Chapter 13
Building More Resilient Communities

Abstract After the description of the methods to assess resilience (part 1) and show some applications (part 2) the goal of this chapter is to shows what actions should be taken to make communities more resilient. After categorizing the different interventions according to the structural type, and presenting the three international frameworks for disaster risk management (Yokohama, Hyogo and Sendai framework), the chapter focuses on the different initiatives developed in New York City after Hurricane Sandy to make the region more resilient.

13.1 Introduction

Disasters brought on by supernatural events are now the most threatening sources of danger to long term advancement around the globe. In the course of the most recent two decades, they have killed 1.3 million individuals, damaged 4.4 billion, and created over 2 trillion USD in financial losses. Nowadays, it is worldwide accepted that the activities and choices of people, communities, and countries have a remarkable difference whether a hazard transforms into a disaster. Decisions made with the point of diminishing the human effect of common perils can be portrayed as disaster risk reduction (DRR) in the broadest sense (UNDP 2014a).

13.1.1 Disaster Risk Management

Disaster risk management (DRM) refers to the systematic process of using administrative decisions, organization, operational skills, and capacities to implement policies, strategies, and coping capacities of the society and communities to reduce the impacts of natural hazards and related environmental and technological disasters. This includes all forms of actions, such as structural and nonstructural measures to avoid (prevention) or to limit (mitigation, preparedness, and response)

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the adverse effects of hazards (adapted from UNISDR 2004). DRM is usually divided into three main areas of activity:

1. Disaster risk reduction (prevention, mitigation, and preparedness),
2. Disaster response (rescue and relief), and
3. Disaster recovery (rehabilitation and reconstruction).

Even if these areas are kept separate in reality they overlap and affect each other, however in the following paragraphs is kept this separation to have an organized description of the following actions.

13.1.2 State-of-Art on Existing Plans for Developing Resilient Communities

Several plans exists to develop resilient communities. Among them it is worth to mention the Plan that the National Institute of Standards and Technology (NIST) recently released, called new Community Resilience Planning Guide for the Built Environment and Infrastructure Systems (Version 1.0) (NIST 2015), prepared with experts and stakeholders from around the nation. The planning guide details a six-step, integrated approach that communities can follow to achieve a more resilient, less disaster-prone future. The six steps are the following:

1. Form a collaborative planning team
2. Understand the situation
3. Determine goals and objectives
4. Plan Development
5. Plan preparation, review, and Approval
6. Plan implementation and Maintenance

It is surprising that the US, however, are not among the leading countries when it comes to disaster risk reduction. According to UNDP (2014a), US falla within the "Medium priority" in the disaster risk reduction classification. It is noteworthy here to mention New Zealand as one of the countries that have given high priority to Disaster Risk Reduction (DRR). New Zealands Civil Defence Emergency Management Act of 2002 (DRM law) does not indicate from its title that it gives a high priority to DRR, but the law has been described as being based on five key principles (UNDP 2014b):

1. Risk management
2. Integration
3. Comprehensiveness
4. Subsidiarity
5. An all hazards and all risks approach to emergency management.28

The DRM law of New Zealand describes an entire DRR process, from risk assessment to monitoring and review. Another interesting feature of the New Zealand DRM laws objectives is the use of the terms "sustainable management of hazards", "acceptable levels of risk", and "cost-effective risk reduction". These place government efforts on DRR within the broader context of national development, recognizing that there may be limitations on the resources and/or capacity available to manage hazards sustainable (UNDP 2014a).

13.2 Resilience as a Preventive Action

13.2.1 Improving Disaster Preparedness

Ideally, buildings and (NIST 2015) infrastructures and their ability to support individuals and social institutions of government, business, education, etc., should not be affected or disrupted in the occurrence of a hazard event. Realistically, hazardous events can disrupt the community functions so extensively that they result in permanent damages. Despite the fact that most people are unprepared to cope with the loss of functionality, the built environment is not always able to retain full service after significant hazardous events occur. This harsh reality is faced every time a significant hazardous event occurs. Two events which have caused extensive damages across communities in the U.S. are the Hurricane Katrina, in 2005, and the Super-storm Sandy, in 2012- events which have left the communities still in need of years to recover. During the period from January 2000 to January 2011 there were between 45 and 81 Presidential disaster declarations in the US yearly for floods, hurricanes, tornadoes, earthquakes, fire events, and severe storms (FEMA 2011). Many of the disaster declarations were for hazard events with loads lower than current design levels. Whether the hazard is due to severe weather, fire, floods, earthquakes, infrastructure failures, cyber attacks, technological accidents, sea level rise, man-made hazards or other disruptive events, each community will eventually need a period of recovery from the event. The ultimate outcome of the recovery depends on *planning, preparedness, mitigation, response, and facilitation of the recovery*. A community that has not been prepared to face a disaster often requires decades to recover and may never achieve full restoration. The best way to improve *disaster preparedness* is to persuade organization and coordination to understand the hazard that has to be faced and to reduce its risk. This task should be developed jointly by civil society, by citizen groups and by building authorities that prepare the society and ensure that all departments understand their role in disaster risk reduction and preparedness. It is a necessity that all cities have an institutional basis for implementing risk reduction, and it should be multi-sectorial and involve all relevant stakeholders in the area. At the *local level*, cities or regional governments have to create councils, committees, agencies and other local disaster risk management institutions for emergency preparedness, response,

Fig. 13.1 Destruction in the wake of superstorm Sandy on Wednesday, Oct. 31, 2012, in Seaside Heights, NJ (Source: http://blogs.pjstar.com/eye/2012/11/02/aerial-photos-of-destruction-left-by-superstorm-sandy/)

disaster risk, climate change and resilience. To strengthen the *city-level* institutional and coordination capacity, a lead entity has to be established, to lead a coordination mechanism among departments. The roles and responsibilities of those departments have also to be defined in detail. Not only council institutions have to work together, but also volunteers, business, NGOs and emergency services have to be involved as well. Those emergency services have to work together, so that a collaborative strategy can be generated to integrate all units responsible for emergency response (Fig. 13.1).

However, it is better to work under a *national-level framework*. National disaster risk reduction legislation has to enable the development of city-level, and to provide a supportive funding structure. To facilitate the coordination across sectors, the responsibilities should be designated at national level and thus be delegated through to the local level. Furthermore, to ensure that these authorities are working at their best, it would be great to institutionalize them. Alliances and networks beyond cities have to be created by developing partnerships with local, national or international universities that can provide data, expertise and research. Exchange programs with cities should be considered, between communities in other countries that face similar risk patterns or challenges. In the Philippines, different cities work together in the field of disaster preparedness to develop an authority community-scale structure for disaster risk management. Today's communities are riddled with issues, policies, and regulations that require attention and demand both time and investment. Without a government mandate or recent event to draw community interest, *low probability-high consequence* hazardous events become a lower priority. These incidents illustrate the role of resilience planning in making a major difference in the

way a community and that the idea of resilience should be an integral part of normal planning and operations. Chile, as a country, is no stranger to seismic activity. In 1960, following a catastrophic occurrence, Chile began to make efforts to develop and update stringent building codes and emergency response procedures. Another earthquake of similar magnitude occurred in 2010, disrupting areas from Santiago in the North to Conception 500 miles to the south and generating a large tsunami. The newly implemented emergency response procedures that were encouraged by past experience, in combination with greatly improved building standards that had been in place for 50 years, resulted in decreased damages, especially to high-rise residential buildings. Power restoration to critical infrastructure began within days and over 50,000 provisional homes were constructed within a few months. It took only 3 years to complete infrastructure repairs and nearly all subsidized home rebuilding projects were complete within 4 years. Despite the widespread damage to older buildings and infrastructure systems, the proliferation of modern construction and response and recovery plans assisted the communities ability to manage the event and swiftly rebuild in a way that better prepared them to face another seismic event (Fig. 13.2).

In the past 15 years, a variety of efforts related to community resilience have been initiated in the United States, and there are constantly individual communities that are working to recover from hazard events. Cedar Rapids, Iowa, has multiple sources of natural hazards, including: floods, severe weather, tornadoes, severe windstorms, and heat waves. This city is precariously situated just downstream from a commercial nuclear power facility. The community is well equipped with an evacuation plan for dealing with a nuclear disaster. During the flooding of 2008 when the river crested at well above its predicted 500-year flood event, these plans played a key role, protecting the lives of the residents who were all safely evacuated

Fig. 13.2 Chile as a resilient city in a resilient nation (Source: en.wikipedia.org)

Fig. 13.3 Downtown Cedar Rapids, Iowa is engulfed by the Cedar River (2008) (Source: en.wikipedia.org)

(NRC 2012). The response by the community and government was so successful because the City Council and City Manager instituted a community engagement process, developing a shared vision and planning system months before the 2008 flood. Currently, the Recovery and Reinvestment Plan is being rapidly implemented, improving the community resilience in the case of flooding events (CARRI 2013) (Fig. 13.3).

The circumstances surrounding the 2005 Hurricane Katrina had been frequently predicted and even focused on by multiple State and Federal response exercises. One scenario considered went so far as envisioning the levee breach. However, following the disaster, numerous communities and industrial facilities that support national fuel supplies were damaged severely. Communities were not cognizant of the threat posed by storm surge or the predictions and therefore were unprepared for response and recovery at the local level (APA 2014). The recovery was stalled by the lack of suitable design codes, response plans, processes to coordinate various local, state, and Federal agencies, and local leadership. A new department in the local government, the New Orleans Redevelopment Authority, was added after the hurricane in order to facilitate land stewardship, commercial revitalization, and affordable housing. Although their efforts are sometimes criticized, service organizations such as Habitat for Humanity, Make-it-Right Foundation, and Rebuilding Together New Orleans have made significant strides in aiding homeowners to return to their communities and rebuild their lives, though collaboration with local government and community leaders. The population of New Orleans is at approximately 75 % of its pre-Katrina levels, 10 years after the disaster (APA 2014) and it may be decades before the city can make a full recovery from hurricane Katrina. On the cutting edge of disaster preparedness is the city of San Francisco, in California (USA). San Francisco is exposed to several seismic hazards. The city is recognized as a leader in sustainability and preparedness against disasters and its buildings have a demonstrated great resilience. The San Francisco Planning and Research

Association (SPUR) began to establish this style of resilience planning in 2007. Their work focuses on the community level, creating policies and programs which aim to make San Francisco a Disaster Resilient City. Multiple policy papers and recommendations regarding the broad issues of disaster resilience have been produced as a result of SPURs work. Their policy recommendations focused on community needs before, during and after responding to a disastrous event. There are key questions related to disaster planning on which previous disaster work has focused. The following is a list of the problems that are addressed regarding preparedness: ensuring a quick recovery of our built environment after a major earthquake, deciding which buildings should be retrofitted and to what level, encouraging better performance in new buildings and strengthening infrastructure so that the buildings are serviceable after an earthquake. Disaster Response focuses on activities during the days and weeks following a catastrophic event will include activities referred to as disaster response, this concerns: damage assessment, responder safety, communications and control, evacuation, public health and safety, and the restoration of vital systems. The goals addressed by the disaster task force after the event include: preparation for rebuilding the city to an improved state, employing plans and systems of governance in order to put the city in a position to rebuild and extracting lessons from recovery experiences in lower Manhattan, New Orleans, Haiti, Chile, China, and beyond. This task force is working to evaluate and understand long-term recovery, in the areas of transportation, governance, planning, and housing cite (NI) (NIST 2015). This resilience is the product of its comprehensive institutionalization of disaster risk reduction. The City and County of San Francisco (CCSF) assigns a budget for disaster risk reduction (staffs and projects) every year. The Mayor and City Administrator are responsible for coordinating the work of these agencies, as well as the correct distribution of the budget to ensure that the goal of contributing to enhance the overall resilience of the City is accomplished. The programs of the CCSF include Disaster Preparedness Coordinators for each department. The CCSF Disaster Council, chaired by the Mayor, ensures stakeholders participation in emergency planning. The CCSF Lifelines Council, chaired by the City Administrator, increases lifelines resilience. A Ten Year Capital Plan connects all the city stakeholders and advises the Mayor regarding future capital project bond issuance. The CCSF has created the Neighborhood Empowerment Network (NEN), which is an alliance of residents, communities, NGOs, universities, private and public agencies. The NEN generates programs, resources and tools for residents in order to increase communities resilience.

13.2.2 Mitigating Natural Hazard

Floods, hurricanes, earthquakes, wild fires and other natural hazards can't be prevented, but through planning, prioritization and sustained follow-through efforts, communities can decrease the impacts of these shocks and shorten the road to full recovery. In the last decade there have been a shift on hazard reduction from one

solely protecting people to protect the built environment to the extent necessary to allow rapid recovery.

In this paragraph are shown the approaches adopted in US for mitigating natural hazards, because many of these plans can be also applied elsewhere. The Federal Emergency Management Agency (FEMA) is a department of the United States Central Government. Its main goal is to coordinate the response after a disaster in US. Nearly 24,000 communities in the U.S. have used FEMA to guide the development of mitigation plans, these communities encompass 80 % of American residents. According to its plan, the State has to submit a plan including a mitigation strategy to reduce the losses by identifying the risk assessment. This plan aims at different goals, which should be related to other State and local jurisdictions plans and policies. By having the goals well defined, it is easier to achieve a long-term hazard protection, however it is also important to identify the funding, that could be from local or private sources. The first step should be to review the previously approved plans and to update them to demonstrate that progress has been made to implement new mitigation strategies. The mitigation strategy updating provides the chance to discuss the goals and objectives of the State and local plans. Since *mitigation* is a component of resilience, these plans evolve a community towards resilience. A comprehensive understanding of community resilience is provided through a planning process which includes a detailed analysis of the built environment as outlined in the Disaster Resilience Framework and incorporates ongoing mitigation planning. The next step after the establishment of community mitigation planning structure is to expand the scope to resilience. There are similar roles and responsibilities to the ones involved in mitigation activities that are necessary for resilience. An important part of the mitigation planning process is the public participation for coordinating strategies with targets, actions and priorities. Existing mitigation plans and techniques related to the built environment can be used as the framework for community resilience plans. The Presidential Policy Directive 8 (PPD-8) on National Preparedness delegated to FEMA the task of producing a series of frameworks to address the spectrum of prevention, protection, mitigation, response, and recovery. Each Mission Area includes a framework document, which describes the roles and responsibilities of the whole community.

13.2.2.1 Hazard Mitigation Objectives

The goals defined in the State plan aim at long-term hazard mitigation and loss reduction. Integration of long-term planning and implementation of measures of improving resilience can be positive for a community, providing an attractive, vibrant place for residents to live and a reliable environment for the location of businesses. There are also daily benefits of having a resilient community, such as reduced daily disruptions with the adoption of improved design and construction practices. The community resilience plan will therefore begin to improve the performance of buildings and infrastructures against cascading effects due to interdependencies.

It is necessary to describe how these goals were developed and why they have been chosen. With these goals in mind, it is possible to implement a guide of mitigation actions, by describing the objectives and explaining the connection between goals, objectives and actions. The goals should focus on local and State risk assessment and represent a long-term vision for hazard reduction or enhance mitigation capabilities. The resources allocation and priorities are evaluated by considering the desired performance goals in comparison to the anticipated performance of the built environment to hazard events, as well as their expected recovery sequences, time and costs provides. Ideally, community resilience planning can achieve improved social and economic well-being in the long-term by integrating it with long-term plans for economic development. This approach to resilience planning has been developed and implemented in San Francisco (SPUR 2009).

13.2.2.2 Estimation of State Capability

A State shall define its financial and legal situation and its capability to program and carry out mitigation actions both before and after a disaster. The mitigation strategy has to focus on the existing capabilities of mitigation and as well as address areas in which strengthened capabilities are needed. Without this evaluation, the implementation of the plan could fall through because of inadequate supplies. The State shall also conduct an evaluation of the laws, policies, regulations and programs that are related to hazard mitigation as well as to develop new ones if it is necessary. The emergency programs have to be discussed, assessing its implementation opportunities and problems, chances to improve them and possible problems related with private development projects in hazard-prone areas. The State should prioritize and highlight tools and policies that have achieved mitigation objectives. Finally, the discussion should include positive aspects and problems that came up.

13.2.2.3 Estimation of Local Capability

The local mitigation policies, programs and capabilities should be accurately defined. These pre- and post-disaster polices have to be described and evaluated to determine their effectiveness. The description of these capabilities can be general and does not need to be detailed for all localities. Basically, the proceeding is the same used for the State capability assessment, but now at a different level.

13.2.2.4 Estimation of Mitigation Actions

The mitigation actions should be identified through both local and state planning process. The State should define the agencies and organizations that have been involved in identifying the *priorities* and the *mitigation actions*. This necessitates

the involvement of all stakeholders that are essential for setting the recovery goals of community resilience. A governance structure is required to set direction and provide services, while the built environment is required to support the social institutions of the community. The recovery process is directed by the governance, paced by financing and supported and propelled by the members of the community. The foundation of the recovery is established by the built environment.

A *resilience plan* is developed through collaboration between the office of a Chief Executive, such as the Mayor, City Council or Board of Supervisors, community departments and key stakeholders, including representatives of the social institutions, representatives of the physical infrastructure systems, and concerned community members. The holistic nature of the plan and the role that support plays in a successful implementation, lends itself to a public-private partnership for its development. The FEMA Local Mitigation Planning Handbook provides guidance for building a planning team. FEMA suggests using existing community organizations or committees as a starting point and involving all agencies and organizations which have a role in hazard response and mitigation planning. These actions were evaluated along with the correspondence between these actions with the plans mitigation goals, which should be directly associated in order to ensure the achievement of the objectives. The actions can be different in nature: statewide or property specific, targeted at government agencies or private organizations, regulatory or programmatic, construction activities or public outreach.

13.2.2.5 Identifying and Describing a Natural Hazard

The hazards likely to affect the area shall be identified and described by the local risk assessment. This is a critical step, due to the fact that the foundation of the plan and the factual basis for the mitigation strategy is the identification of the hazards that can affect the jurisdiction. All the hazards that are commonly recognized as threats to the jurisdiction have to be identified, if not, this plan cannot receive a satisfactory score. In this way, it is necessary to describe how these hazards have been identified and explain why a hazard has been disregarded. The process for identifying hazards could involve the reviewing of the policy and mitigation plans of the State, talking to experts, searching information in different sources and interviewing long-term residents. A list of potential hazard is given in Sect. 1.1.1.

Communities should then consider three levels of *intensity* or *magnitude* for each hazard selected, in order to apply it in the framework. The terms used to define these levels should be consistent with the design (NIST 2015).

- *Routine*: This hazard level is below the expected (design) level, but is of a higher frequency of occurrence. Full functionality of buildings remains and the infrastructure systems should not experience any significant damage or disrupt daily life.
- *Expected*: This is the design hazard level, according to the codes, possibly greater than the minimum required by codes, or could be based on other criteria

surrounding the building or infrastructure system. Buildings and systems should remain functional and capable of supporting the recovery and response period of the community. This level is based on the typical design level used for buildings.
- *Extreme*: This hazard level exceeds the expected (design) level. The hazard level doesn't necessarily have to be the largest possible hazard level that can be envisioned, but is one that the community intends to be able to recover from, however long it may take. At this level, critical facilities and infrastructures should remain functional. It is expected that infrastructures and other buildings should perform at a level to protect the occupants and allow them to safely and easily evacuate. Emergency response should be prepared for scenarios at this hazard level.

There are standards and code specifications for the national minimum hazard levels of design, for example, *Standard 7–10 Minimum Design Loads for Buildings and Other Structures* (ASCE 2013) defines minimum hazard levels for design nationwide and then communities may define the size of a hazard they wish to consider for each level.

The *impact* of a hazard depends on the size of the area affected, the conditions and development in the affected area, and the community ability to respond. However, the size of the area affected in a disaster as well as the geographic distribution of the intensity depends on the particular hazard.

After identifying a hazard it should be described using the following criteria:

- Probability that the hazard occurs in the area;
- Information of damages due to past events occurred in the community;
- Level of severity of past events;
- Date and duration of previous hazards;
- Sources of information for assembling these past events;
- Maps identifying the affected areas by previous episodes and composite maps combining information;
- Characterize the area describing the topography, meteorology and other conditions that could mitigate or exacerbate the potential of the hazard;

13.3 Resilience as Restorative Care

13.3.1 Post-disaster Recovery

Disaster recovery (rehabilitation and reconstruction) refers to the resolutions and actions taken after a disaster with the goal of restoring or improving the pre-disaster living conditions of the stricken community, while encouraging and facilitating necessary changes to reduce disaster risk. Recovery affords an opportunity to develop and apply disaster risk reduction measures (UNISDR 2004). When a disaster strikes in a poor community, it cause serious loss of life and property and it

often threatens the livelihoods and futures of those who survived. This is especially the case where productive household members have been lost or permanently disabled. For many households, not only will their short-term economic and social vulnerability be increased, but their ability to cope with future shocks may also be eroded. These pressures can increase poverty in a society. They can exacerbate tensions or conflicts that may have already existed within or between communities prior to the disaster. In the case of regularly recurring hazard events or shocks, many poor communities live in a constant state of recovery, where temporary relief has become a permanent coping strategy. For example, in Malawi drought occurs with such frequency that people have little time to recover before another drought hits. This has resulted in expanding poverty, chronic food insecurity, and aid dependency. Thus, in order to be effective and sustainable, recovery initiatives must be linked to the national and local development context and processes, as well as an understanding of the economic, social, and political conditions that were prior to the disaster. Some of these are likely to have been contributing factors to the risk and vulnerability that turned the hazard event into a disaster; others for instance, underlying structural issues may have an impact on the strategies adopted for recovery. Lack of understanding of these processes can lead to poorly targeted and inappropriate assistance. This is the case for infrastructure rehabilitation and reconstruction. There are many examples of schools and health centers rebuilt after natural disasters that could not afford ongoing maintenance costs or the staff to run them.

13.3.2 The Role of Legislators

Laws and regulations are considered the foundation for building community resilience. They are essential for reducing existing danger posed by natural hazards, preventing new risks from growing and making the world safer. Following this international guidance, many countries have sought to strengthen their laws and regulations. The *Post-disaster recovery* is an essential part of the disaster risk reduction. Most of the countries nowadays have already started doing intensive work in this field. The Federal Emergency Management Agency (FEMA), for example, released the National Disaster Recovery Framework (NDRF) in September 2011. This guide wants to promote effective recovery, particularly for those incidents that are large-scale or catastrophic. The NDRF provides the overarching inter-agency coordination structure for the recovery phase of "Stafford Act incidents", and elements of the framework may also be used for significant "non-Stafford Act incidents".[1] It also defines core recovery principles, roles and responsibilities of recovery coordinators and other stakeholders, a coordinating structure that facili-

[1]The Stafford Act is a United States federal law designed to encourage state and local governments to develop comprehensive disaster preparedness plans, prepare for better intergovernmental

tates communication and collaboration among all stakeholders, guidance for pre- and post-disaster recovery planning, and the overall process by which communities can capitalize on opportunities to rebuild stronger, smarter, and safer (FEMA 2011).

13.4 Land Use Intervention Planning

Applying and enforcing risk *compliant building regulations* and *land use planning* are effective tools to mitigate the damage after an earthquake or other kind of natural hazards. This land use planning can be applied in several ways as (i) *an upgrade of informal settlements* or (ii) the *identification of safe lands* for incoming citizens. However, these two approaches for reducing disaster risk are not easy to implement. Upgrading informal settlements is politically controversial and has become the norm in some cities. Instead the identification of safe lands of incoming citizens is not an easy task, because no one can ensure that people will buy there and even worse, the government can't guarantee that low-income households can afford safe sites. It is important for the city government to integrate hazard risk information into their urban planning processes. A wider understanding of disaster risk is needed to develop urban plans and land-use management. Likewise, good inter-sectorial coordination as well as detailed local data on hazards and its reduction are required. Safer infrastructures are definitely achieved when standards are in place through building codes and regulations. They are a valuable way to mitigate disaster vulnerability and risk from extreme natural hazards. The responsibility of its application belongs to the local authorities. Different aspects have to be taken into account to develop efficient land-use intervention planning:

- The municipal regulations and laws shall include codes for design, location and construction that minimizes the disaster risk. These codes shall also enforce the investigation of building capacity to make them more resilient and increase public awareness. The regulations should be different for each type of construction.
- The disaster risk reduction should be incorporated into the urban land-use plan and regulations, underpinned on the city risk assessment, also including the peripheral land around the city.
- These plans have to prevent and control the development of the risk and mitigate it. The plans include restrictions on building type, use, density and occupancy in high risk areas. In vulnerable buildings already built, the plan should implement other ways to reduce risk.
- Identify escape routes and routes for the delivery of relief supplies. Provide the city with evacuation shelters, critical infrastructure, emergency services and lifelines.

coordination in the face of a disaster, encourage the use of insurance coverage, and provide federal assistance programs for losses due to a disaster.

Fig. 13.4 Mudslide after Santa Teclas earthquakes in 2001

- Take into account the populations needs and difficulties of swiftly changing existing building practices. Relocate informal settlements to safer locations when possible.
- Promote the design of more resilient, safer ways of constructions and strengthening of non-engineered buildings.
- Share and show the safer construction techniques to the public with campaigns to aware the population.

An example of how useful these building regulations are can be shown in the construction details. To provide a building of more resilient elements would increase its cost from 1 % to 5 %. But in non-structural elements, the cost saving is huge. For instance the cost of replacing a damaged electric generator could be up to 50,000 dollars, but if a seismic isolator device is installed (that its cost is about 250 dollars) the damaged situation can be avoided. Another example is the measures that were taken in Santa Tecla (Fig. 13.4), in the city of San Salvador (capital of El Salvador), after the two earthquakes stroke in 2001. Two tremors in 5 s caused more than 700 deaths, displaced 20 % of the city and damaged 38 % of the infrastructure. The mayor of the city announced a 10-year plan in order to make the city more resilient when disaster strikes. This plan involved the citizens. The government created citizen groups to encourage their participation, to have periodic discussions and to help make decisions.

13.5 Public Policy

Policies can be categorized according to the structural type as follow:

1. *built environment*
2. *infrastructures*
3. *communities*

By strengthening the resilience of its built environment, a community is better able to maintain vital functions during an emergency and to recover efficiently so that "normal life" can resume within a reasonable time after the hazard has passed. According to FEMA, the main local policies related to the mitigation of disasters are

- *Building codes*, adopted by the States, which local governments are required to adopt and also to build up. These codes are applicable to the design and construction of buildings in order to withstand natural hazards such as winds, floods and earthquakes. They are effective in all structures that have been erected after 1999 with the new building code.
- *Zoning laws and ordinances*. Regulate development by dividing the communities into zones and by setting development standards for each zone. Restrictive zoning can keep inappropriate development out of areas prone to natural hazards. It has been proved in 8 out of the 12 counties of the United States which have applied space ordinances that these regulations are totally favorable to the disaster mitigation process.

FEMA has also planned future local policies:

- *Land-use planning*, prevents the development in hazardous areas or if it is necessary to build anyway, it allows the development in a manner that minimizes hazard risks. With this planning, local governments can identify areas subject to hazards and work on it.
- *Subdivision regulations*, sets construction and location criteria for subdivision layout and infrastructure.
- *Capital improvements planning*, identifies where the biggest public outgoes will be made over the next 5–10 years. It is really useful for planning because it can identify utilities that have to be strengthened, replaced or realigned.

13.6 Role of Policy Makers

There is an ascending acknowledgment among policymakers at all levels that disaster risk reduction, climate alteration, and sustainable development are connected. These issues show commonly subordinate difficulties, which require joint effort, incorporated systems, solid, comprehensive administration structures, sound urban arranging practices, and creative technological and financial arrangements. Since

economic development and risk aggregation take after the same way, as urban cities populations and economies expand, regional governments will assume an undeniably critical part in standing up to the difficulties emerging from more incessant, contained compelling occasions, which can negatively affect the social, ecological, and economic infrastructure and organizations on which lives and jobs depend. Generally, local pioneers must have the political will to enhance disaster resilience. Especially where considerable changes to the norm are vital, political will has demonstrated essential as far as presenting new and dynamic risk reduction policies. In the meantime, on the grounds that a high turnover in leadership is frequently the chief obstruction to supporting urban risk reduction programs, local policymakers must advance a society of strength from the base up. This begins with an eagerness to draw in communities, grassroots associations, organizations, and different accomplices, as well as taking an interest in information imparting stages and exchanges to other local policymakers. Local leaders should likewise enable a city's specialized and expert staff to build civic capacity and guarantee the congruity and attainment of risk reduction activities. Local policy makers have the ability to significantly impact nationals' choices and responsibility. This can prompt a more productive, fair, and composed way to deal with risk management, which can at the same time support other urban plans, including social and economic advancement, safety and security, resource management, and natural assurance. For example, enhancing citywide storm and surface drainage systems to adapt to extreme precipitation can give chances for reusing the water, parks, or community services. Similarly, building stock and other infrastructure that are intended to withstand high winds or seismic movement can improve vitality proficiency and tap into green development opportunities (UNISDR 2013).

13.7 Policy Actors

In this section the primary policy actors are identified and the parts they play in building effective legislative framework. In some cases these groupings frame a plainly defined lobby, in different cases they are a loose coalition of interest. The TEARFUND (Christian action with the world's poor) in their report about the legislation mainstreaming disaster risk reduction (Pelling and Holloway 2006) distinguished six possible actors for risk reduction legislation. They are classified in the following paragraphs.

13.7.1 Policy Insiders and Outsiders

Policy coalitions work best when they assemble (a) *policy insiders* who have the ear of policy-makers, and might incorporate abnormal state legislators, yet who may not have specialized knowledge; and (b) *policy outsiders* who have technical mastery but are not routinely counseled in the policy making process. Insiders can

be considered as policy-navigators, and thus who might be liable to be excited or hesitant to backing change. Such mindfulness is extremely helpful when lobbying for change.

It is critical that DRR has a comprehensible policy character that separates itself from prior disaster management work directed towards response and relief. Policy discussions are also significantly helped by an evidence base to show the benefits to be gained in social and economic improvement and in environmental protection by adding a DRR approach to deal with existing disaster management. DRR acknowledges the need for disaster response, however it will at least improve the increasing size of vulnerability and loss in society. The responsibility of external facilitators can be essential in both elucidating the connections between DRR and other segments, and obligations in other national settings, and by representing the social, economic and environmental gains of a DRR approach when home data is small.

13.7.2 Civil Society Policy

Coalitions can be significant and incorporate grassroots actors that are capable of activating local resources and prevalent opinion to advocate for change as well as line ministries. Civil society actors are important because they can provide a vehicle for bringing bits of knowledge from the grassroots, a component for the representation of popular views, and the potential for legitimacy and oversight.

13.7.3 Policy Champions Processes of Reform

Policy supports processes of reform can be simplified when the leadership is provided by policy champions with high-level administrative office. For instance, the Madagascar program for DRR has a top-level political support (the President is involved in the design of hurricane-resistant buildings). Its programme has also developed training programs for district-level officials. The champions must be respected by several policy actors, to be effective in the multi-sectoral environment of risk reduction legislation and policy-making. Reliability in leadership is a great asset in building trust and technical competency. For instance, the India DRR legislation was supported by Shri Shivraj Patil, Minister for Home Affairs, who took the initiative of piloting the legislation and succeeded in guiding the drafting of the law, introducing the bill and controlling it through both houses of Parliament.

13.7.4 Sub-national Government

In some cases, the national framework need to be enacted through regional, local or metropolitan governments. For instance, the Ghana disaster management plan

is managed through a National Disaster Management Organization situated in the Ministry of the Interior and upheld by 10 local, 140 regional and 900 zonal (town and metropolitan) workplaces and contact points. In some cases, the laws on risk reduction may cause a variation in the relationship between national and sub-national governments. For instance India has encountered such vulnerability with the state government assuming a central role in disaster mitigation and reconstruction, however, the national government has managed the discussion on risk reduction inserting it in the plan and financial programs.

13.7.5 Scientific and Technical Bodies

Practical skills are required as soon as a decision has been made to explore the chances that need to be done in the legislation. For example, in Iran, experimental and technical interests has lead and push for the development of the national disaster risk reduction plan that has been endorsed by the Council of Ministers in 2003.

13.7.6 International Actors

There are many examples of countries learning from each other. International actors such as the ISDR and UNDP-BCPR have been active in organizing meetings between people interested in developing national legislation programs and experts from other countries where the legislation has been drawn up.

13.8 International Schemes for Disaster Risk Management

This paragraph reviews the literature regarding the United Nations International Strategy for Disaster Reduction (UNISDR), such as the Hyogo Framework for Action (HFA), and how community institutions (are recommended to) engage in disaster risk reduction (DRR) practices. The United Nations International Strategy for Disaster Reduction (UNISDR) is a global strategy to engage a wide range of actors in a coordinated effort to reduce the risks of disasters and to build "a culture of prevention" in society as part of sustainable development" (UNISDR 2011a). The UNISDR designs and uses cooperative mechanisms (most recently, the biennial Global Platform for Disaster Risk Reduction), through which governments, intergovernmental organizations, international financial institutions, technical institutions and networks, nongovernmental organizations, and civil society organizations interact, share information, and collaborate on risk reduction initiatives. Primarily, UNISDR coordinates the partnerships and leads a global DRR movement focused on meeting the objectives of the Hyogo Framework of Action (UNISDR 2011b).

The United Nations International Strategy for Disaster Reduction (UNISDR) has done a significant work in the field of disaster risk reduction. It is worth to mention the world Conference on Disaster Risk Reduction which is a series of United Nations conferences focusing on disaster and climate risk management in the context of sustainable development. The World Conference has been convened three times, with each edition to date having been hosted by Japan: in Yokohama in 1994, in Kobe in 2005 and in Sendai in 2015. As requested by the UN General Assembly, the United Nations Office for Disaster Risk Reduction (UNISDR) served as the coordinating body for the Second and Third UN World Conference on Disaster Reduction in 2005 and 2015.

13.8.1 Yokohama Strategy for a Safer World (1994)

The United Nations General Assembly, based on the growing concern and recognition of the devastating outcomes of natural disasters, announced 1990–1999 as the International Decade for Natural Disaster Reduction. The First World Conference on Natural Disasters in Yokohama was a significant event that took place during this period. The main result of the mid-term review of the decade was the Yokohama Strategy for a Safer World and its Plan of Action. The strategy lists ten principles on preparedness, prevention and mitigation of natural disasters (UNISDR 1994):

1. Risk assessment is a required step for the adoption of adequate and successful disaster reduction policies and measures;
2. Disaster prevention and preparedness are of primary importance in reducing the need for disaster relief;
3. Disaster prevention and preparedness should be considered integral aspects of development policy and planning at national, regional, bilateral, multilateral and international levels;
4. The development and strengthening of capacities to prevent, reduce and mitigate disasters is a top priority area to be addressed during the Decade so as to provide a strong basis for follow-up activities to the Decade;
5. Early warnings of impending disasters and their effective dissemination using telecommunications, including broadcast services, are key factors to successful disaster prevention and preparedness;
6. Preventive measures are most effective when they involve participation at all levels, from the local community through the national government to the regional and international level;
7. Vulnerability can be reduced by the application of proper design and patterns of development focused on target groups, by appropriate education and training of the whole community;
8. The international community accepts the need to share the necessary technology to prevent, reduce and mitigate disaster; this should be made freely available and in a timely manner as an integral part of technical cooperation;

9. Environmental protection as a component of sustainable development consistent with poverty alleviation is imperative in the prevention and mitigation of natural disasters;
10. Each country bears the primary responsibility for protecting its people, infrastructure, and other national assets from the impact of natural disasters. The international community should demonstrate strong political determination required to mobilize adequate and make efficient use of existing resources, including financial, scientific and technological means, in the field of natural disaster reduction, bearing in mind the needs of the developing countries, particularly the least developed countries.

This strategy served as international model in disaster reduction. Communities were aware that natural disasters posed a big threat to human life and economic losses and concluded that the solution to this problem was mainly disaster prevention. The objective of the next World Conference would have been the complete review of the Yokohama Strategy with the intention of providing an updated guide and framework on disaster reduction. Following the idea of working on disaster prevention, the conference aimed at increasing the global awareness and importance of building disaster reduction policies, with a focus on developing countries where disasters have a greater impact.

13.8.2 Hyogo Framework for Action (HFA) (2005)

The Second World Conference on Natural Disasters concluded introducing the *Hyogo Framework for Action (HFA)* to the participating members as a common strategy to work on disaster risk reduction.

Adopted in 2005, the HFA was developed to substantially reduce the losses to social, economic, and environmental assets of communities and countries from disasters (UNISDR 2009). The HFA is the international blueprint for DRR and has been adopted by 162 UN member states. Its overarching goal is to build the resilience of nations and communities to disasters, [and] achieving substantive reduction of disaster losses by 2015 (Nkala and Helena Graziosi 2010).

The HFA outlines five priorities to be addressed and acted upon in order for vulnerable communities to build and maintain resilience.

1. Ensure that DRR is a national and a local priority with a strong institutional basis for implementation;
2. Identify, assess, and monitor disaster risks and enhance early warning;
3. Use knowledge, innovation, and education to build a culture of safety and resilience at all levels;
4. Reduce the underlying risk factors;
5. Strengthen disaster preparedness for effective response at all levels.

Hyogo framework is the framework used to determine adequate Disaster Risk Reduction (DRR). It is the structure of resilience and preparedness created by the United Nations International Strategy for Disaster Reduction (UNISDR). Twigg (2007) simplified the HFA into five thematic areas, they are: *governance, knowledge and education, risk management and vulnerability reduction, risk assessment, disaster preparedness and response*. According to the study, the sub-themes of the themes are more or less the characteristics of resilient communities.

Governments applying HFA had to submit their reports during four different periods of 2 years each. In these reports, each priority is met with a different set of core indicators that are evaluated with a score from 1 to 5, 1 being the least progress achieved and 5 being the highest. In order to fill these reports and give a score, countries need to answer specific questions for each indicator in an effort to give as much information as possible for every step they took towards disaster reduction.

After the application of the HFA, some DRR specialists and activists have communicated doubts and dissatisfaction with the administrative course, contending that the numerous new laws and policies that have been produced to deliver DRR appear not to have had the effect they guaranteed, referring to, specifically, crevices and gaps in execution at the community level (UNDP 2014a). The International Federation of Red Cross and Red Crescent Societies (IFRC) and the United Nations Development Program (UNDP) in their report (UNDP_&_IFRC 2015) claim that since the endorsement of the framework, and succeeding the staggering impacts of recent immense scale catastrophes, many nations have looked to amend and enhance their legal systems for disaster risk reduction (DRR), particularly by embracing new laws for disaster risk management. Throughout this process, several governments have been asking: "What works? In what capacity would we be able to gain from different nations experiencing the same process?" in the meantime, various reports relating to HFA execution have demonstrated moderate advancement in decreasing disaster risk at the community level, and an absence of clear data and examination on the role of legislation. To label this gap, in 2012, the International Federation of Red Cross and Red Crescent Societies (IFRC) and the United Nations Development Program (UNDP) left in a joint activity went for supporting the fortifying of domestic legislation for disaster risk reduction (DRR). The program conceived the development of two items:

- A multi-nation report on the DRR-related legislation of 31 nations, and
- A ten-point Checklist on Law and Disaster Risk Reduction.

A blend report of the largest comparative study of enactment for disaster risk reduction embraced to date, titled A report titled "Effective law and regulation for disaster risk reduction: a multi-country report" (UNDP_&_IFRC 2014), was released on June 2014, which include the largest comparative study of enactment for disaster risk reduction. The findings of the synthesis report and case studies, together with the opinions and practical knowledge of stakeholders accumulated through ten consultations held around the globe, were then used to be added to the Checklist on Law and Disaster Risk Reduction (UNDP 2015).

13.8.3 Sendai Framework (2015)

The Hyogo Framework for Action has given the basic directions to minimize the disaster risk and has made some steps towards the accomplishment of the Millennium Development Goals. Its execution has, nonetheless, highlighted various gaps in addressing the basic disaster risk variables, in the creation of objectives and priorities for action, in the need to encourage disaster resilience at all levels and in guaranteeing a satisfactory method for implementation. The gaps demonstrate a need to grow an action-oriented system that Governments and important partners and stakeholders can implement in a strong and correlative way, and which recognizes disaster risks to be overseen and directs investments to enhance resilience (UNISDR 2015).

This has prompted the Third United Nations World Conference on Disaster Risk Reduction that took place in Sendai, Miyagi, Japan in March 14–18th, 2015, attracting more than 6,000 representatives to the conference itself and 50,000 individuals to the related Public Forum. The Sendai Framework for Disaster Risk Reduction 2015–2030 (SFDRR) is a 15-year non-binding agreements which perceives that the State has the essential part to decrease disaster risk, yet this obligation ought to be imparted to different partners and stakeholders including local government and the private sector. It is the first global policy framework and represents a step in the direction of global policy coherence with explicit reference to health, development, and climate change. To develop SFDRR, the United Nations Office for Disaster Risk Reduction (UNISDR) organized and facilitated several global, regional, national, and intergovernmental negotiations and technical meetings in the period preceding the World Conference on Disaster Risk Reduction (WCDRR) 2015 where SFDRR was adopted. UNISDR also worked with representatives of governments, UN agencies, and scientists to develop targets and indicators for SFDRR and proposed them to member states for negotiation and adoption as measures of progress and achievement in protecting lives and livelihoods.

The Sendai Framework for Disaster Risk Reduction 2015–2030 aims to protect lives, health, livelihoods, ecosystems, cultural heritage, and critical infrastructure from natural and human-caused hazards over the next 15 years. It seeks to bring about "the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries" (UNISDR 2015). The Sendai Framework outlines seven global targets:

- a substantial reduction in global disaster mortality;
- a substantial reduction in numbers of affected people;
- a reduction in economic losses in relation to global GDP;
- a substantial reduction in disaster damage to critical infrastructure and disruption of basic services, including health and education facilities;
- an increase in the number of countries with national and local disaster risk reduction strategies by 2020;

- enhanced international cooperation for developing countries; and
- increased access to multi-hazard early warning systems and disaster risk information and assessments.

Implementation of the Sendai Framework for Disaster Risk Reduction requires strong commitment and political leadership both at national and local levels. This is essential to ensure stronger risk governance and capable institutions that can take the lead and mobilize and motivate stakeholders. A key outcome of the 15-year strategy must be the development of communities that are not only risk informed but are also knowledgeable about risk, and therefore understand how to eliminate or mitigate underlying drivers of risk and how to build back better after a disaster.

13.8.4 Decision Making

The hierarchy of the causal factors of disasters is unique to each community. Hazards that occur in different geological locations with different cultural traditions, standards of living, and social expectations makes "best practices" or universal rules obsolete and makes DRR fundamentally contingent. It is in the communities best interest to design their own DRR structure based on their particular causal factors, their culture, and their way of life. It is important that different livelihood strategies are taken into account because understanding or at least recognizing ways that different types of communities live will help us understand how other types of communities and cultures cope with hazards (Wisner et al. 2006). Similarly, the way different communities view and analyze risks as well as what causes a disaster and their impacts can affect the modes and types of decision-making drastically.

Petal (2007) explains that origins of disasters can be assessed at three overlapping levels of social organization: (1) the *micro level*, or individuals and households, (2) the *meso-level*, which comprises schools, businesses, local governments, faith-organizations, etc., and (3) the *macro-level*, consisting of regional, national, and international policy making entities. Petal (2007) also explains that there are three primary actions considered when conducting DRR. These are risk assessment and planning, physical protection, and response capacity development. It is crucial to think of the different levels of social organization and the different actions taken in order to effectively create and enforce DRR. Understanding these fundamental characteristics of community institutions will help shape an understanding of their level of engagement and capacity in DRR. The following are examples of how the fundamental characteristics of *meso community* institutions can shape their types of engagement in DRR (across risk assessment and planning, physical protection, and response capacity and development).

1. Government can implement legislation and policies dictating how far to build off of the shore of a hurricane swept beach;
2. Schools can educate students about how they can protect themselves at school and at home;

3. The private sector can advocate for DRR and therefore strengthen the resilience of their businesses; Healthcare facilities can be prepared for a high magnitude event, both in the availability of their services as well as in the accommodations they provide;
4. Grassroots organizations can reach out to those who are unable to increase their coping capacity and provide them a safer location to live, a safer building in which to live, and mandate certain maintenance take place in order for the tenant to remain safe.

There are many options that community institutions can take, at various levels, in order to implement the idea of reducing risk. By understanding the causal factors of disasters, a general level of risk can be assessed, which can inform community institution's decision-making and actions.

13.9 Case Study of Hurricane Sandy

Several initiatives can be implemented to increase the community resilience of a region affected by an extremely disruptive event in order to make it able to withstand and recover from similar events in the future. A precise set of initiatives cannot be put in place prior to an event, nor can they be selected to encompass every region and type of event. For each specific scenario, it is necessary to evaluate what the best strategy is to adopt. This means that decision-makers need to be guided in choosing one or more of the initiatives to implement, and this selection can be made based on certain criteria: the type of event and the risks that an area may face, the goals to reach in order to obtain resiliency, the funding made available to reach those goals or to recover from that specific event. These are just some of the parameters to consider when making a decision. The extent of damage and economic loss in communities and specific infrastructures can also support this choice and lead to the prioritization of initiatives to adopt. By categorizing initiatives based on this and other criteria, it is possible to provide a tool to better plan an intervention strategy in order to increase preparedness before, during, and after an event. The application of these initiatives has a broad impact on entire communities and individual infrastructures in terms of increasing of their ability to withstand the threats posed by climate change. In the end, the goal is always to mitigate the effects of natural and man-made disasters on communities, giving them the instruments to bounce back to their state prior to the event, or to an even better situation, and improving their ability to withstand future similar events. This paragraph describes the initiatives proposed by the New York City government to increase the resilience of the infrastructure sectors hit by Hurricane Sandy, organized according to the type of infrastructure and the intervention strategy they have in common. Among the more than 200 initiatives reported, this analysis focuses only on those proposed for utilities, liquid fuel, and transportation infrastructures. Finally, to better understand the features of these several possible initiatives, and thus the best one for each specific situation, they are further organized according to the selection criteria described above.

13.9.1 Initiatives Proposed in New York City

After Hurricane Sandy, the New York City government understood the need for a long-term plan to increase resiliency in the city's several infrastructures. In the aftermath of the first recovery phase, when all attention was focused on repairing the damage caused by the storm, it was clear that there was a need to intervene in order to solve several problems presented before, during, and after the event, which caused delays in restoring the area to its previous situation and made the impact worse than expected. The efforts put in place to prevent the worst were not enough and something needed to be done to prevent this situation from happening again. The extent of damage suffered was unexpected and the recovery phase took longer than predicted, despite some resiliency efforts that had made the region more prepared and protected. In December 2012, the New York City government launched the Special Initiative for Rebuilding and Resiliency (SIRR), a program specifically for resilience that addressed the consequences of the hurricane itself and the risks posed by similar future events. The SIRR produced a plan of strategies to adopt in order to strengthen the protection of New Yorks infrastructures, buildings, and communities from the impacts of future climate risks, published in the report *PlaNYC: A Stronger, More Resilient New York*. The plan outlines more than 200 initiatives for several infrastructure sectors that should be implemented to increase the preparedness, strength, and resilience of New York City against future events. These initiatives make New York a reference model of a resilient city able to address climate change and are an example of what decision-makers can do to have a more reliable and resilient infrastructure. The focus now is on the initiatives proposed to increase resiliency in utilities, liquid fuel, and transportation systems, since several analyses of Hurricane Sandy itself and other natural and man-made events showed that intervention in these sectors must be focused on better planning and recovering from these events. The reason of this is due to the fact that these sectors are key in the overall infrastructure network, therefore intervening in them would have a wide effect on the other sectors that rely on them. Initiatives in other sectors are also equally important, but their effect are mostly limited to the sector in which they are organized, as they are not crucial to the network. After explaining the initiatives focused on in this chapter and describing some examples of their effects on their sector and others, the reason for their emphasis will be more evident. A brief analysis of these initiatives is provided to answer the following questions:

- Why is the initiative needed?
- What will be/has been done to solve this problem?
- What is goal needs to be achieved?
- What are the consequences/effects/benefits of the application of the strategy on increasing the resiliency of a sector and other sectors that rely on it?

A complete analysis of the each initiatives features, in terms of reason, description, goal, and benefits, is summarized in a table at the end of the chapter. This table summarizes and explains more in depth the features of each initiative, following the same structure used to briefly describe them within the chapter.

13.9.2 Initiatives for Utilities

The utilities sector includes power, natural gas and steam systems, which are the critical energy infrastructures that provide electricity, heat, hot water, and other services to several facilities. These systems are highly interconnected, making each one of them more vulnerable to disruptive events that occur to one or more of them. The initiatives for increasing resiliency in utilities are organized into the following strategies:

- Redesign the regulatory framework to support resiliency
- Harden existing infrastructure to withstand climate events
- Reconfigure utility networks to be redundant and resilient
- Reduce energy demand
- Diversify customer options in case of utility outage

Each strategy focuses on different aspects of the utilities sector, from the regulatory framework to the physical single infrastructures and overall network, and aims to achieve one or more goals. Overall, these strategies are designed to increase the resiliency of the utilities systems by upgrading their features and assets, reducing their possibility of being disrupted and the time it takes to restore them when these disruptions occur.

13.9.2.1 Strategy: Redesign the Regulatory Framework to Support Resiliency

The initiatives to accomplish this first strategy are thought to reduce the lack of laws and rules that characterize the energy systems. This will make utilities systems more resilient by assisting utilities and regulators in carrying out several projects. For this reason, the initiatives that utility companies and regulators should work together for are:

- Develop a cost-effective upgrade plan of utilities systems
- Consider climate risks in system design and equipment standards
- Define a set of performance metrics for climate risk response
- Develop a cost-effective upgrade plan of utilities systems

Utilities generally are not required by regulators to account for the possibility of losing entire facilities due to severe weather events, yet they can guarantee energy supply during minor weather events or when a single part of the facility fails. This means that utility systems are not designed to address events like Sandy with low-probability and high-impact consequences. In order to solve this issue, some actions have already been taken by the Office of Long-Term Planning and Sustainability (OLTPS), such as the development of a probability risk assessment model to efficiently plan the use of budgets or the quantification of possible customer outages and economic losses. Other actions planned are the development of costs, benefits,

and risks analysis tools by utilities and the upgrade of their systems to withstand risks related to future high-impact events by giving them a reasonable motivation to recover those investments with an improvement of the ratemaking process. This initiative aims to better prepare utilities to address high-impact climate risks, by forcing them to take into account storm probabilities and future surge heights and by providing them with a tool on which they can base storm hardening investment decisions. This upgrade makes them more resilient in the future, in addition to it being affordable and sustainable.

- Consider climate risks in system design and equipment standards

The second initiative addresses the fact that utility systems are not able to remain operational during extreme weather events and recover quickly when parts of the system fail. If on one hand the systems are considered reliable through adequate system planning approaches and design standards, on the other hand these approaches and standards do not guarantee resiliency needed to withstand climate risks. For this reason, the impact of climate change has to be considered when evaluating system planning decisions, e.g. taking into account temperature and humidity forecasts, the possibility of extended exposure to flooding and saltwater, and stronger and more sustained winds when planning for the strengthening and update of power systems and equipment design standards. Voltage reduction is another solution that can be put in place to address the impact of heat waves and other events that cause a high-peak system demand. In this way, the goal of optimizing reliable systems resiliency and obtaining adequate power supply for climate change can be achieved.

- Define a set of performance metrics for climate risk response

The third initiative highlights the need for establishing performance metrics, since they are often not considered when evaluating utility performance in the different stages of the events impact. To accomplish this, updated resiliency metrics and realistic performance standards need to be developed, and utilities need to publish annual progress reports to show their preparedness and investments for climate risks. This strategy aims to increase resiliency and reduce vulnerability through increasing preparedness and the ability to plan and manage emergencies and through upgrading system asset characteristics to improve their reliability. It provides several benefits for the utilities sector and for all the others that are directly dependent on it. If an upgrade plan is determined, utility systems will be strengthened and their possibility of failure will be reduced, decreasing, at the same time, the possibility of cascading effects on dependent systems. Based on performance metrics, utility companies will be more capable of identifying the priorities in terms of what damaged areas need to be repaired first. They will also be able to deal with critical situations that limit the availability of resources better. Moreover, buildings, health care and other facilities would have a lower chance of power outages from line overloads because of upgraded systems, while

transportation, fuel, and telecommunication sectors would be more resilient and able to withstand future events if systems and equipment design standards are updated. These are just some examples of the benefits.

13.9.2.2 Strategy: Harden Existing Infrastructures to Withstand Climate Events

Sandy and other past disruptive events showed that existing power infrastructures are vulnerable to severe damage and that the interruption of power supply is caused mainly by the failure of key nodes in the energy supply systems, like power generators, transmission and distribution infrastructures. There is therefore the need to identify and harden vulnerable high-priority nodes of the power infrastructure against climate risks. The hardening strategy regards different utilities, from electric to gas to steam in the case of New York, and involves several agencies to work to:

- Harden key power generators against flooding
- Harden key electric transmission and distribution infrastructure against flooding
- Harden vulnerable overhead lines against winds
- Harden natural gas system against flooding
- Harden steam plants against flooding
- Harden key power generators against flooding

The first initiative focuses on the most important assets of the electric infrastructure, which are the power generators. More than half of NYC generators are currently at high risk of flooding and almost all of them will be in 2050. Moreover, the owners of these power plants are not obliged to protect them with flood-protection measures, since no regulations exist. Plant owners, utilities, and regulators have to work together to prioritize, plan, and budget for the hardening of key in-city assets. Through a cost-benefit analysis, some existing plants will be upgraded to withstand at least a 100-year flood, while new ones will be built with a 500-year flood protection, through different measures and timeframes for completion that need to be determined. The aim of this initiative is to put in place all the measures needed to allow plants to remain operational during, or recover quickly from, a 500-year flood event.

- Harden key electric transmission and distribution infrastructure against flooding

The second initiative focuses on the hardening of other key infrastructures of the power system, such as transmission and distribution substations, utility tunnels, and underground equipment, which are all at risk of flooding as they are located in the flood maps: 37 % of transmission substations are currently in the 100-year floodplain and 63 % will probably be by 2050. Starting with those considered priority due to their role in network reliability, the customers they serve, and the impact their failure would have on the economy, several site-specific measures can be adopted to harden these systems against flooding. The elevation above flood level of certain assets and the replacement of tunnels underground equipment with

waterproof ones are just a few of them. Together with other ideas, the protection of transmission and distribution infrastructures from future flood events can be guaranteed.

- Harden vulnerable overhead lines against winds

The third initiative deals with the hazard of high-speed winds that, like in the case of Sandy, can down trees over overhead line equipment, like electric poles, transformers, and cables. To address this problem, utilities are requested to perform ordinary and extra tree maintenance when hazardous events are forecasted, strengthen their overhead lines, and eventually consider the possibility of rerouting some of them underground. Since this option is expensive and not practical, a cost-benefit analysis is needed to evaluate its applicability. The goal of increasing the protection of overhead lines from these threats can be achieved including wind risks in the overall regulatory framework that governs system reliability.

- Harden natural gas system against flooding

The fourth initiative instead focuses on the actions needed to ensure higher protection of the natural gas systems and so that utilities can better control and monitor them. Sandy showed that the gas system was affected by the failure of remote operation of parts of it and by localized outages to the distribution system caused by the infiltration of water. The idea is to harden all city-gates, interface regulator stations, and control equipment against flooding through, for example, replacing inefficient equipment that is at risk of corrosion, fixing leaks and cracks, and installing devices to prevent water from infiltrating into the gas.

- Harden steam plants against flooding

Finally, the fifth initiative stresses the need to increase resiliency in the steam system. After electricity and gas, steam is the third power source in the city in terms of the number of customers served. Most steam plants are located in the current floodplain, and are thus vulnerable to future flooding. Several flood-protection measures can be adopted to achieve the resiliency goal. Among these, some are the same of those proposed for other systems, like the elevation of equipment; others are specifically designed for the steam system, like the installation of floodwalls and of flood-protected, natural gas-fired back-up generators. Overall, the hardening strategy puts together initiatives to increase the protection of existing infrastructure assets. These hardening initiatives mainly address flooding, which is one of the main features of coastline hurricanes due to their ability to move high volumes of water inland via high speed winds, and can be worse than expected due to their superposition with high tide during the full moon. Flooding, together with wind, is the main cause of most damage to utility systems reported after similar events. These systems are vulnerable to such kind of hazard because they are often located in the most recent floodplain maps. Several physical measures can be adopted to physically harden these systems. Among these, the most common and feasible one is elevating key nodes of the power system chain, such as power stations and substations, above flood level. Due to the extent of the number of

systems in need of hardening, attention is focused on high-priority infrastructures that are fundamental to keep the most critical infrastructures operating, like health care and other emergencies facilities. Hardening initiatives are, essentially, mostly physical measures to implement on the existing utility network of systems, which is vulnerable to several consequences of an extreme event, like a hurricane, which are mostly flooding and wind. Due to their nature, these initiatives can be implemented in a short time with short-term planning, but with term effects. A choice cannot be made among the initiatives for power utility, since they regard different assets of the same utility that are in need of the same protection. The impact of these hardening initiatives is broad and leads to improvements in the resiliency of other infrastructures that are not utilities. Despite the fact that they are proposed specifically based on the number of damage caused to utilities by Sandy, they can be considered in various geographical contexts and can reduce the consequences of several other events, like heavy rainfall. The hardening of these systems allows utilities to have better control of them during the recovery phase following an event and to better manage repair crews that can be then deployed to repair the most critical damage, like the one of local systems in buildings, rather than the one in power plants. Some economical and feasibility evaluations are needed to harden overhead lines, which are the most damaged by strong winds that tear down trees. Burying power lines is expensive and makes them prone to flooding, therefore frequent tree maintenance and overhead line strengthening is preferred rather than the rerouting of overhead lines underground. Gas and steam systems showed to withstand the impact of the hurricane; however, this does not mean that they do not need hardening against flooding. Since their key assets are located in the current floodplain, their lines need to be protected from water infiltration, which causes localized outages to the distribution system. There are several benefits of applying this strategy both on the utilities sector and others. Despite reducing the possibility of power outages from downed trees or flooding of critical assets, utility infrastructures would have less damage because of their ability to better withstand these extreme events and their consequences, like flooding. Moreover, utility repair crews would be able to focus only on those critical situations where damage occurred despite the protection put in place. By reducing the number of criticalities to repair, it would also be possible to reduce recovery time and repair costs and guarantee the availability of utility infrastructures during the recovery phase. In addition to these benefits to the utility sector, several others regard other sectors. Through protection measures against flooding and wind, transportation equipment, like traffic lights, switches, and other facilities, would also work if the area was flooded and physical transportation infrastructures, such as roads and railways, would not be interrupted by downed overhead lines. Buildings and healthcare facilities would not be affected by power outages and would not need backup generators to keep functioning, and therefore these structures would not need to be evacuated like the case during Sandy.

13.9.2.3 Strategy: Reconfigure Utility Networks to Be Redundant and Resilient

After hardening, reconfiguration of utilities with the aim of redundancy and resiliency through these measures is essential to reduce the probability of failure of the utility systems and to ensure faster service restoration in the event of failures. To increase redundancy and resiliency of utility infrastructures, the initiatives that several regulated utilities and private companies working together have put in place include:

- Strengthen New York Citys power supply
- Require more in-city plants to be able to restart quickly in the event of blackout
- Develop a long-term resiliency plan for the electric distribution system
- Minimize electric outages in areas not directly affected by climate impacts
- Implement smart grid technologies
- Speed up service restoration for critical customers via system configuration
- Speed up service restoration via pre-connections for mobile substations
- Expand and diversify natural gas supply
- Strengthen the in-city gas transmission and distribution system
- Launch an energy infrastructure resiliency competition
- Strengthen New York Citys power supply

The first initiative considers the fact that the majority of power generation plants are old, at risk of flooding because they are located in the 100-year floodplain, and rely on natural gas and liquid fuel supplies to function. Their supplies themselves are susceptible to interruption caused by extreme events, consequently making power supply increasingly vulnerable to these events. The goal to achieve with this initiative is to diversify and improve the sources of the city's power supply by increasing the number of power lines linked to other external markets and the number of supply sources, considering, for example, low-carbon electricity generation and re powered, upgraded older and inefficient power plants.

- Require more in-city plants to be able to restart quickly in the event of a blackout

In addition, as highlighted by the second initiative, many New York City power generation plants, both oldest and newest, need external power sources to be restarted after extensive outages. In order to increase the ability to recover these assets more quickly, the so-called black-start capacity has to be implemented in existing plants, since this requirement was not established by regulations at the time they were built, and considered when building new plants, since this requirement has now been implemented by State regulators.

- Develop a long-term resiliency plan for the electric distribution system

On the other hand, with the third initiative, the focus is directly on increasing the resilience of the electric distribution system, rather than focusing on hardening, since utilities actually develop their long-term expansion plans without accounting for resiliency. Several actions can be put in place to make the electric distribution

system more able to withstand heavy blows from extreme weather, such as storm and heat waves. For example, new systems can be built inland to reduce the load on coastal ones and to avoid the geographical concentration of systems in vulnerable areas. New links and transmission corridors can be created to strengthen the connection to out-of-city electric supplies, as well.

- Minimize electric outages in areas not directly affected by climate impacts

Often customers are subjected to power disruptions not because they are directly damaged by flooding, but because of so-called sympathetic outages, which are preemptive shutdowns determined by utilities to prevent larger damage to parts of the network that have the probability of being flooded. Therefore, with the aim of solving this, the fourth initiative focuses on building new network boundaries and installing new equipment for controlling power line sections to address this effect, thus reducing the number of customers affected by an outage, especially in critical infrastructures like hospitals.

- Implement smart grid technologies

The implementation of new technologies would allow utilities to evaluate system conditions in real-time and dispatch crews and equipment to the highest priority problem locations better and quicker. This initiative is needed because utilities actually base the identification of location and extent of damage solely on information obtained through customer reports of power outages and on-site inspections by crews. Together with inaccessible roadways and other similar problems, this only way to identify damages can increase the time needed to collect information and thus delay the dispatch of repair crews. Low-cost sensor technologies, system integration, automated control, decision-aided tools, and smart meters are just some of the new technologies that utilities could implement to achieve that goal.

- Speed up service restoration for critical customers via system configuration

Damaged customer equipment has to be repaired or replaced before utilities can restore power service to individual customers. Critical customers, such as hospitals, are also subjected to this dependence on efficient equipment and can be just as impacted by it as less critical customers are. To avoid service interruption to critical customers and to restore their service quicker than other customers, the first initiative regarding service restoration defines several solutions for system configuration that can be adopted to isolate the critical customers from the rest of the network, e.g. installing switches and other equipment along feeders that supply them.

- Speed up service restoration via pre-connections for mobile substations

Another way to accomplish the same goals of avoiding service interruption is to provide customers with the necessary equipment to connect to mobile substation units. Often times, these units cannot be immediately used because of missing pre-connections in the system, even if they are critically important because they allow electrical distribution circuits to have partial functionality restored while utilities are

proceeding with the repair of damaged substations. To use mobile substations during this recovery time, the initiative suggests that necessary connections in the system have to be pre-installed, and ways to source them must be found. After a primary technical evaluation for the effectiveness of utilizing of these units as a strategy for high priority substations, the idea is to permanently implement them for individual customers or for neighboring regions, by sharing mobile units to reduce their cost.

- Expansion and diversification of natural gas supply

The two initiatives regarding natural gas supply focus on different things that have occurred in the past. The first initiative regards the five city-gate connections that are all needed during high-demand days to prevent disruptions. Despite the fact that the existing natural gas connections to New York City generally are able to provide the citys customers with gas, an increase of their capacity is needed. This can be obtained through the installation of additional city-gate capacities, linking the city to new natural gas pipelines, and the construction and completion of new pipelines, such the Spectra pipeline. This is an effective way to increase gas supply redundancy and avoid forced shutdowns.

- Strengthen of the in-city gas transmission and distribution system

On the other hand, the capacity of New Yorks natural gas system to move gas supply through transmission and distribution systems has to be strong enough to move the current and the extra gas supply provided by new sources. The second initiative addresses this limitation, due to which significant outages could be recorded during high demand days because the system is not able to supply an area through a different source if that areas city gate is down, meaning the systems lacks redundancy. In order to avoid this, natural gas outage risks have to be evaluated and the transmission systems have to be strengthened according specific plans.

- Launch of an energy infrastructure resiliency competition

The last initiative focuses on the need to find new cost-effective approaches to protect these utility systems in the future, despite floodwalls and equipment elevation, which are among the many resiliency solutions for the citys already available energy systems. To accomplish this need, the Resilience Technologies Competition, an energy infrastructure resiliency competition, was launched in the summer of 2013 to explore and compare new projects that use innovative technologies to increase building and infrastructure resiliencies. Some initiatives aim to diversify and improve the sources of the citys power supply in order to reduce the chance of power outages, since several sources can feed the same systems and it is highly improbable that multiple sources are unavailable at the same time. Other initiatives want to reduce restoration time in different ways otherwise utilities may not be able to restore electric service to individual customers until damaged customer equipment is repaired or replaced. For this purpose, new technologies can be used to reduce the number of interventions needed and to understand more quickly priority interventions where repair crews and equipment can be reasonably dispatched. Redundancy will also mean letting repair crews work at their own pace,

since the service is being provided anyway through other sources, and reducing the dependency of power plants on natural gas and liquid fuel supplies. The initiatives for gas supply will surely increase system redundancy and consequently increase the availability of gas, especially during high-demand peak days, by reducing forced shutdowns on these days caused by limited gas supply. Finally, the energy infrastructure resiliency competition can provide decision-makers with several new ideas to implement in order to increase building and infrastructure resiliencies.

13.9.2.4 Strategy: Reduce Energy Demand

One further strategy to consider when planning for increasing resilience, in order to address rising temperatures that will lead to higher peak energy demand, is to manage this high demand by reducing it, a more effective and economic approach than increasing the energy supply. The initiatives put forward for this strategy, which imply utilities, regulators, the government and private sector partners working together, are:

- Expand citywide demand response (DR) programs
- Increase the energy efficiency of buildings
- Expand citywide demand response (DR) programs

Demand response can be defined as "a wide range of actions which can be taken at the customer side of the electricity meter in response to particular conditions within the electricity system, such as peak period network congestion or high prices. DR programs include activities such offering time-based rates and other forms of financial incentives to reduce or shift customers electric usage. The first initiative is thus proposed because, despite a new demand response capacity of 500 MW being built in recent years to manage brief periods of peak electrical demand, this new capacity demonstrated not being enough for demand, and thus its increase is needed and can be obtained in different ways. A reduction of the price of DR generation to the price of traditional generation is a first incentive for DR participation to increase capacity. A further increase of the existing number of large customers that participate in DR can be obtained by improving the participation standards and increasing the importance and participation of private companies that manage DR capacity among many small users. This would also avoid costly system expansions that could be needed to manage peak demand periods.

- Expand the energy efficiency of buildings

On the other hand, the expansion of energy efficiency programs for buildings is another way to reduce both their energy demand and overall energy demand. If these programs are implemented, buildings themselves can withstand a power outage for a longer period of time, as they rely on a lower energy demand in order to function. Buildings owners would also save money and the chance of peak season outages, together with carbon emissions, would be reduced. These programs include several actions, such as the adoption of energy use benchmarking, audit

and retro-commissioning requirements, the upgrade of lighting, and the creation of centers to improve the knowledge of best practices for lighting and building system integration. These two initiatives thus highlight the need to focus on energy efficiency efforts to increase utilities' ability to recover from extreme events that lead to higher peak energy demand. For this purpose, they both focus on the development of expansion programs of the existing actions already taken for energy efficiency. If these initiatives are implemented, several effects and benefits can be obtained. More buildings could be supplied with energy and could all together maintain their functions at the same time during a reduction of power supply and their recovery can be faster since less power would be required to run them. The chance of outages during high peak demand due to overload would be reduced and, consequently, system reliability and stability would be increased. Critical facilities such as hospitals would also be able to work with a reduced energy supply and telecommunication systems would always be able to function. Overall, the impact of high peak demand on people's lives, such as pollution, for example, would be reduced.

13.9.2.5 Strategy: Diversify Costumer Options in Case of Utility Outage

The last strategy for the utility sector takes into account the importance of alternative energy sources in addition to the main networks, as this could fail even if it is reliable. The initiatives are therefore focused on increasing the redundancy of the utility sector, both at level of individual customers and districts, since its insufficiency makes the sector vulnerable. In order to diversify customers options in case of a utility outage, the initiatives proposed are:

- Scale up distributed generation (DG) and micro-grids
- Incorporate resiliency into the design of City electric vehicle initiatives and pilot storage technologies
- Improve backup generation for critical customers

- *Scale up distributed generation (DG) and micro-grids*

Distributed generation (DG) refers to the production of power in the proximity of the final users through the employment of small-scale technologies, like solar photovoltaic systems (PV) and other systems to produce renewable energy. Micro-grids are defined as local energy grids with control capability, which means they can be disconnected from the traditional grid and operate autonomously, (CITE) and can thus be seen as the expansion of the DG concept at the neighborhood level. A significant expansion of the DG systems in New York is constrained by regulatory structures, financing challenges, and lack of information. Therefore, the first initiative aims to promote the diffusion of these systems by addressing regulatory, financing, and information barriers, e.g. by changing the existing tariff structures and interconnection standards related to DG and by providing incentives for its expansion, especially in critical facilities such as hospitals. The initiative

also supports further studies of the applications of PV systems during outages and the technical and regulatory solutions for enabling cost effective and safe implementations of them. On the other hand, utilities do not take micro-grid expansion into account in their planning. To encourage micro-grid adoption as an effective alternative power source to use during outages, several actions can be underlined. Among others, this includes the clarification of the rules governing the export of energy and feasibility studies of the effects of micro-grid technology on buildings and on the entire energy network.

- *Incorporate resiliency into the design of City electric vehicle initiatives and pilot storage technologies*

Electric vehicle (EV) fleets could potentially be used as alternative energy sources, e.g. to power a small home for a day, thus redundancy can be obtained with the second initiative by improving the adoption of this fleet, looking at the resiliency benefits it can provide during outages. Despite the lack of power flow standards between vehicles and chargers, the idea is to make the EV infrastructure sturdy and resilient for when these standards will be available. The adoption of new storage technologies, such as batteries to add to buildings, is also considered another good action to adopt to improve grid reliability, provide emergency power to critical systems, and manage peak loads.

- *Improve backup generation for critical customers*

Critical customers, such as hospitals, nursing homes, police and fire stations, and wastewater treatment plants, should have backup generators working in-place. Less critical users, such as gas stations, pharmacies, and food supply stores, should be able to connect to backup generators, too. For this purpose, the last initiative is focused on preventing the failures demonstrated by backup generators during extreme events and reducing the impossibility of several users to connect to backup generators that utilities put in place at the time. To achieve this goal, the City proposes, among several actions, to increase the capacity to supplement the backup generator needs of different kinds of customers and to develop a generator plan to pre-wire a subset of less critical facilities to accept backup generators when needed. This strategy puts together different kind of initiatives to accomplish the goal of redundancy. It highlights the need to expand existing power generator systems and the need for new power sources to supply disrupted areas when disruptions occur, focusing on the need to guarantee the operability of systems and facilities that are considered to be critical both during normal times, but especially during emergencies. The interventions listed show that both individual customers and utilities can do something to increase the redundancy of the utility system at different scales. Several benefits of the utilities sector and of other dependent sectors can be obtained with this strategy. For example, the diffusion of alternative power sources would imply a reduction in the probability of extensive outages during hazardous events, since a certain area would be supplied by many sources and there is a low likelihood that would be disrupted all together at once. This initiative would also increase the availability of clean energy and reduce

costs, complexity, interdependencies, and inefficiencies associated with classic transmission and distribution systems, since it would guarantee more ability of isolating single customers and clusters of buildings in case of widespread power outages. EVs would reduce air pollution and increase independency from fuel, while also increasing the possibility of powering the most remote facilities. Together with storage technologies that are to be developed, they would reduce the risk of insufficient supply for high demand facilities. Finally, improving backup generators for critical customers would make different facilities more capable of restarting more quickly after a disruption to their main power systems and would make it easier for them to connect to temporary backup generators implemented for the occasion. Generally, these solutions would make several critical facilities able to perfectly perform their operations during emergencies. Hospitals and other critical infrastructures, for example, wouldn't risk being evacuated due to the failure of backup generators.

13.9.3 Initiative for Liquid Fuel

The liquid fuel sector is one of the most important sectors in the network of critical infrastructures, as well as one of the most damaged by Hurricane Sandy. Its importance is clearly demonstrated through the fact that it powers vehicles, heats buildings, fuels airplanes, works as an alternative energy source for power and steam generators, and overall provides the flexibility needed during disruptions to other energy sources. Disruptions were reported at nearly every level of the fuel supply chain, causing a wide impact on the whole network due to the high reliability of other sectors on liquid fuel. The lack of fuel supply and the consequent lines at gas stations were the most visible effects of the damage experienced by the sector. Three strategies are proposed by the government to accomplish the goal of making the sector resilient and preventing the supply disruptions that occurred because of Sandy. These strategies are:

- Seek to harden the liquid fuel supply infrastructure
- Enhance the ability of the supply chain to respond to disruptions
- Improve the City's ability to fuel first responders and private critical fleets

Each strategy focuses on one or more specific interventions that can be carried out in order to increase the overall resiliency of the liquid fuel sector. Hardening, increasing preparedness, and improving response are just some the objectives that can minimize the frequency and severity of disruptions and minimize their impacts. Overall, the initiatives proposed for the liquid fuel sectors have a broad impact on the entire network of critical infrastructure systems.

13.9.3.1 Strategy: Seek to Harden the Liquid Fuel Supply Infrastructure

The initiatives to accomplish the first strategy address the vulnerability of the fuel supply infrastructure by hardening its key assets in order to decrease disruptions and

allow for faster restoration. In order to obtain this, the municipal government wants to work with federal government and New York State to:

- Develop a fuel infrastructure hardening strategy
- Develop a reporting framework for fuel infrastructure operators
- Build pipeline booster stations in New York City
- Provide incentives for the hardening of gas stations
- Ensure that a subset of gas stations and terminals have access to backup generators in case of widespread power outages

- *Develop a fuel infrastructure hardening strategy*

New York City relies mainly on liquid fuel infrastructures located along New Jerseys coastline, which are vulnerable to the effects of coastal hazardous events, like wind and flooding. In the case of Sandy, they were the most damaged and the main cause of the widespread fuel supply shortage in the area. One of the reasons for which this happened is that the current regulatory framework does not require owners to harden their liquid fuel infrastructures against climate change. The other reason is that often they are not able to adopt the resiliency measures needed to harden their waterfront assets because they lack the necessary resources and long-term outlook. The first initiative focuses therefore on bringing together the necessary stakeholders to develop a common hardening strategy for all the infrastructures that are critical to maintain the fuel supplies in the region. This is needed because the City and State of New York have no regulatory or legislative authority on the infrastructure in New Jersey, which means they cannot control actions taken by their owners.

- *Develop a reporting framework for fuel infrastructure operators*

On the other hand, the government considers worthwhile the development of a reporting framework in order to allow infrastructure operators to better understand the actions and the challenges that must be dealt with in the aftermath of a disruptive event like Sandy. Delays in recovery and restoration efforts are also caused by the lack of updated information reported about the operational status of all the sectors infrastructures, such as terminals, pipelines, refineries, and gas stations. By developing a global IT system and information-reporting framework, it would be possible to better support post-emergency restoration and monitor the operational status of fuel facilities. This framework includes the employment of several IT systems, like automated sensors, and streamlined reporting protocols for operators, so as to increase the ability to access the most updated information needed during the emergency.

- *Build pipeline booster stations in New York City*

The third initiative is proposed because many existing pumping stations located along pipelines are not hardened against extreme weather. Pipeline booster stations ensure the pressurization of liquid fuel inside the pipelines and would allow additional fuel supply to be brought especially during emergencies, making the

management of fuel shortages easier. For this reason, one or more booster stations need to be installed and verified to be able to withstand the worst climate change impacts.

- *Provide incentives for the hardening of gas stations*

Gas stations can be considered as one of the weakest nodes of the liquid fuel sector since they are vulnerable to several threats, such as power outages. fuel shortages, and flooding. The last two initiatives mainly address their vulnerability to widespread power outages that would make fuel supply unavailable, even if the lack of fuel was shown to cause the most gas station inoperability in the aftermath of Sandy. Therefore, gas stations need to be hardened to withstand extreme weather events. Those located in critical points, such as in the proximity of controlled access roads and designed evacuation routes, are already required to be able to function during emergencies. For example, they need to enter into supply contracts for emergency generators and implement the necessary equipment to connect these generators quickly when a power loss occurs. Further hardening can be obtained with the development of effective hardening incentive programs for key retail fueling stations in vulnerable areas, which include hardening measures against flooding or other climate-related risks. These measures are not considered in the generator connection program, another effort that needs to be designed and implemented for the same hardening purpose.

- *Ensure that a subset of gas stations and terminals have access to backup generators in case of widespread power outages*

The New York State Energy Research and Development Authority (NYSERDA) is in charge of developing a generator pool program for vulnerable gas stations and creating a pre-event positioning plan. These plans can ensure the access to backup generators to a subset of gas stations and terminals and the faster deployment of generators to impacted areas immediately after a disaster. As seen, the goal of hardening can be achieved both with physical interventions, like the installation of booster stations to increase supply, and with several upgrade programs and plans, like the generator connection program, that have to be planned and put in place. This means that not only the actual liquid fuel infrastructures have to be strengthened but a review of the actual regulatory framework is also needed. This would prevent the liquid fuel sector from failing during future disruptive events and would help operators to better control and manage their infrastructures. Moreover, the strategy shows the dependency of New York City on liquid fuel infrastructures located in New Jersey, highlighting that both States and their governments have to collaborate in the development of a common hardening intervention approach. Due to the high number of assets that would need to be strengthened, the focus is on those considered to be critical during emergencies because of their geographical position. Hardening the fuel supply infrastructures would reduce the need to import fuel from abroad and thus the extra costs that this entails. The strategy would reduce the recovery time in several ways: by improving the ability to control fuel infrastructures, and consequently speeding up the intervention to damaged ones;

by improving communication among several operators; and by reducing the extent of damage that can occur to fuel assets. Moreover, if updated information were more accessible, owners would be more able to understand the emergency actions to take in the immediate aftermath and thus optimize the deployment of repair crews. This means that repair crews would waste less time waiting to know where to go or waiting for other interventions that have priority, thus they would be able to restore more places at the same time. Booster stations would increase the ability to import fuel during emergencies, which means more fuel available in these situations and consequently shorter lines at gas stations. Finally, incentives programs would increase the willingness of petrol companies to harden their assets and the availability of backup generators to run in order to maintain gas stations operations. It is clear that the other dependent sectors would benefit from this strategy too, in particular the transportation sector. Regular and temporary transportation services put in place would work with the usual number of customers and wouldn't be overcrowded because most of the people would be able to fuel and use their own cars. Traffic would be normal, less congestion would be reported in the proximity of gas stations, and less fuel trucks would circulate to cover the disruption of the usual fuel supply chain. Airport activities wouldn't be delayed because of the unavailability of fuel to pump into airplanes. Limited fuel shortages also mean that more power plants would be able to function, as well as more backup generators to run buildings and other facilities and heating oil could keep homes warm and water hot.

13.9.3.2 Strategy: Enhance the Ability of the Supply Chain to Respond to Disruptions

This strategy focuses on the need to improve the response of the fuel supply chain during and after extreme events that can cause its disruption despite the hardening focused on in the previous strategy. The lack of redundancy and market flexibility needed to respond to such disruptions slowed down the restoration of fuel supply. They can be addressed through market and regulatory changes, which are focused on by the following initiatives:

- Creation of a transportation fuel reserve
- Modification of price-gouging laws and increase of flexibility of gas station supply contracts
- Development of a package of City, State, and Federal regulatory actions to address liquid fuel shortages during emergencies

- *Creation of a transportation fuel reserve*

The goal to reach with the first initiative is to temporally supply the private market during disruptions. For this purpose, several entities are involved in the evaluation of feasibility and cost of the creation of a transportation fuel reserve. This program also allows the support of restoration and relief efforts in the event of widespread disruption to the fuel supply chain.

- *Modification of price-gouging laws and increase of flexibility of gas station supply contracts*

The second initiative addresses two issues that came up in the circumstances of widespread disruption of fuel supplies. The first one is the lack of clarity in New York State price-gouging laws, which results in the unwillingness of retail fuel station owners to raise prices after a disruption to pay for out-of-the-region supplies. The solution to this problem is to allow and control the increase in prices during fuel supply emergencies, while still ensuring fair pricing. The second one refers to the contractual obligations that prevent station owners from temporarily sourcing fuel from different suppliers. This other problem can be solved by including a "force majeure" clause in fuel supply contracts to let franchised stations to temporally supply fuel from any wholesaler if the retailer's usual suppliers are unable to deliver. Overall, the initiative aims to increase fuel availability during disruptions, and specifically to also cover the additional transportation costs to bring fuel into the city during a liquid fuels shortage.

- *Development of a package of City, State, and Federal regulatory actions to address liquid fuel shortages during emergencies*

The last initiative of this strategy highlights the need to change various regulations relating to the transportation and consumption of fuels in New York City that limit the flexibility of the market when responding to disruptions. There are multiple objectives: to quickly mitigate the supply-demand imbalances in the fuel supply, to allow foreign-flagged ships to deliver fuel into the region, to bring and sell within the city fuel that is normally consumed upstate and elsewhere, and to use heating fuel to power vehicles. In order to achieve these goals, a fuel-rationing plan has to be developed and regularly maintained, as well as a package of regulatory waivers and modifications to implement immediately after the declaration of a liquid fuel shortage. This strategy is proposed because the fuel supply chain showed to be unprepared to withstand and respond to the impact of Sandy. Each initiative proposes a specific solution to fuel shortage, aiming to increase preparedness to future disruptions, as evidenced by the creation of a fuel reserve, or market flexibility and redundancy, as reported by the other two initiatives. Moreover, the first initiative would surely reduce the dependence on imported fuel and increase the ability to withstand long-term widespread supply disruption through more fuel available to use during this time. It would also allow for a faster deployment of fuel to critical users, thus reducing their disturbance and increasing their ability to intervene during emergencies. Overall, through the several actions listed, the strategy would increase the availability of fuel in the aftermath of disruptive events and would affect the other sectors in several ways. For example, the transportation of goods and the entire food supply chain, as well as the deployment of utility repair crews, would not be delayed. Furthermore, transportation services that require fuel to work (buses, planes, etc.) would not be limited due to fuel rationing and water and wastewater services would not be interrupted.

13.9.3.3 Strategy: Improve the City's Ability to Fuel First Responders and Private Critical Fleets

Fuel supply must always be guaranteed for first responders and private critical fleets that are fundamental for emergency response, infrastructure rebuilding, and disaster relief, so as to avoid a lack of emergency management that can cause the amplification of the impact on the community. The only initiative proposed for this strategy is to:

- *Harden municipal fueling stations and enhancing of mobile fueling capability*

This initiative is needed to guarantee continued service to City, government, and critical fleets and to by-pass the regular supply chain. These goals can be obtained by using the municipal network of gas stations and mobile fueling trucks during a widespread disruption to the retail liquid fuels market. The use of additional equipment that can also be quickly deployed everywhere (mobile fueling trucks, generators, light towers, forklifts, water pumps) can provide the mobile fueling capability needed to run emergency fueling operations immediately following a disruption in the supply chain. Furthermore, other options can be evaluated for sourcing fuel to first responders and critical fleets during emergencies, so as to ensure that the municipal fuel supply is not used for them. By providing fuel to these fleets through the several ways listed, the strategy would improve the ability of local and national institutions of intervention and the management of emergency situations, preventing them from being slowed down by the disruption of the usual fuel supply chain, as normal users would be. For example, emergency vehicles would be able to regularly respond to emergencies, doctors and nurses who treat patients would not be delayed, and the overall restoration of other critical infrastructures would not be delayed.

13.9.4 Initiative for Transportation

The New York region's transportation network is considered to be the largest public transportation system in the U.S. and is demonstrated to be one of the most impacted along Sandys path, as well as the one that influenced and delayed the peoples and communities return to normality in general. A highly dense network of infrastructures, made up of busy highways, railways, ports, bridges, tunnels, etc., provides mobility to millions of people that visit, live, and work in the region, giving them the option to use their own vehicles or several public transportation systems, such as buses, trains, subways, ferryboats, etc. These systems are also heavily used by commuters to travel to/from and move inside New York City for all of their activities. The sectors area infrastructures are old, unreliable, in need of improvements and, because of their geographical position, vulnerable to disruptions that could be caused by many extreme events, such as flooding and wind. Sandy itself caused several damages to vehicular tunnels, subway stations,

roads, and airports, and lead to an extensive transportation outage that affected 8.5 million public transit riders, 4.2 million drivers, and 1 million flyers, as reported by the New York City government report. Generally speaking, extreme events like Sandy demonstrated the importance of the transportation system to the citys economy and overall ability to function. Given the size and complexity of it, the goal of resiliency represents a major challenge. Several initiatives are proposed to make the transportation system more resilient, focusing on upgrading the existing infrastructures and improving the reliability of its systems. These initiatives are organized according to the following strategies:

- Protect assets to maintain system operations
- Prepare the transportation system to restore service after extreme climate events
- Implement new and expanded services to increase system flexibility and redundancy

13.9.4.1 Strategy: Protect Assets to Maintain System Operations

The first strategy aims to increase the protection of existing infrastructures by implementing interventions to restore and harden them against damages and loss of service. The initiatives to account for this objective are:

- Reconstruction and resurfacing of key streets damaged by Sandy
- Integration of climate resiliency features into future capital projects
- Elevation of traffic signals and provision of backup electrical power
- Protection of NYCDOT tunnels from flooding
- Installation of watertight barriers for mechanical equipment of bridges
- Protection of Staten Island Ferry and private ferry terminals from climate change-related threats
- Integration of resiliency into planning and project development
- Implementation of protection strategies to address climate change threats

- *Reconstruction and resurfacing of key streets damaged by Sandy*

Several roadways were damaged in varying degrees by wave action and flooding generated by Sandy, leading to building inaccessibility and the interruption of transportation services. These damages were the most visible impact of the storm on the transportation systems, because they were also reported from several locations. In order to address these damages and prevent future ones in road infrastructures, the streets that reported serious damages have to be reconstructed or repaired following upgraded resiliency measures. On the other hand, some may only need to be resurfaced because of underlying structures still in good condition. The New York City Department of Transportation (NYCDOT) was in charge of reconstructing 60 lane-miles and resurfacing 500 lane-miles of streets damaged by Sandy.

- *Integration of climate resiliency features into future capital projects*

The current roadway network is vulnerable to several threats, such as surface flooding from heavy downpours, wave action from storm surge, and asphalt damage from heat waves. The overall impact of these threats can be mitigated with the adoption of several storm water management best practices and tools. These include, for example, the raising of street grades and bulkheads and the installation of pre-cast permeable concrete gutters and bioswales (planted areas in the sidewalk designed to capture stormwater from the adjacent roadway). The adoption of these measures allows water captured on the streets to soak into the ground rather than flow into the sewer system. Many others climate resiliency features can be considered for the development of future capital projects.

- *Elevation of traffic signals and provision of backup electrical power*

The most critical assets for the management of the transportation network are the traffic signals. The third initiative focuses on their protection against damages from flooding and power losses caused by several extreme events. The goal is to maintain the roadway network operational efficiency and avoid the placement of New York City Police Department (NYPD) traffic agents to control traffic. In order to achieve these objectives, controllers and electrical hardware vulnerable to flooding need to be raised and possibly placed above the 100-year flood elevation (flooding has 1 % of probability of occurrence per year). For a more immediate intervention when power outages occur, NYPD vehicles could be provided with power inverters to be used as alternative power sources for critical traffic signals.

- *Protection of NYCDOT tunnels from flooding*

Road and rail tunnels were among the most damaged transportation infrastructures by the storm. NYCDOT, Amtrak, and MTA tunnels under the Hudson and the East River were flooded and reported remarkable structural and equipment damage. Therefore, there is the need to reduce their vulnerability to flooding from storm surges and heavy downpours. To achieve this goal, several flood protection strategies can be put in place, e.g. tunnel entrances and ventilation structures can be raised above flood elevations and floodgates can be installed at tunnels entrances and closed at the occurrence. These actions would therefore provide protection from water infiltration and from damage to sensitive mechanical and electric equipment and overall prevent the disruption of these critical assets of the transportation network.

- *Installation of watertight barriers for mechanical equipment of bridges*

On the other hand, the bridges withstood the impact of Sandy well. Despite this evidence, their mechanical equipment is still vulnerable to flooding. This equipment controls the opening/closure of bridges needed to provide a clear path for marine traffic, thus damages occurring to it could block the bridges in either one of the two positions, impacting marine or roadway traffic. The solution proposed is

the installation of watertight barriers to protect movable bridge machinery and to prevent the occurrence of this situation, so as to ensure the proper functioning of these critical crossings.

- *Protection of Staten Island Ferry and private ferry terminals from climate change-related threats*

The last initiative that directly addresses the risk of flooding focuses on the protection of ferry services that, due to their nature/geographical position, are vulnerable to disruptions and damages caused by flooding and wind. Several actions can be put in place to avoid the consequent service suspension and reduction of mobility and to allow quicker service restoration. On one hand, physical improvements can be carried out on several terminal infrastructures. On the other hand, critical equipment of these facilities can be protected, e.g. waterproofing or relocating them.

- *Integration of resiliency into planning and project development*

Climate adaptation and resiliency are not considered critical factors in planning, funding, and developing capital projects that address the vulnerability of the citys transportation network to climate change. These factors need to be included and prioritized in the federal legislation funding surface transportation. Moreover, there is the need for a joint planning for resilience and climate adaptation among the various transportation agencies in the region, in order to avoid duplicate investments.

- *Implementation of protection strategies to address climate change threats*

Another way to address climate change threats is to increase transportation system flexibility, whose critical assets otherwise could remain vulnerable to damage and disruption from future events. Therefore, a comprehensive implementation of appropriate investments in resiliency and protection strategies across all transportation systems is needed to ensure their protection against the aforementioned threats, as well as their preparedness for quick restoration. Transportation agencies are called to implement hardening and preparation measures to protect several infrastructures (vehicular, rail and subway tunnels; bus depots, terminals, and other facilities that are critical to providing bus service; rail, subway yards, and other facilities that are critical to providing rail service; runways, lighting systems, navigation systems, terminal buildings, and other airport facilities; port and marine facilities) and to also support projects to expand the flexibility and redundancy of the transportation network. (These projects include the Amtrak Gateway Project; the extension of the MTA New York City Transits seven subway line to New Jersey, or alternatives that would significantly expand cross-Hudson commuting capacity; transit improvements along the North Shore of Staten Island; and extension of Metro-North Railroad service to Penn Station.) As seen, the strategy focuses mostly on physical measures needed to protect and harden existing infrastructures. The initiatives included mainly address the risk of flooding of several vulnerable assets that were not originally designed taking this risk into account. Some of these

initiatives refer only to the protection of specific transportation infrastructures and equipment, while others are thought to have a broad application to the entire sector, like the last two. Each initiative focuses on addressing something specific to reduce the sectors vulnerability, like the need to upgrade existing assets or increase the flexibility of the whole sector.

Overall, the strategy leads to several benefits. For example, by upgrading the existing infrastructures through the interventions considered by the first and second initiatives, the impact of future events causing mobility disruption would be surely reduced, as more roads would satisfy the resiliency requirements, would not be flooded, and thus would be able to withstand such events. At the same time, the accessibility to damaged areas in need of repair would be increased. The elevation of critical assets would surely reduce traffic congestion, allow for the deployment of police officers where actually needed (i.e. not controlling traffic), and speed up the restoration of traffic management services. Actions conceived for tunnels and bridges would guarantee mobility especially during recovery phases, reducing congestion in other access points, and also reducing the amount of equipment that has to be replaced, allowing for a faster reopening of crucial infrastructures. Many other sectors would benefit from this strategy too. Utility repair crews would not be delayed by closed roads and consequent detours, as well as emergency services (ambulance, police, firefighters, etc.). Damaged buildings would be reached and repaired faster. Waste service would continue its operation, and thus prevent the accumulation of waste, causing further problems. Food delivery to major and minor customers would not be delayed by a lack of access to warehouse and delivery locations. Fuel would be delivered to gas stations and other critical users faster.

13.9.4.2 Strategy: Prepare the Transportation System to Restore Service After Extreme Climate Events

The second strategy focuses on increasing redundancy, preparedness, and the ability for a quick response following a disruption, listing a series of initiatives that mostly regards temporary services to restore mobility and specific assets of the transportation system. In fact, its extent, complexity, and age make challenging to act with an overall intervention. For these purposes, the government proposes to:

- Plan for temporary transit services in the event of subway system suspensions
- Identify critical transportation network elements and improve transportation responses to major events through regular resiliency planning exercises
- Implement High-Occupancy Vehicle (HOV) requirements
- Plan for and install new pedestrian and bicycle facilities
- Construct new ferry landings
- Deploy the Staten Island Ferrys Austen Class vessels on the East River Ferry and during transportation disruptions
- Improve communication about the restoration of transportation services

- *Plan for temporary transit services in the event of subway system suspensions*

The forecasted impact of Sandy on the transportation system led, among others, to the total shutdown of the subway system for the entire length of the storm and the provision of limited service for the few days following. The subway system usually runs non-stop, 24 h a day, 365 days a year, and provides most of the transportation network capacity. As a consequence, its partial or total suspension brings this capacity to a reduction, and the rest of the regular network cannot handle the resulting increased volume of commuters and other travelers. Temporary transit services can be adopted to address this reduction of transit capacity. The initiative proposes the development and regular updating of temporary transportation plans, such as those regarding several services like high-capacity bus bridges, already successfully implemented during Sandy, point-to-point ferries, dedicated bus lanes, and necessary enforcements to adopt for the time needed. To understand the best type of temporary services needed in every situation, it is recommended that companies identify and study potential threats and their impacts on their infrastructures and evaluate the level and type of support they could provide. Another solution is to allow temporary access to other transit service through cross-honoring. This solution is often adopted during several transit service disruptions and has been proven to relieve system stress. Overall, the initiative aims to provide alternative mobility options during the partial or total suspension of the transportation system.

- *Identify critical transportation network elements and improve transportation responses to major events through regular resiliency planning exercises*

The second initiative aims to improve the response of transportation agencies to several possible transportation outages and restoration scenarios and to allow them to understand where to focus their resources in the different stages of emergency management. This need is highlighted by the vulnerability to disruption and the damage of critical transportation facilities that are needed during disaster response. Their interruption can potentially delay the delivery of emergency services, the supply of goods, and the restoration of critical non-transportation infrastructures and economic activity. To avoid this, transportation agencies and other stakeholders have to work to identify the critical elements of the network that have to be quickly available following different types of events. This can be done, for example, through a series of detailed and multi-disciplinary resiliency planning exercises, including live drills. Focusing on these elements, resiliency investments can be prioritized and response can be improved.

- *Implement High-Occupancy Vehicle (HOV) requirements*

The use of HOV lanes is an effective way to reduce the volume of circulating private vehicles. Especially when extended transportation disruptions occur, this volume can overwhelm road capacity (which may already be reduced by damages) and create gridlocks. The requirement adopted by New York City immediately after Sandy was that vehicles entering the city needed to have three or more occupants, while, at the time, HOV lanes permitted only vehicles with a minimum of two

passengers. Given the positive results exhibited during the storm, the idea is to develop standard protocols for the implementation of HOV requirements in the occasion of similar disruptions to the transportation network. This also implies the establishment of minimum conditions that must be satisfied in order to adopt these protocols and other details, such as their exemptions.

- *Plan for and install new pedestrian and bicycle facilities*

Another initiative created to provide additional capacity during subway interruptions focuses on the expansion of pedestrian and bicycle paths, which were overwhelmed by the extra number of people walking and biking due to this disruption. To overcome this problem, several actions can be undertaken, such as the deployment of temporary facilities to increase pedestrian and bicycle capacity in the event of an emergency situation and the expansion of the bike-sharing network to cover the areas vulnerable to transportation interruptions. Overall, the initiative proposes to improve connectivity to key transportation hubs through transportation options that do not rely on electricity to function.

- *Construct new ferry landings*

Waterways can be used as alternative methods of providing mobility when emergencies and other events occur and disrupt regular land transportation services. The initiative focuses on the expansion of the network of ferry landings available for both regular and emergency use in order to provide a more dense transportation service via water. This goal can be achieved in several ways: on one hand, through the design and deployment of ferry landing barges as temporary landings, in order to provide basic ferry service to potential locations vulnerable to climate-related transportation interruptions; on the other hand, by designing new mobile permanent ferry landings that can be temporarily relocated to provide alternative transit services where needed. In this way, private and emergency ferry services are enhanced and made available during extreme events.

- *Deploy the Staten Island Ferrys Austen Class vessels on the East River Ferry and during transportation disruptions*

The Staten Island Ferrys Austen Class vessel is a type of boat that can carry 10 times the number of passengers of a typical East River Ferry. As it can be seen, this initiative specifically refers to the context of New York City, but it can surely be considered in other circumstances where there is a similar level of service. This vessel can be deployed during transit service disruptions that cause large numbers of commuters to use ferry services in order to supplement the increased demand that otherwise would exceed the capacity of typical private ferry vessels.

- *Improve communication about the restoration of transportation services*

The last initiative focuses on the need to improve the reliability of communication between the several agencies involved in the restoration process and the general public. The lack of reliable information during and immediately following an emergency situation can lead to additional unreliable communication

and considerable confusion. The goal is to provide accurate and trustworthy information, for example, to truck companies and drivers about detours to follow during emergencies, in order to minimize their impact on sensitive infrastructures and to facilitate the safe, fast, and efficient delivery of relief supplies. For these purposes, standardized communication protocols need to be developed for use during transportation disruptions in order for agency stakeholders and the public to receive proper information regarding system status and interim measures. As seen, the strategy's goals can be achieved through different measures. Several transportation systems are in need of interventions to increase their ability to withstand extreme events. The strategy highlights how the entire transportation network can suffer from the suspension of one or more of these systems, but also how there are several actions that can be taken to make up for it. The last initiative, in particular, shows how distribution of information has a key role in the development, adoption, and effectiveness of the temporary solutions suggested. The importance of waterways as alternative transportation, which, because of this, need to be reinforced, is something that can be considered in other contexts rather than NYC, despite one initiative being written specifically for ferry transportation in the New York Harbor. Overall, the strategy would increase the preparedness of all the agencies involved in the management of these events. Through the several temporary transportation services listed, it would be possible to maintain service capacity in certain directions, especially for users who do not own a car, and prevent the overcrowding of regular transportation services that are still functioning. As a result, less people would be forced to use their own cars, and thus less accidents would take place due to, for example, unfamiliar drivers who are not used to the traffic. Resiliency planning exercises would increase agencies preparedness for several extreme events, as well as their ability to adopt emergencies actions and thus reduce the time needed to restore critical infrastructures. The installation of new pedestrian and bicycle facilities would provide an incentive for the use of these alternative transportation systems during a disruption of the regular ones and would reduce the overcrowding of existing bike and pedestrian paths. Finally, buildings and health care facilities would be accessible as usual, since temporary service would still guarantee people access to them, and emergency services and supplies of food, fuel, and medicine would not be impaired by transportation disruptions. Overall, the restoration of several other critical infrastructures and economy activities would not be delayed.

13.9.4.3 Strategy: Implement New and Expanded Services to Increase System Flexibility and Redundancy

The last strategy focuses on the expansion of several temporary transportation services that demonstrated to be effective for the entire transportation network in the aftermath of Sandy, preventing other means of transportation from being overwhelmed. As seen in its title, the strategy seeks to increase flexibility and redundancy to increase the networks overall resiliency to a variety of weather events

and other emergency situations, in addition hardening existing assets and creating additional capacity and responsiveness. To achieve these goals, this strategy includes three initiatives:

- Expand the citys Select Bus Service network
- Expand the network of bus priority strategies on arterial highways
- Expand ferry services in locations citywide

- *Expand the citys Select Bus Service network*

The Select Bus Service (SBS) is a bus service designed by MTA to specifically address general mobility challenges by reducing travel time and increasing customers level of comfort. The SBS network is made up of several corridors that cover portions of the city that are not directly served by subway service. These routes represent the backbone of the alternative high-capacity bus service network, which accounts for the reduction of capacity following subway disruption, and include what are also known as high-capacity bus bridges. Therefore, a significant expansion of the current SBS network, with the addition of several new routes, would allow for an increase in the efficiency of this service.

- *Expand the network of bus priority strategies on arterial highways*

Congestion on the regions highways reduces regular mobility and, above all, can slow recovery efforts put in place during emergency situations. Bus priority strategies for express, local, and intercity buses represent a solution to account for this problem. These strategies include solutions such as median bus lanes and the use of shoulders for bus traffic. The idea is to expand the current network with the creation of 15 new miles of these bus priority corridors on major arterial highways as they are improved or reconstructed. The goal of the NYC government is to implement these strategies as soon as possible.

- *Expand ferry services in locations citywide*

Ferry services provide an additional transportation option especially during other transit services disruption. However, they are vulnerable to damages suffered by key crossings, which can therefore limit waterway movement. To address this problem, the last initiative focuses on the expansion of current ferry service beyond existing routes, to guarantee service in critical locations in the city. The strategy proposes to expand already existing transportation services that proved to be useful during the reduction of transportation capacity. Despite the reliability of the entire transportation network, during its disruption, alternative mobility options must taken into account, otherwise the impact of the disruptive event is further amplified. Overall, the strategy brings several benefits to the transportation sector. For example, the first of the two initiatives designed for bus service would increase its capacity during unusual service interruptions, similar to the subway interruption, and would increase and guarantee mobility to areas that can only be reached by certain transportation services. On the other hand, the second initiative would increase bus service reliability, due to its independence from local traffic. It would also allow

for faster movement of buses along critical roadways and a reduction of transit service congestions along them. Finally, the last initiative would increase the ability to use waterways as an alternative to regular transportation service. The strategy would also reduce the impact of transportation disruption on other sectors. Several businesses, e.g. food services, would suffer less economic loss, as people would be able to reach certain places despite the emergency situation. Critical buildings and health care facilities located close to waterways could also be reached by water more easily and quickly.

13.10 Summary and Remarks

Each community has to develop a resilience plan from its unique perspective. This involves accounting for the risk toleration, anticipation of provided services, and the planning process which are all specific to the community. The success and endurance of a community plan depends on its unique adaptations. In order for a plan to be developed and implemented in a community, it requires extensive support. The resilience target isn't necessarily expensive, but for each community the process is different and will take time to implement and to see results. A resilient community is achieved through maintenance and on-going efforts. The process involves intensive planning, aiming at a combination of mitigation before the hazardous event, along with phases of emergency response, restoration and long-term reconstruction after the occurrence of the event. The process of achieving disaster resilience requires concentration, persistence and efforts to understand the current social institutions, governance, economics, the buildings, and infrastructure systems and their effectiveness, as well as the consequences that the occurrence of a hazardous event would cause. The basis of resilience planning is formed by the intersection of community daily needs and the anticipated damage from hazardous events. Communities are currently making efforts to reduce threats and vulnerabilities through adoption and enforcement of codes, standards, and regulations, as well as exercising preparedness, mitigation, emergency management and codes and standards-based design. These activities are necessary and prudent, but they are not enough to make a community resilient. Proper community resilience also requires that the built environment can sustain acceptable levels of functionality during and after events. Therefore, there should be a specified time frame for which communities have developed the plans to recover the built environment to its full functionality. The recovery times are determined by the function and importance of each facility or system within the community and the extent of disruption that the facility can tolerate and still remain functional. During an emergency, short term plans and interim solutions can be developed for implementation, if the event occurs tomorrow. In the long term, plans will provide the roadmap for eventually achieving disaster resilience. This process begins with the vision of a better outcome, a better understanding of your community, the development of a resilience plan, and the initiation of the implementation.

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