggregate necessary unique data would not be required. This is, of course, easier said than done. These types of data are often more outdated than desired, lag behind current affairs, are missing portions of needed data, and limited to generalized data that is made public. Had the GENETICS framework required data that was unavailable in this manner, a major hole in the methodology would have arisen with no immediate solution. Though the framework could have been adjusted to compensate, or data from less trustworthy sources potentially found, both of these solutions introduce new issues into the framework and make its results more questionable.

Limitations of a Quantitative Approach

Though well-known non-profit and international institutions possess generally reliable data, some individuals and organizations still question data, regardless of its source, thereby not immediately resolving issues relating to subjectivity, nor addressing concerns regarding removing errors from being incorporated into the analysis. Data should always be questioned, whether it is from the techniques used to acquire it, the inclusion of bias (intentional or otherwise), the source of the data, or that the data meaningfully conveys the information it is meant to. In this way, even the data sources mentioned are not without concern. This is not meant to suggest such data is inherently flawed, but rather that any data used for a purpose other than its original collection purpose presents yet another layer of concern as the limitations of that data towards its new purpose are often unknown or unclear. Organizations that release their data publicly typically take measures to try and mitigate this issue through the disclosure of details regarding the data's origins, intent, and organization, but the concerns remain.

Data shortcomings potentially could have also manifested themselves in the timeliness of the data, wherein data from months and years needed is not available, or that data for various Stability Factors is available in the right period but with timing that does not align properly with the disruption itself, further reducing the reliability of the outcomes. The GENETICS framework that the group ultimately decided on, eschewing the quantitative approach, allows for some omissions in data and the ability for human deduction to fill gaps in such a way that a hard coding process would not have been able to. It also addresses the ability to apply the framework to contemporary and current events, as there is no need for regimented and cleaned data (referring to data that has been prepared and formatted specifically for data analysis use) to be available for use in the tool.

By this token, some of the data would have likely been questionable, regardless of the source. In particular, the Expectancy Benchmark metrics would pose some challenges as they would have to rely heavily on public polling requirements. Such polling data does not exist for many cities, let alone the polling addressing the specific concerns of this study, or even the right timing. Although some technologies and tools use variations of sentiment analysis to capture this type of data using a number of different methods (most notably through social media), the technology is still unrefined and meaningful sentiment analysis data is highly questionable to include. Without this data, a manual approach would have been required that mirrored that of the current method wherein analysts are able to extrapolate data and expectations in the absence of such polls based on other considerations. In this way, the current GENETICS framework is not limited by such absences, but it is also unable to generate the types of numerical data that would have been needed for a quantitative approach, and thus one leg of the Urban Stability dimensions would have been critically lacking.

Attempting to find a "silver bullet" metric and a parsimonious model through statistical means is also a temptation for this type of framework, such as finding a particular metric for each Stability Factor (or perhaps even Urban Stability itself). However, this too is easier said than done. This would have not only required copious amounts of data initially; it would have also required the ability to toggle on and off independent variables in such a fashion as to determine their effects. Though not necessarily impossible, the timeframe and resources needed to even attempt such a course of action was immediately ruled beyond the scope of this study – especially considering the fact that the likelihood of such a powerful metric even existing is extremely unlikely given the broad nature of the study. Had any particular metrics proven to be more effective, there may also have been some temptation to use the tool to predict

outcomes. Tempting as this may have been, it is outside the scope of the study, and is itself fraught with additional concerns that will remain unaddressed in this appendix.

Another concern for a quantitative approach was simply the time requirement. Regardless of the approach, many of the same processes ultimately taken were still required to be completed upfront, such as building the framework based on logical assumptions, previous studies, and test-case scenarios, but a quantitatively heavy approach also required additional time to code the tool itself. Although some sections may have benefited from this approach due to their numerical dependency, such as Economics, other sections would have become burdened with extra steps that would not have otherwise been necessary. For anyone with data analysis or programming experience, the debugging process is a known frustration even under the best of conditions, and is almost always a time-intensive endeavor. The more complex this approach became, the more time would have needed to code and debug, not to mention the potential time requirements to run multiple iterations, scrutinize results, make adjustments, and so on. Even after this monumental task, there was no guarantee the outcome would have been more significant, or even substantially different, from the non-quantitative approach. In fact, had the results been substantially different, additional time would have been needed to determine why the outcomes varied, and determine which process was more reliable and meaningful.

A Security-Centric Approach

During the course of developing the GENETICS framework, a brief attempt was taken at approaching what a more quantitative metric approach would have looked like to the security Stability Factor. In particular, this factor was attractive for some metrics-based approaches given the substantial academic research into quantifying military power and running simulations, such that some analytical methods already exist, as well as ample data to feed them.

Unfortunately, this is still a difficult task as there is no universally accepted methodology for determining even nation-state military power, let alone that of a city. In the context of this study, for example, would military infrastructure be significant due to the preponderance of bases, the quality of the bases, the redundancy of their locations and abilities, or some other factor(s)? The answer likely is - it depends. This logic applies to many of the security factors, and exhausting the literature to determine the best approach was again beyond the scope of this study.

Figure B.1 below represents an early approach at incorporating quantifiable data, weighting, and proposing thresholds in the security section. In this way, a Defense Budget was used as a trial as a readily available metric for most states, and as a quantifiable term that is easily imagined. When evaluating how relevant a large military budget is to a specific city, as compared to an infrastructure or natural environment metric, it is not immediately apparent how they might relate. To address this, a threshold was incorporated to show whether or not the metric even mattered to the city (and somewhat subjectively defined in this case, as a starting point). Weighting then would have later been applied to the overall criteria or security Stability Factor itself to address how significant this was relative to the other Stability Factors. Clearly, more deliberation was needed on how to best improve this technique, let alone on how to apply it to the numerous other metrics to which it would be weighed against. For these many reasons, this technique was abandoned.

CRITERIA	METRIC	THRESHOLDS
Defense Budget	Total size and % of GNP	Highest 50% of their sub-region and/or top 15 total miilitary expenditure in the world

Fig B.1 A quantitative-based Military Forces metric example

Future Quantitative Approaches

One of the benefits of using open-source and publicly available data is the option to automate more of the process, potentially insofar as to make a tool that requires little more than inputting the specific city and time of concern. Doing so could have been a fairly painless process after the tool itself was finished, requiring only the periodic updates to website addresses (if not designed to crawl the web for them), and ensure that the data used adhered to the terms of services for their respective site sources. Had this been achieved, the entire tool would have become extremely powerful for its portability and quickness, if for no other reason, in that it could provide some baseline results immediately. Depending on the circumstances, analysts could use these results to further build upon, compare with other information, or abandon entirely with little extra effort expended.

It is also impossible to discuss a data-driven approach to such a methodology without considering the potential benefits of incorporating Machine Learning (ML) and Artificial Intelligence (AI). With so much data available for the various metrics, and adding in some of the concepts previously mentioned in this section, some ML/AI additions to this methodology could have potentially applied additional data or otherwise ran simulations to enhance the outcome ability, or else adapt the tool to changing environments. This concept is highly underdeveloped in regards to how it would have been implemented for this tool specifically, but would likely have received some significant attention had a quantitative approach been explored more fully.