Regional Resilience Initiative

Background and Context

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Introduction

The research conducted through the Regional Resilience Initiative at ABAG may offer larger lessons for other communities facing similar regional resilience issues, but is grounded in the unique context of the Bay Area and the factors that characterize our region and vulnerabilities. The research perspective is also based in the Earthquake and Hazards Program's grounding in resilience and recovery theories, definitions, and tools, which gives these papers their unique voice. This paper provides the background ideas for the rest of the work, as well as paints our regional context's picture. Each of the subsequent papers comes from the point of view expressed in this paper.

The definitions and theory presented here may also help the region establish a baseline understanding of what resilience means, hopefully engaging a wider variety of stakeholders. While it is not necessary to be fully engaged with all the concepts laid out here to implement actions towards increased resiliency, this paper may provide the narrative that some need to further explore the topic of disaster resilience.

The first part of this paper defines of "resilience" and relates it to sustainability and disasters. With many definitions of resilience in use, we felt it was useful to define within this paper what constitutes resilience and a resilient region. The paper then describes the importance of planning to recover, as well as some of the tools that can be leveraged to address recovery and resilience. We then address where recovery fits within the context of the umbrella of resilience, which also includes mitigation and response.

The second part of the paper describes the Bay Area's unique conditions, including our assets and vulnerabilities. Understanding general trends and characteristics of the Bay Area, as well as a sense of the potential threats, allows stakeholders to better predict the types of issues we will face after a major disaster. The Bay Area enjoys a high quality of life with many natural and man-made resources and assets. By understanding what makes our region unique, we can plan to preserve and enhance our quality of life, despite major disruptions.

The following papers in this suite, with their high-level goals and specific recommended actions, all emerged from the foundation herein, which guided our process and set the context for the Resilience Initiative work.

Defining Disaster Resilience

Resilience itself is not a new concept. Cities and counties have been and are currently pursuing various strategies to become more resilient, but may use a wide range of language to define, understand and communicate what they are doing.

Resilience may combine aspects of environmental sustainability, economic strength, risk management, emergency preparedness, and strong social communities; however a major aspect of defining resilience as a region is coming to a common understanding about what a desired resilient state looks like. It is ultimately not important that every county, jurisdiction, and special district in the Bay Area use the same definition of resilience, but it is helpful to have an overarching common concept to use to begin to create a usable and common language within the region.

Below are some widely accepted definitions of many of the elements we feel contribute to resilience to help create a platform for regional understanding.

Sustainability

Sustainability and resilience are tightly integrated concepts – a sustainable region is inherently more resilient, and a resilient region is inherently more sustainable. Sustainability is commonly defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." [1] California's *State Hazard Mitigation Plan* further defines sustainability using a vision by the National Commission on the Environment, which states that sustainability is "a strategy for improving the quality of life while preserving the environmental

1 *Our Common Future, Bruntland Commission (1987)*

Resilience and sustainability have a symbiotic relationship. Increasing the sustainability of a community can increase resilience to disasters.

potential of the future," of "living off interest rather than consuming natural capital."[2] Sustainability largely refers to the way that a society uses resources and the implications of those actions on various systems, scales, and timeframes.

The term sustainability is often used to speak about environmental issues, but can be expanded to also include social and economic sustainability. This basic pyramid of environmental, social, and economic sustainability is often referred to as the "triple bottom line." Expanding on this thought can include any valuable resource that a community relies upon for its quality of life, including physical, historical, and cultural resources. This multiple-resource approach to sustainability is particularly beneficial to use in the context of resilience, as resilience addresses not just protecting the built environment or physical world but maintaining and enhancing economies, social systems, and any number of other resources as well.

Resilience and sustainability have a symbiotic relationship. Increasing the sustainability of a community can increase resilience to disasters. For example, resilience to disasters cannot be maximized if environmental sustainability is not valued – in many instances, the degradation of the environment in fact can contribute to disaster vulnerability, such as the loss of wetlands increasing vulnerability to hurricanes or sea level rise. In addition, disasters that destroy or dramatically alter resources render communities unsustainable, since they impact the long-term ability of the community to access and use resources. Increasing resilience to disasters thus inherently increases the sustainability of a community, as it helps maintain access to resources, now and in the future.

Resilience

There are many specific definitions of resilience in academic literature, but we have found that all definitions share common characteristics. The National Academies Committee on Increasing National Resilience to Hazards and Disasters defines resilience as "the ability to prepare and plan for, absorb, and recover from or more successfully adapt to actual or potential adverse events."[3] California's *State Hulti-Hazard Mitigation Plan* similarly defines resilience as "the ability of a system to absorb shock and maintain its structure and functions with a minimum loss… (and) resume pre-event functionality in a relatively short time."[4] From these definitions, we can gather that the inherent attributes of resilience are that it is a function, not an end state (it is an ability); it helps to minimize negative impacts of large events; and it facilitates the quick resumption of an operable state to a system, which may be similar to the previous state or superior to the previous state.

The San Francisco Planning and Urban Research Association's (SPUR) *Resilient City* initiative defines "seismic resilience" specifically around the concept of resilience to a major earthquake. The organization's definition is the "ability of a city to remain safe and usable after a major earthquake. A resilient city is able to contain the effects of earthquakes when they occur, carry out recovery activities in ways that minimize social disruption, and rebuild following earthquakes in ways that mitigate the effects of future earthquakes." [5]

While the exact definition of resilience may vary in its specifics in terms of describing its focus and scope, the Community and Regional Resilience Institute (CARRI) gives us a language of five core concepts to anchor every definition:

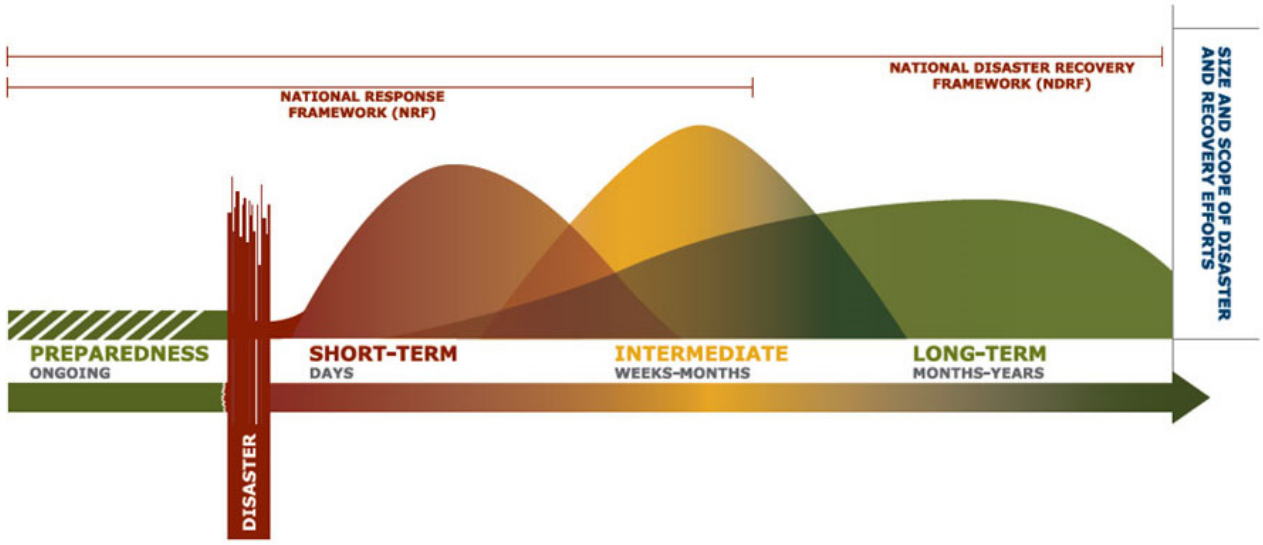
- Resilience is an **attribute** of the community, system, region, etc
- Resilience is **continuing**, an inherent and dynamic aspect of the system

2 *State Hazard Mitigation Plan, p. 102 (2010)*

3 *Disaster Resilience: A National Imperative (2012). The National Academies Committee on Increasing National Resilience to Hazards and Disasters and Committee on Science, Engineering, and Public Policy*

4 *California State Hazard Mitigation Plan (p. 102) http://hazardmitigation.calema.ca.gov/docs/2010_SHMP_Final.pdf*

5 *Defining what San Francisco needs from its seismic mitigation policies, (2009). SPUR.*



Disaster Recovery Continuum, Federal Emergency Management Agency's National Disaster Recovery Framework, p. 8

- Resilience involves elements of **adaptation** and can easily adapt to new variables
- Resilience puts systems on a positive **trajectory** relative to its pre-disaster state
- Resilience is **comparable** and **relative** – it is possible to compare systems' ability to be resilient. [6]

It is helpful to examine a few other factors that contribute to a state of resilience or that help to explain how resilience is defined. First is the concept of scale – the state of being resilient is greatly enhanced when it exists at multiple scales, ranging from the individual, neighborhood, community, city, county, and region to the state and federal levels. Second, for our purposes we also wish to emphasize adaptability and the ability to recognize opportunities for growth and improvement as a key element of resilience – the ability to see a disruption as a chance for transformation – to "build back better."[7] Lastly, as discussed above, it is important to see resilience and sustainability as highly interconnected.

Resilience can also be viewed through the complete life cycle of a disaster: beginning with mitigating a system to be able to withstand or adapt during a disaster, continuing with response immediately after a disaster. An effective and resilient response effort understands how actions undertaken during the response phase have implications for the long-term health and recovery of the system. Resilience continues throughout short-term and long-term recovery, and effectively shortens the period of time between the disaster and full recovery. Lastly, in a resilient society, the long-term recovery phase includes the integration of mitigation measures in rebuilding practices, effectively beginning the life cycle again.

Similar to the term "sustainability," the term "resilience" applies more to a "philosophical perspective than a scientific concept."[8] An understanding of the many definitions and attributes of resilience helps to form the baseline concept of regional resilience, despite variations that neighborhoods, communities, cities, counties, infrastructure providers, and businesses may define in terms of system boundaries and scale within their own definition of resilience.

Defining a Disaster

It is also helpful to understand what we mean by the term "disaster." In general, the types of disasters considered are those that are due to natural hazards, have disruptive

6 Definitions of Resilience: An Analysis. (2009). Plodinec, M.J. Community and Regional Resilience Institute (CARRI)

7 State of California Multi-Hazard Mitigation Plan, California Emergency Management Agency (2010). http://hazardmitigation.calema.ca.gov/docs/2010_SHMP_Final.pdf

8 Disasters by Design: A Reassessment of Natural Hazards in the United States (1999). Joseph Henry Press.

consequences on one or more built environment, social, or economic system (man-made system), and are large enough to cross jurisdictional boundaries or overwhelm the capacity of a single jurisdiction or entity to overcome, making them regional in nature.

Disasters and their consequences can take on many forms and characteristics. Disasters can be "fast," such as a sudden earthquake or tornado; "slow," such as long-term degradation due to sea level rise or changes in weather patterns; or "hybrid," when fast and slow disasters occur simultaneously and a sudden event is exacerbated or compounded by existing slow disasters.[9] The impact of the disaster can be low or high, and can range in geographic scale. [10] Impacts can also vary based on pre-existing conditions – if a community has a strong economy and is on a general upward trajectory in terms of quality of life and well-being, an impact may be much less devastating than in a community dealing with disinvestment and lowering of quality of life.

It should be noted that natural hazards are not in themselves disasters. In *Disasters by Design*, a natural hazard – an extreme, low-probability phenomena – has the potential to cause a disaster when it strikes a human collective, but is not in and of itself a disaster. The disaster emerges at the point of intersection between the hazard and man-made systems, and only if the hazard causes negative impacts on the systems. This interrelationship is a complex one with many variables – for example, man-made systems often create a negative feedback system that increases the frequency or strength of a natural hazard, such as when paving over wetlands reduces its ability to attenuate hurricanes and major storms; additionally the consequences of a natural hazard become more severe as man-made systems become more complex. The trauma and consequences of a disaster are inherently defined, reshaped, and redirected by human actions and perception. [11]

It is also worth examining the difference between a disaster and a catastrophe. Webster's dictionary defines a catastrophe as a disastrous event that results in a final end or conclusion. This definition implies a disaster that is insurmountable and where recovery to a pre-disaster or equivalent state is not feasible. According to thinking by San Francisco author Rebecca Solnit, in her book *A Paradise Built in Hell: The Extraordinary Communities That Arise in Disaster*, communities can overcome disasters, but by definition they cannot overcome catastrophes. The defining element that differentiates a disaster from a catastrophe is resilience. The elements that allow a community or system to adapt and overcome a disaster prevent any one event from becoming catastrophic and insurmountable.[12]

Objectives of Planning for Recovery

Why plan to recover?

After a disaster, many people in positions of authority face immense pressure to quickly make decisions and ensure that recovery action is taking place. The public expects quick restoration of the life they had previously known, and this pressure can often lead to decisions that are uncoordinated, not fully considered, stopgap in nature, or do not align with a community's agreed-upon long-term goals. Communication among various levels of authority and different systems may be lacking. Outside interests or financial constraints may place additional pressure on decision-makers. Decisions may be made without public input or public consideration. Outdated rules and regulations may present unforeseen problems, with no public policy tools available for change. Many ad-hoc groups may arise and make decisions of their own without awareness of or regard for other groups. Outside experts with little or no knowledge of local issues may come in to contribute their opinion, without sufficient knowledge of the local social context and with little regard to follow-through and consequences.

9 Envirenew Resilience Part 1 Report: Creating Resilient Communities (2012) http://quake.abag.ca.gov/wp-content/documents/resilience/toolkit/Envirenew%20Resilience%20Part%201%20Report_Creating%20Resilient%20Communities.pdf

10 Ken Topping (2012)

11 Disasters by Design: A Reassessment of Natural Hazards in the United States (1999). Joseph Henry Press.

12 A Paradise Built in Hell: The Extraordinary Communities That Arise in Disaster (2009), Penguin Books.

Many issues may arise in the recovery phase that can have repercussions in the community for decades.

Planners can play a large role in how quicly and effectively rebuilding happens and what the vision is for the process and outcome of rebuilding.

While specific recovery actions cannot be known or implemented until after a disaster, when the full consequences are assessed and the immediate needs of the community are met, there are many actions that can be taken before a disaster that assist and expedite recovery, such as adopting a Long Term Recovery Plan, creating a Recovery Task Force, and adopting a Recovery and Reconstruction Ordinance.

It is possible, however, to begin to understand, anticipate, and put planning tools in place before a disaster to minimize or eliminate many of these issues and conflicts. The region, as well as individual jurisdictions, has many tools at its disposal to "plan for recovery." Planning for recovery can result in an expedited recovery, due to coordinated communication, pre-approved recovery plans, and established planning systems and frameworks. Resilience and recovery planning in advance of a disaster may also result in a recovery phase that requires far less repair or restoration investment, because interjurisdictional efforts are not duplicated, money is spent in a coordinated manner, and pre-disaster mitigation has lessened damage. Anticipating where people will live and creating a post-disaster housing plan means fewer displaced residents, which can contribute to a more stable economy post-disaster. Planning with businesses on how to retain their services after a disaster can also stabilize the local economy, and minimize disruption to people's everyday lives.

Planning for recovery can also identify and prioritize actions for vulnerable populations and anticipate their unique needs. Lastly, the process of planning for disaster recovery before a disaster happens can result in a shared vision for the future, as stakeholders and residents begin to understand how they want their region to grow and what it could look like if a disaster expedites change and renewal. This can also result in a more empowered and informed public.

What planning/policy/legislative tools are available to support disaster recovery planning?

There are many tools currently in use today that can be used by stakeholders to plan for recovery. In considering these tools, we must keep in mind that the post-disaster decision-making landscape will likely be significantly different than the current landscape and so the way these tools are used may change. In examining existing tools it is also useful to consider which tools are not helpful or useful or may hinder recovery, and to begin to identify new tools that may be needed for long-term disaster recovery.

Planners largely have tools for managing land use, housing distribution, and the urban character in the recovery phase. Planners can play a large role in how quickly and effectively rebuilding happens, and what the vision is for the process and outcome of rebuilding. Some planning tools are below.

- General plans and specific plans: These will guide the vision of the city with or without a disaster, but must make it clear that in the event of a disaster, the vision will still be followed.
- Zoning tools such as overlay districts, nonconforming use regulations, special use permits, etc: Review existing zoning through the lens of recovery and rebuilding to identify potential conflicts or issues.
- Zoning for temporary housing and temporary commercial spaces: Temporary zoning has major implications for reconstruction and land use decisions. Understanding how this will work before a disaster will greatly aid recovery.
- Buyouts and financial incentives for where to build/not build, easements, etc.: Have a plan for where a buyout program might be a possibility and where funding might come from.

- Other tools: Historic preservation/historic district ordinances, historic landmark designations, and associated state and federal tax credits.

Who conducts this work?

Traditionally, work around disasters has been largely conducted by emergency managers. Yet as the practice of recovery planning evolves, the work involves new and different stakeholders throughout the recovery process. In addition to emergency managers, elected officials, city managers, county administrators, city/county attorneys, planners, community development staff, economic development staff, finance staff, and many other players in day-to-day government operations will likely play a large role in the recovery process. Additionally, a new type of professional is emerging that engages in recovery planning as a large percentage or all of their job. These professionals are largely still defining their role and developing support for their positions. The *National Disaster Recovery Framework* from FEMA identifies the role of a Recovery Manager and Recovery Coordinator at the local, state, and tribal levels along with a Federal Disaster Recovery Coordinator position within FEMA. These FEMA-designated roles can help inform what recovery professionals may look like.

As recovery planning evolves, these new professionals, as well as existing staff who will perform beyond their daily duties after a disaster, will need outlets for sharing information, learning new skills and knowledge, and making connections with other recovery professionals. The region needs a forum to gather these professionals including hosting lectures, learning events, and networking events, publishing newsletters, conducting research, setting standards for newly-defined tasks and job roles, and helping to match professionals to jobs and needy cities to professionals.

Schools may also begin to develop curriculum and new degrees, similar to the newly developed Graduate Programs in Sustainable Management at the Presidio Graduate School of Management.

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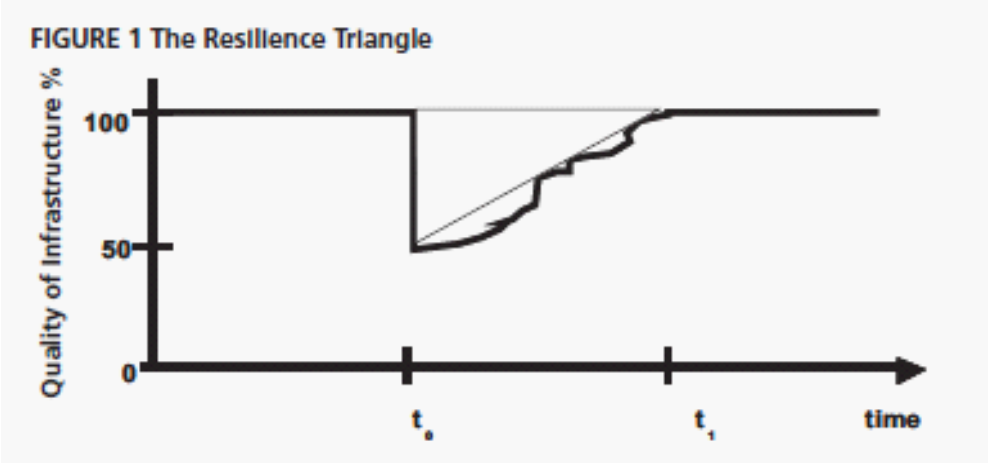
Mitigation and response planning to facilitate recovery

Appropriate and robust pre-disaster mitigation can mean the difference between a speedy, stabilized recovery process and a city or area that does not ever fully recover. Most disasters will cause the greatest amount of damage, by far, to the built environment. Damage to the built environment can cause injuries and deaths, displace residents from their homes and employees and employers from places of business, and disrupt the provision of basic services. Damages to infrastructure can impede the flow of people and goods and have spillover effects on multiple sectors. While not all damages can be anticipated and mitigated against, structurally mitigating homes and other buildings to withstand ground shaking can significantly lessen overall damage to the built environment, and mitigation to infrastructure can reduce loss of service.

Mitigating damages means a more intact built environment after a disaster, greater stability for residents and businesses, and far less money required for physical repairs. If people are able to stay in their homes because of minimal damage, they are less likely to leave the area and also do not require temporary housing. Minimizing physical damage to businesses allows them to begin functioning again more quickly and keeps the economy more stabilized.

While mitigation to buildings now may require an upfront investment, the money spent pre-disaster will likely prevent a much larger outlay of money that would be required post-disaster to make repairs or rebuild in a tightened and competitive construction market. One federally-sponsored study on multi-hazard mitigation efforts states that for every dollar invested in pre-event risk reduction, four

The Resilience Triangle illustrates the typical disaster cycle of sudden loss and recovery, with the triangle representing economic loss. Mitigating before a disaster reduces the size of the triangle, minimizing economic loss. Source: Conceptualizing and Measuring Resilience (Tierney and Bruneau, 2007)



dollars in response and recovery funds are saved.[13] Keeping the built environment more intact through mitigation also preserves the character of the urban area, maintains existing affordable housing, and minimizes the likelihood of a significant change in demographics after a disaster.

The way disaster response is conducted also has lasting impacts on long-term recovery. Traditionally, these two phases have been seen as separate. However, the connection between response and recovery should be made explicit, since they so heavily influence one another. Disaster response procedures set up structures, timelines, and precedents that can carry long into recovery.

Where emergency housing is located impacts where rebuilding and new development goes. Structures for decision-making may be set up hastily and place important decisions in uninformed hands or leave out important stakeholders. Short-sighted and compartmentalized decisions made to expedite rebuilding may not be coordinated regionally or fit in with long-term goals. Hours-long delays in decision-making during the response phase can translate into months-long delays during the recovery process. Actions during response can easily set a community on a difficult or unintended recovery path unless there is clear-sighted, long-term thinking taking place during response and communicated widely and effectively.

Quick, confident, and coordinated actions that foresee the long-term future, however, can be very powerful in instilling confidence and faith in residents and business leaders. If the community trusts that recovery will be effective and beneficial, people will be more likely to stay in the region. Transmitting this message quickly is highly important – if people perceive incompetence, lack of coordination, delay, or contentiousness in decision-makers, they will quickly lose confidence in the recovery of their community and are far more likely to leave. The same is true for businesses – small and large alike.

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Context

While the concepts of resilience and recovery planning may be largely universal and relatable to many different locations and conditions, the unique characteristics of the Bay Area allow us to tailor our understanding to the specific needs and vulnerabilities we face. The following briefly describes many of the major components of the Bay Area's assets and vulnerabilities – what we want to protect and preserve, what we can leverage for a successful recovery, and what types of threats we can anticipate that will disrupt our quality of life.

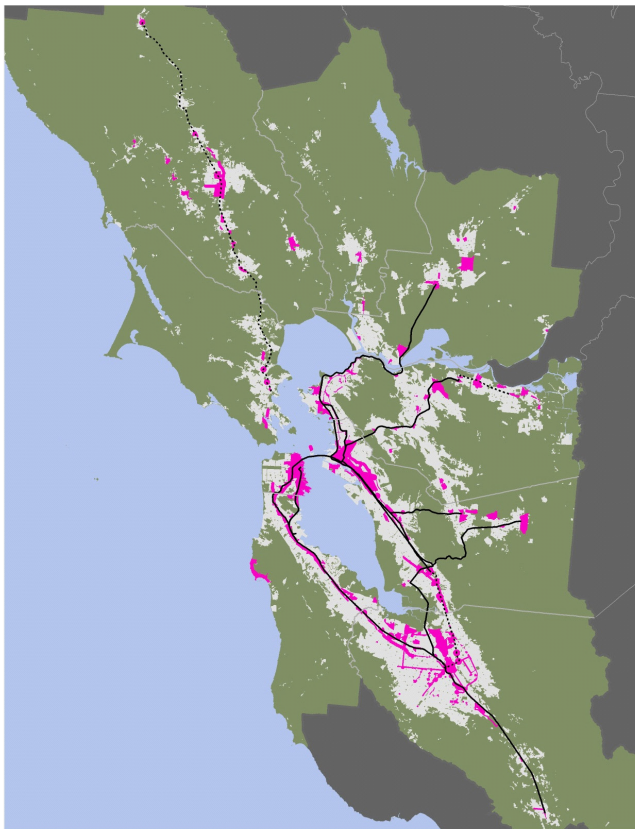
13 *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities. Multihazard Mitigation Council/National Institute of Building Sciences, (2005)*

Bay Area Overview[14]

The focus of this study is the greater 12-county Bay Area, which combines the 9-county San Francisco Bay Area, consisting of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma Counties, plus the counties of Santa Cruz, Monterey, and San Benito around Monterey Bay. The greater Bay Area is extremely diverse in every sense of the word - it is culturally rich, with a large diversity of ethnic groups; it is geographically diverse, with the bay, salt marshes, estuaries, wetlands, and hills and valleys, all shaped by major and minor faults; and its urban character ranges from downtown San Francisco with its high-density, highly urban form to the preserved farmland and rural areas to the North and South including the area around Monterey Bay. This diversity is what makes our region a unique, beautiful, and desirable place to live, but this is also what creates many unique challenges to building regional resilience.

Population

In 2010, the greater 12-county Bay Area had a population of 7.88 million people, with 7.15 million people located in the San Francisco Bay Area and 732,000 people in the Monterey Bay Area. The three most populous cities in the San Francisco Bay Area are San Jose (Population: 946,000), San Francisco (Population: 805,000) and Oakland (Population: 391,000). The three biggest cities in the Monterey Bay Area are Salinas (Population: 150,000) Santa Cruz City (Population: 60,000) and Watsonville (Population: 51,000). While the core area around the San Francisco Bay is densely populated and has a highly urbanized character especially in the big three cities (San Jose, San Francisco and Oakland), the area north of the San Francisco Bay and around Monterey Bay have a lower population density and a more rural character, dominated by open space and agricultural land. The greater 12-county Bay Area population is expected to grow by 1.98 million people or 25% in the next 25 years taking the overall population to 9.86 million by 2035. The majority of this growth will be focused in the core urban areas around the San Francisco Bay within the urban growth boundaries to protect open space and agricultural land.

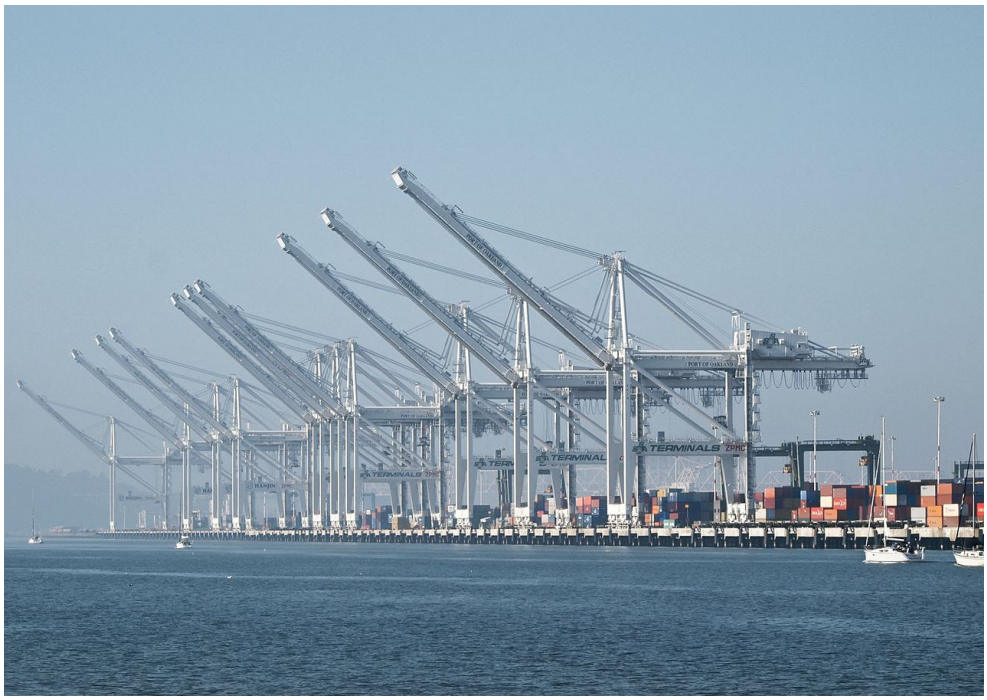


Bay Area map, illustrating areas of urbanized land (grey), non-urbanized land (green), and Priority Development Areas for future growth (pink).

Jobs and Economy

The greater 12-county Bay Area was home to around 3.71 million jobs in 2010. A large majority of jobs (3.39 million) are located in the San Francisco Bay Area with the biggest employment centers in San Francisco (569,000 jobs), San Jose (375,000 jobs) and Oakland (190,000 jobs). The Monterey Bay Area had a total of 329,000 jobs. San Francisco has the highest proportion of jobs to population, making it an employment hub for the region. The biggest employment sectors in the San Francisco Bay Area in 2010 were Professional Services, Government, Leisure and

14 Source for the following numbers are: ABAG (2012): Plan Bay Area, Jobs-Housing Connection Scenario (Draft) and AMBAG (2011): Envisioning the Monterey Bay Area, A Blueprint for Sustainable Growth and Smart Infrastructure, unless marked differently.



The Port of Oakland is the fourth busiest container port in the U.S., handling over 2 million freight tons annually. Photo source: Flickr user ingridtaylar

Hospitality and Manufacturing and Wholesale. The biggest employment sectors for the Monterey Bay Area were Educational Services and Health Care and Social Assistance, Retail Trade, Agriculture and Fishing and Professional Services.[15]

With the economy expected to grow in the next decades, employment for the 12-county Bay Area is expected to increase by 22% to 4.72 million jobs in 2035. A large proportion of those new jobs will be concentrated in the employment centers of San Jose, San Francisco and Oakland or in the development corridors that stretch along both sides of the San Francisco Bay.

The employment growth will be driven by the Knowledge-Based sector, which includes professional services, Information and Finance, the Health and Education sectors and the Leisure and Hospitality sectors. Many major corporations are headquartered throughout the region. Silicon Valley and the broader South Bay is home to many leading IT and high-tech companies making it a world-class business location. There are four national laboratories, over 30 public and nearly 50 private colleges and universities, and over a dozen seminaries. Students, faculty, visiting lecturers, and researchers come to the Bay Area from around the world to take advantage of the rich resources these facilities provide, and they also contribute greatly to our economy by being major regional employers.

15 US Census (2010)

Regional Infrastructure

The regional transportation system in the greater Bay Area is divided between the San Francisco and Monterey areas with some linkages between. The highly urbanized core area around the San Francisco Bay is serviced by multiple transit options, such as Bay Area Rapid Transit (BART), Amtrak, or the regional rail system operated by Caltrain as well as inter-county light rail and ferries. The areas outside the core area such as the North Bay, West Peninsula or the areas south of San Jose, are more dependent on bus services or the personal use of the automobile and the network of highways.

Much of this transportation system has been retrofitted over the 20 plus years since the 1989 Loma Prieta earthquake. Weaknesses, however, still exist and according to a recent study by the San Francisco Planning and Urban Research Association (SPUR), the failure or significant damage to any of these regional transportation systems could temporarily paralyze San Francisco or a wider regional area.[16] In addition to maintaining the currently existing infrastructure and its public transit network, expansion compatible with future population growth of the greater

16 *Lifelines: Upgrading Infrastructure to Enhance San Francisco's Earthquake Resilience. SPUR (2009)*

The Oakland Hills Firestorm in 1991 killed 25 residents and destoryed almost 4,000 homes. The economic loss has been estimated at over $1.5 billion. Source: www.sfgate.com

Bay Area is crucial. Developments in this direction are already being made with the planned expansion of BART to San Jose.

In general, there is a regional priority to increase non-auto modes of transportation, including walking, biking, and public transportation. Besides various transit improvements the region has seen developments to improve 'bikeability' with the San Francisco Bay Trail, which covers almost the entire shoreline of the San Francisco Bay. This improvement not only meets regional goals of sustainable development, but also provides alternate transit routes post-disaster.

The region has three major airports – San Francisco, San Jose and Oakland International, as well as Monterey Regional and Sonoma County Airports. San Francisco and Oakland International are directly connected to BART, while San Jose International is also well connected to other public transport.

The Bay Area has three ports located in Oakland, Richmond, and San Francisco. The Port of Oakland is the fourth busiest container port in the U.S., handling over 2 million freight units annually, and is served by the Burlington Northern Santa Fe and Union Pacific Railroads. Oakland loads and unloads over 99% of the containerized goods that move throughout Northern California. The Port of Richmond handles oil tankers and associated shipping, as well as automobiles and other dry and liquid bulk goods, and is the leading port in the San Francisco Bay Area in tonnage of automobiles and bulk liquids. The port has five city-owned and ten private terminals and is served by the Burlington Northern Santa Fe and Union Pacific Railroads.

The Port of San Francisco handles mainly cruise ships, passenger ferries, and commercial and sport fishing activities on the northern waterfront. Fisherman's Wharf is the center of Northern California's commercial and sport fishing fleets, and is a key tourist destination. Pier 45 houses the West Coast's largest concentration of commercial fish processors and distributors. All three ports play a major part in the regional economy, not only as hubs of trade, but also as employment centers.

The region has five major oil refineries in Benicia (Valero), Martinez (Shell and Tesoro), Richmond (Chevron), and Rodeo (ConocoPhillips), and depends on multiple power plants, wastewater treatment plants, waste management locations, and an extensive telecommunications system located throughout the Bay Area. The majority of the Bay Area depends on Pacific Gas and Electric (PG&E) for power (some jurisdictions, including Palo Alto, Marin, and Alameda, generate their own), while multiple entities provide water, wastewater, and waste services, which vary widely in size and scope. Both the San Francisco Bay and Monterey Bay Areas are serviced by a dense network of PG&E gas transmission pipelines.

Natural and Manmade Hazards Affecting the Bay Area

While the focus of this Initiative was on the effects of earthquakes on the region, other natural and manmade hazards can have regional consequences requiring a recovery effort similar to that for an earthquake. These threats include tsunamis, firestorms and windstorms, prolonged rain events with widespread flooding and landslides, droughts, pandemics, terrorist attacks, catastrophic events caused by aging infrastructures and systems failures and technological disasters.

There is a need for additional assessment capabilities and studies of impacts particularly to infrastructure from earthquakes and other major disasters, including vulnerability of the Bay Area water supplies to Delta levees and flooding from a super storm, to better determine restoration requirements, timelines, and costs in advance of an event. There is also a need to identify vulnerable neighborhoods that might be most heavily impacted by various earthquake events in the Bay Area. Focusing on areas that may suffer significant structural damage, housing and business loss could stimulate pre disaster recovery planning and discover organizational, programmatic, financial, and legislative gaps.

Earthquakes

The region is particularly vulnerable to large earthquakes. There are numerous major active faults in the region with a combined thirty year probability of a major earthquake in excess of sixty percent. Two fault systems pose significant risk in the Bay Area. The Hayward Fault runs about 74 miles long mainly along the western base of the hills on the east side of San Francisco Bay through densely-populated Richmond, El Cerrito, Berkeley, Oakland, San Leandro, Hayward, Fremont, and San Jose.

The San Andreas Fault, which cuts through Tomales Bay in Marin, runs offshore as it passes San Francisco and returns to shore as it passes through the San Francisco Peninsula,

Crews work to stabilize a hillside after heavy rains caused a landslide in densely popualted North Beach, San Francisco, forcing evacuations.
Photo source: www.sfgate.com

is the other significant regional threat. A large magnitude earthquake on either the Hayward or San Andreas Faults would cause significant damage to the region.

Soil liquefaction is a significant problem throughout much of Bay Area. Large areas around the Bay have been filled and now support residential and commercial buildings and infrastructure assets. Often the soils compaction at these sites is not sufficient to prevent liquefaction. Underground infrastructure assets—water and sewer pipes, natural gas and liquid fuel pipelines, power distribution lines, and communications cables and equipment are particularly vulnerable to liquefaction, as well as above ground structures. Deep soil basins, such as in Silicon Valley, can amplify ground shaking. Bridges, tunnels, and roadways will be impacted by disaster damage and debris. Large proportions of older buildings are not retrofitted for earthquakes and will be at risk, and others will be subject to land and mudslides. Along the coastal areas, there is the threat of tsunamis. For detailed information on earthquake and tsunami threats and impacts, see the ABAG website at http://quake.abag.ca.gov/.

Catastrophic Rain Events and Major Floods

So-called "pineapple express" storms which start off the ocean near Hawaii can cause a "super storm" that can result in a rapid "mega flood" which, in turn, could trigger a

catastrophic failure of many of the old and degraded levees in the 1100-mile area in the Sacramento-San Joaquin Delta, originally built to control floodwaters and increase farmland. Such a flood would submerge hundreds of square miles, impacting and washing away communities and some of the region's (and the nation's) most productive farmland.

Fire and Windstorms

Between late November and early March strong Pacific storms can bring both substantial rainfall (saturating and weakening soil) and strong wind gusts that can cause trees to fall on power lines, sometimes affecting hundreds of miles of coast and interrupting essential services for up to several days in some more remote localities. In the spring and fall, strong offshore winds often develop. These winds are an especially dangerous fire hazard in the fall when vegetation is at its driest. Examples of firestorms are the 1923 Berkeley Fire and the 1991 Oakland-Berkeley Hills Fire (Tunnel Fire). In the last 120 years, there have been over 100 significant urban/wildland interface fires in the East Bay hills alone.

Mudslides and Landslides

Some geologically unstable areas have been extensively urbanized, and can become mobile due to changes in drainage patterns and grading created for development. These are usually confined to small areas, but there have been larger problems in the Santa Cruz Mountains.

Climate Change

In coming years, the Bay Area will be subject to increasing effects of climate change. The extensive coastline and bay shoreline will be subject to rising sea level, leading to more frequent and more severe temporary flooding as well as eventual permanent inundation. The Bay Area will also experience more frequent and more severe storms and storm surges, increased risk for wildfires, and increased temperatures, heat waves, and air pollution. Increased snowmelt earlier in the season could flood the delta, and beaches will experience increased erosion and sand loss.

Sea level rise will put many regional assets at risk, including transportation, water, and power infrastructure, and will impact shoreline ecosystems and recreational space. Existing flood control measures will soon become inadequate, bearing greater loads and experiencing overtopping.

Disaster recovery is not separate from many of the tasks that cities pursue today – it is the process of city-building and economic development, amplified and intensified.

Multiple Hazards

Some locations in the Bay Area are located in areas that have conditions that make them susceptible to multiple hazards. In the case of earthquakes, many areas will experience not just ground shaking, but liquefaction, landsliding, surface fault ruptures, or tsunamis. Many of the same areas that will experience sea level rise are also areas that are highly vulnerable to liquefaction, and so will need to consider multiple hazards in the future. Fire ignitions after an earthquake due to damaged natural gas valves may cause significant damage in areas particularly susceptible to firestorms. In planning for recovery and resilience, hazards must be considered together, as planning efforts may be wasted if all hazards are not considered.

Conclusion

We have placed the work of the Regional Resilience Initiative and the papers that have resulted from this initiative in context and embedded in theory helps to validate our work. This standard definition and theory of resilience within the region provides a platform for all additional work initiated by this project and helps create a baseline standard for discussing the idea of resilience. We can expand the conversation around resilience beyond the well-known realms of mitigation and response also encourages new professionals to join in the conversation, which helps ensure a more complete recovery process. Disaster recovery is not separate from many of the tasks that cities pursue today – it is the process of city-building and economic development, amplified and intensified. Resilience is largely

about maintaining and improving the Bay Area's quality of life, despite natural events that may have the potential to disrupt our most significant systems. Presenting this more holistic vision allows resilience-building actions to become more integrated into all aspects of developing and planning for our region. •