Rising Seas: Adaptable Planning Strategies for Coastal Urban Greenways - Case Studies in the US and China

Hongbing Tang[1] and Jeanne Lukenda[2]

[1]*University of Massachusetts, Amherst, Department of Landscape Architecture and Regional Planning*
[2]*Weston & Sampson, Inc.*

Abstract

This paper discusses adaptable planning and design strategies for coastal urban greenways to deal with rising seas due to global warming and climate change. It advocates taking steps to protect the coastal landscapes, increase adaptation, and mitigate disastrous outcomes associated with sea level rise from a global perspective. Greenway planners must consider the costs and risks of accommodating the rising seas, retreating from them, or trying to defend the greenways with protective measures.

The City of Boston and the City of Shenzhen in China have been selected as our case studies. Boston, a paradigm of U.S. resilient coastal cities, is well-placed to deal with the challenge, with experts and resources accessible and at hand. With increased understanding of the successes and failures of existing natural and man-made protection, accommodation, and retreat measures; increased acknowledgement of current sea level rise impacts; and a vision for the opportunities that may come from proactive reduction of vulnerabilities, the City of Boston is taking charge of its future. The City of Shenzhen, on the contrary, does not have the knowledge and resources, and is far from getting ready to react to the threats of sea level rise and other climate-induced changes at the scale being forecasted by scientists. An important portion of its newly built greenways was severely damaged by Super Typhoon Mangkhut recently. Coastal resilience solutions are much needed for Shenzhen and other parts of Pearl River Delta greenway networks along the South China Sea.

This paper attempts to raise public awareness and perception on this emergent topic. It concludes with recommendations of adaptable planning strategies for coastal resilience by establishing planning and design guidelines, utilizing greenways as resilient infrastructure, restoring damaged ecosystems as natural coastal defenses, and advocating multi-functional greenways and land use with public involvement.

Introduction

The rate of global sea level rise has been accelerating in recent decades, rather than increasing steadily (NASA, 2018). Sea level rise, combined with worsening storm surge and increasing precipitation, threatens to impact millions of people, destroy infrastructure, and damage the ecosystems in coastal communities worldwide. Coastal resiliency is one of the most pressing and challenging issues which landscape architects face today.

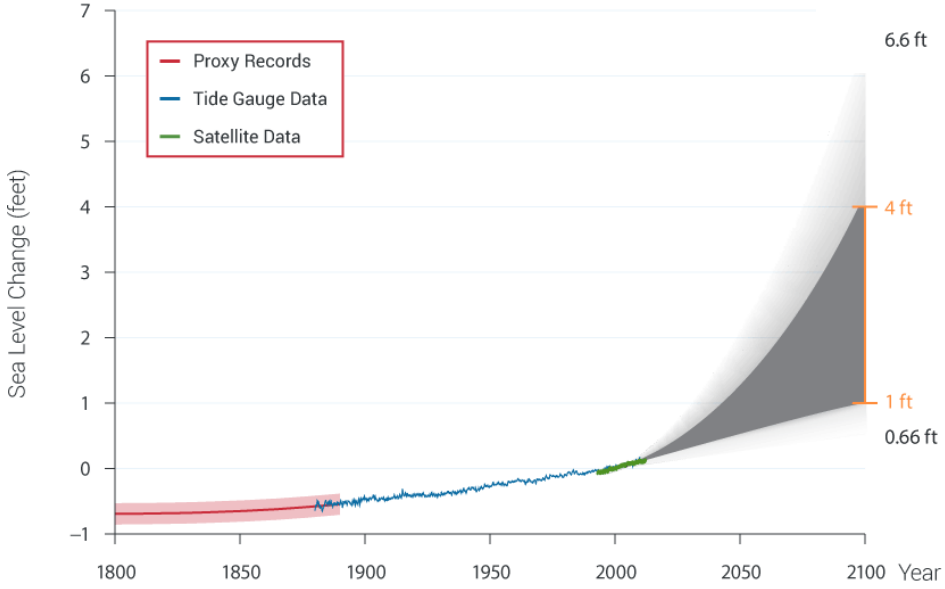
While greenways can contribute to the resilience of any city, the role they play in coastal cities is particularly significant. Often part of larger connected networks and with linear characteristics, they present an opportunity to develop a continuous line of defense against both coastal and inland floods

(Martin, 2016). Fortuitously, utilizing this physical framework for a holistic strategy can be balanced with the flexibility of site-specific customization.

Background/Literature Review

Global mean sea level has risen by 8 inches (20 centimeters) since 1870, with an average of nearly 3 inches gained since 1992 (NASA, 2017). Sea level rise from melting ice sheets is accelerating around the world and the annual rate of the rise could more than triple every year by 2100 (United Nations, 2018) (Figure 1). It is projected to rise another 1 to 4 feet (NASA, 2017) by the end of this century.

Figure 1. Past and Projected Changes in Global Sea Level
Source: https://serc.carleton.edu/eslabs/cryosphere/6b.html



Sea level rise, in general, and the movement of this increased water volume, in particular, will continue to have devastating consequences and detrimental effects. Higher sea levels may mean bigger, more powerful storm surges that can strip away everything in their path, both as the storm surges strike land and as they pull back in retreat (National Geographic, 2017). Although contemporary urban greenways tend to have multiple functions, the current coastal greenway planning and design has not taken the threat of sea level rise into consideration in many parts of the world.

Goal & Objectives

The goal of this paper is both to raise public awareness and perception of coastal resiliency and to offer ideas for consideration through sharing recommendations for adaptive greenway planning strategies.

The objectives are to:

- Offer adaptive planning strategies for consideration using the case study of Boston, MA;
- Describe sea level rise implications and consequences using the case study of Shenzhen, China; and
- Provide adaptive recommendations using greenways as resilient infrastructure for cities to frame, strategize, and act toward local coastal resilience.

Research Method

This paper uses a descriptive-analytical method with case examples to identify problems, support findings, and explore potential strategies for adaptable planning considerations. City of Boston, MA and City of Shenzhen, China are selected as our case studies.

Case Studies

US Case Study: The City of Boston and its Coastal Greenway Network

Founded in 1630, Boston has doubled in physical size as a result of filling its coastline. It is recognizing its increasing exposure to the effects of sea level rise and climate change, both now further exacerbated by this earlier change. The City, led by the Mayor, is choosing a flexible planning strategy approach that embraces and prioritizes adaptation of its people, neighborhood, economic, and cultural assets (Climate Ready Boston, 2018), and is preparing its core population of about 670,000 (and almost 5 million in the metropolitan area) for 40 inches of sea level rise by 2070 (Climate Resilient Design Guidelines, 2018).

At the macro scale, Boston is focusing on integrating climate preparedness into all aspects of its city planning, review processes, and regulations updates. It is coordinating multiple, simultaneous efforts including: *Imagine Boston 2030*, its first city-wide comprehensive master plan in 50 years; *Go Boston 2030*, the Transportation Department's look at the next 15 years; and *Resilient Boston Harbor*, a planning study that advances *Climate Ready Boston* by focusing on a 47-mile length of shoreline, and acknowledges the tremendous benefits of utilizing connected open space - its greenway network - as part of the vision to better protect Boston's assets (Boston.gov, 2018).

Resilient Boston Harbor encompasses four key geographical districts along Boston Harbor, including East Boston/Charlestown, through which the City can implement immediate measures within its greenways, as it works toward adopting longer term standards, and contribute to improving and securing the quality of everyday life in Boston. From the climate vulnerability assessment, East Boston/Charlestown was identified early on as one of Boston's most vulnerable areas and was prioritized as the first neighborhood to be studied in greater detail (Resilient Boston Harbor, 2018) (Figures 2 & 3).

Its vision plan, *Coastal Resilience Solutions for East Boston and Charlestown*, demonstrates how Boston's greenway network can help this city adapt to climate change impacts, and looks at more extensive ways in which this site-specific greenway can be utilized, in combination with other area open space improvements, to provide flood protection, for example, while still accommodating waterfront access, recreation, and mobility (City of Boston, 2017) (Figure 4).

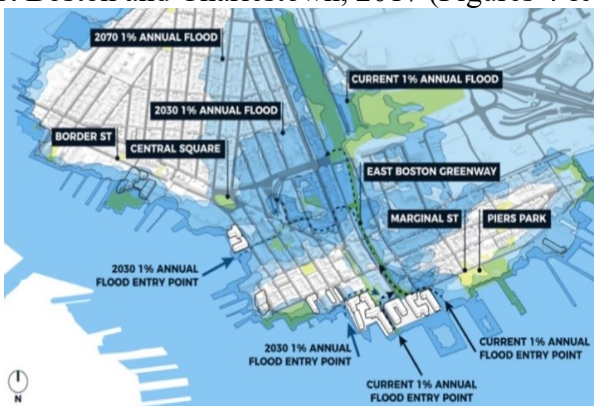
As a result of site-specific conditions, relatively narrow and clearly-defined flood pathways exist; thus, the solutions considered for East Boston can be targeted, with the likelihood that large parts of this district might be spared from widespread flooding (City of Boston, 2017). Studies show that flood waters will move from a low-lying street adjacent to the waterfront edge and follow a flood pathway that extends to the entrance of, and then into, the Greenway itself (Figure 5).

Figure 2. Four Visioning Study Areas
Source: Resilient Boston Harbor, 2018

Figure 3. East Boston, 36 inches of rise by 2070's
Source: Same as Figures 4 & 5

Figure 4. Potential Coastal Resilience

Figure 5. Flood Entry Points and Pathways
Source: Coastal Resilience Solutions for East Boston and Charlestown, 2017 (Figures 4 & 5)



At the micro scale, Boston considers each of its open space parcels (existing and proposed) as a vital link in the overall system and, therefore, crucial to its resilience planning. General considerations include the potential to elevate green open space, improve connections, optimize the use of natural buffers, utilize tree canopy to counter rising temperatures, and use site amenities to serve multiple purposes including flood protection functions. The design process includes three main steps:

1. Establishment of design guidelines to provide flood protection;
2. Study of a range of flood protection options, and consideration of short- and long-term costs, maintenance, and operations factors; and
3. Development of feasible solutions that protect from flooding due to tides and storm surge.

Specific to East Boston and its greenway network, Figure 6 illustrates a softscape solution to define the greenway entrance, transforming it from a flood path gateway to a flood path deterrent; by elevating the entrance area, a raised entrance "green" is created. A hardscape plaza solution would be an equally viable concept. Figure 7 shows the potential to shape resilience solutions into meaningful place making spaces for social gathering. The *Climate Ready Boston* "principles of effectiveness, feasibility, design life and adaptability, social impacts, equity, value creation, and environmental impact" are demonstrated (Climate Resilient Design Guidelines, 2018).

Figure 6. Elevating the Entrance **Figure 7. Creating Social Spaces Source:** Coastal Resilience Solutions for East Boston and Charlestown, 2017 (Figures 6 & 7)

The City of Boston has taken this moment in time to reflect on its history of making isolated decisions, as many have been shown to ultimately affect the environment in detrimental ways. The unparalleled sense of urgency driven by the rapid acceleration of sea level rise has drawn together stakeholders and decision makers. A model of U.S. resilient coastal cities, Boston continues to embrace input from the public, and utilize experts and resources to help it deal with the challenges of climate change impacts.

China Case Study: The City of Shenzhen and its Coastal Greenway Network

Bordering Hong Kong to the south, the City of Shenzhen in Guangdong Province, China is a leading global technology hub and a major financial center in southern China. A rising metropolis of 11 million in the Pearl River Delta, Shenzhen used to be a fishing village before it was established as China's first special economic zone in 1980, following China's "open door" policy.

Similar to Boston, which was largely built upon landfills, the rapid urban expansion of Shenzhen resulted in filling of its coastline to a great extent (Figure 8). During the past 30 years, the sea area that had been converted into land by reclamation was more than 69 square kilometers (Yangcheng Evening News, 2013). In 2017 Shenzhen government officials announced new plans to add another 28.2 square kilometers of landfill along the City's coast to be completed within 3 years (Shenzhen Land Use Master Plan, 2017).

In 2010, the City of Shenzhen began to develop its greenway system as part of the Pearl River Delta (PRD) greenway network following a typical top-down process. The government of Guangdong Province set ambitious goals and constructed the basic structure of the PRD regional greenways within the first year after planning, to have all in place within the second year, and to refine to perfection within the third year (Guangzhou Housing and Urban-Rural Construction Bureau, 2010).

Figure 8: Shenzhen Bay 1973 vs 2016

Source: earthexplorer.usgs.gov

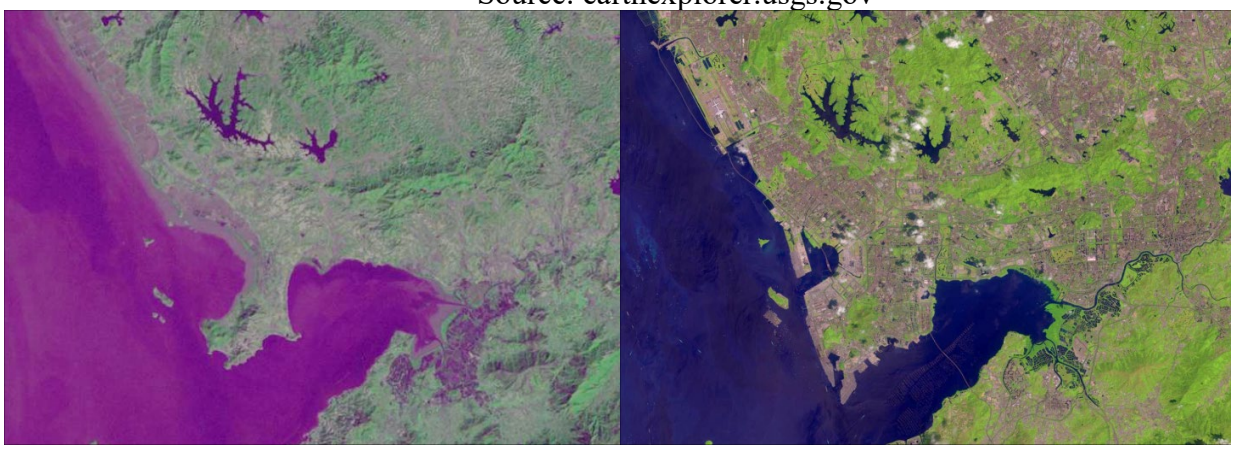
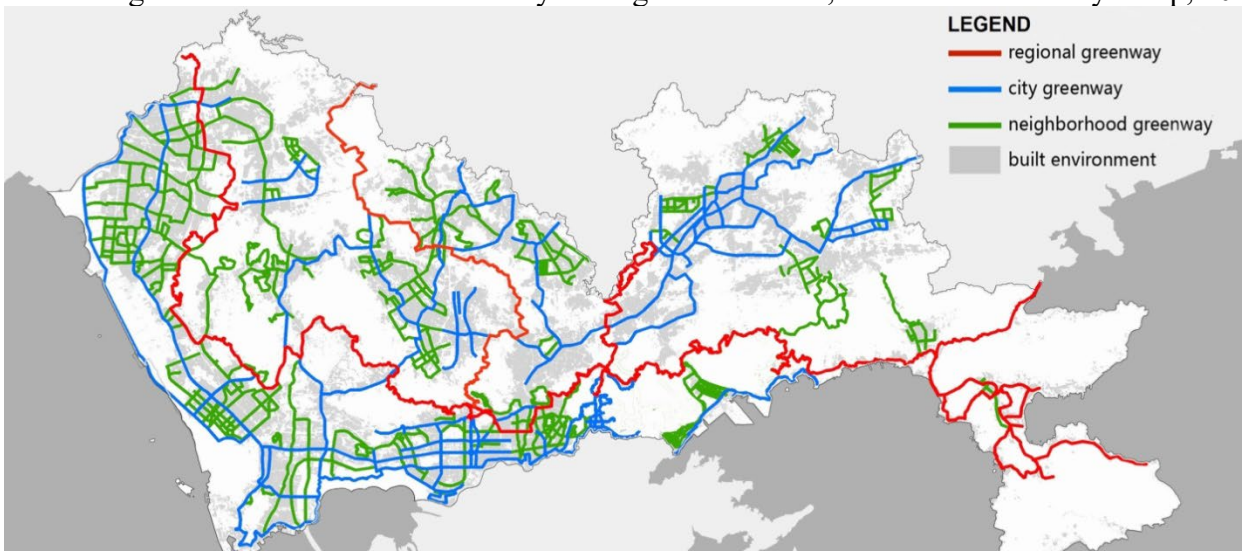


Figure 9：Shengzhen Greenway Network

Original Source: The Shenzhen City Management Bureau, Shenzhen Greenways Map, 2013



There is an interwoven grid of regional and local urban greenways running through the City of Shenzhen, totaling 1,640 kilometers in length (Figure 9). The Shenzhen greenway system has three greenway hierarchies: regional greenways which link Shenzhen to other cities; urban greenways to connect different clusters in the City; and neighborhood greenways to reach community parks and street-corner green areas primarily for daily recreation (Liu, 2016).

Although global climate change and sea level rise is an emerging issue, Shenzhen's greenway planning did not take it into consideration. Figure 10 is a prototype design of coastal greenways in Shenzhen. The low-lying pathway design is subject to coastal flooding.

Figure 10: Shenzhen Greenway- Prototype Design along its Coastline
Source: Shenzhen Greenway Network Special Plan, 2011

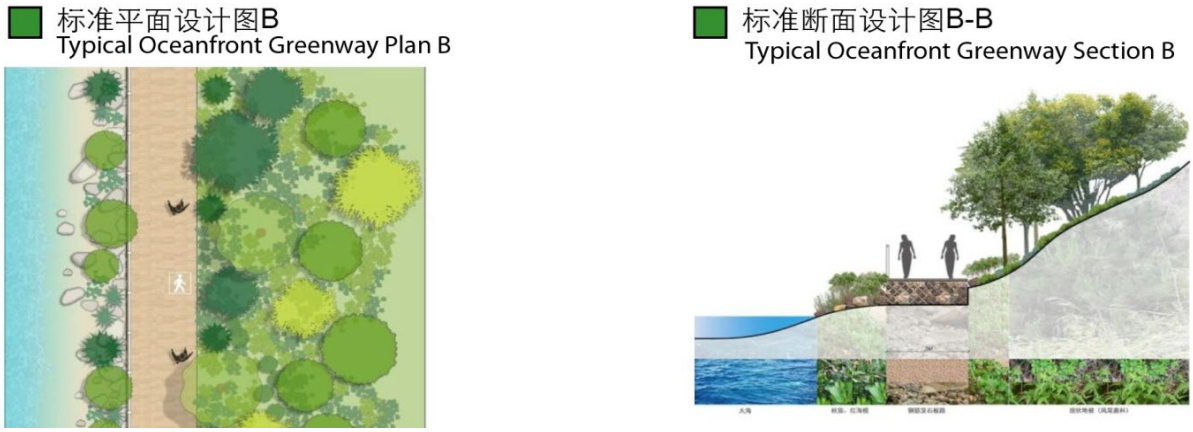


Figure 11. Shenzhen Greenway's Southern Coastal Section
Source: Shenzhen Greenway Network Special Plan, 2011

In September 2018, Super Typhoon Mangkhut devastated the Philippines and lashed southern China, leaving many areas in the Pearl River Delta region damaged and flooded. An important portion of Shenzhen's newly built greenway network was severely impacted (Figure 11). The destroyed greenway linked the Yantian Golden Coast Pier, Great Meisha Park and Small Meisha Park along the City's southern coastline, which was famous for the beautiful ocean views and beaches. The typhoon brought the worst tropical storm since 1983. More than 250,000 cubic meters of sand had been swept away at the Great Meisha Beach, and the economic loss was 85 million Chinese yuan (12 million USD) (People.cn, 2018). The Moon Plaza, the Sun Plaza, the Sunshine Corridor, and famous "Forever Love Rocks" - Shenzhen people's favorite sculpture built along the greenway's oceanfront - were in ruins.

Figure 12. Great Meisha Beach & Forever Love Rocks after the Super Typhoon
Source: http://wemedia.ifeng.com/79095386/wemedia.shtml

No urban area in human history has expanded so much so fast as the City of Shenzhen. The biggest consequence of the City's astonishing growth is environmental degradation and ecosystem destruction. Due to the rapid urbanization and short-term economic benefits, Shenzhen has cleared out 70% of its original redwood forests, including the magnificent mangroves in the downtown area that the Shenzhen people used to be very proud of. Many wetland areas in the City have been destroyed, filled, or drained for development. The rising South China Sea and the overstressed Pearl River network lie just a meter or so below much of Shenzhen's new multi trillion-dollar development (Kimmelman, 2017). With an average sea level rise of 3.3 millimeter per year along China's coastlines from 1980 to 2017 and projected future sea level rise of up to 130 millimeters (about 5 inches) by 2030 (Xinhua News Agency, 2018), Shenzhen's decades of progress are jeopardized by the rising sea in the 21st century.

Recommendations

The challenges from rising seas demand new solutions for coastal cities. More than just parks or amenities, greenways represent an adaptation - a response to the physical and psychological pressures of urbanization (Searns, 1995). As a result of this study, four key adaptable greenway planning strategies are recommended, as follows:

Establish Greenway Planning and Design Guidelines to Cope with Climate Change and Sea Level Rise in the Short and Long Run

Since each city is unique in terms of its history, culture, ecology, climate, and state of development, it is important for coastal cities across the world to establish their own adaptable greenway planning and design guidelines to address the specific challenges and threats these cities are facing. The customized guidelines should have a holistic approach, with adaptable strategies blending natural and man-made systems to help cities achieve coastal resiliency. The City of Boston has set a good example of establishing planning and design guidelines at macro and micro scales, in both the short- and long-term, that other communities can learn from.

Utilize Coastal Greenways as Resilient Infrastructure for Stormwater Management,Flood Defense and Beyond

As the backbone of a larger, sub-watershed, sustainable stormwater network, greenways can be the first line of defense against big storms (Martin, 2016). Coastal cities can develop a toolkit of options based on

specific needs and conditions in the regional, local, and site context similar to the toolkit developed by the City of Boston for coastal resilience solutions (Figure 13).

Figure 13. South Boston Coastal Flood Protection Technical Toolkit
Source: Climate Ready South Boston, 2018

In some areas, the simplest and most cost-effective cross-section might be to lift the greenway on top of a dike; in other areas, such as along commercial corridors, more transparent design solutions might be more appropriate (Martin, 2016). Coastal flood protection systems can be further elevated using integrated seating, planters, and/or seat walls, as demonstrated in Figure 14.

Figure 14. Seaport Boulevard Resilient Edge Concept, South Boston
Source: Climate Ready South Boston, 2018

Restore Damaged Coastal Ecosystems as Resilient "Natural Coastal Defenses"

To sustainably cope with rising seas, engineering structures such as dikes, dams, and spillways must be complemented with "natural coastal defenses" from our ecosystems. Worldwide, tropical mangrove ecosystems provide natural bio-shields from the ocean, mitigating the impacts of storm surges, filtering out salt from the seawater, absorbing carbon dioxide, and adjusting micro climates. Wetlands, among the most productive ecosystems in the world and comparable to rain forests and coral reefs (EPA.gov, 2018), act as buffer zones between the sea and the city. Yet, despite the vital role of ecosystems, the world has lost over 50% of its original mangrove forests (Lacambra, et al, 2013) and 64% of wetlands worldwide since 1900 (UN Environment Programme, 2015). It is urgent and crucial to restore damaged ecosystems and integrate nature-based solutions in a holistic approach for addressing the impacts of climate change on people and their environment.

Promote Multi-Purpose and Multi-Functional Coastal Greenways with Public Involvement and Community Engagement

Global environmental change requires implementation of new coastal greenways and adaptation of existing greenways with multi-purposes, including protecting public health and safety at the neighborhood, local, and regional scales; focusing on infrastructure and how our systems work together to make our cities and greenways more resilient; and working with our neighboring municipalities, because climate change knows no borders (Climate Ready Boston, 2018).

The multipurpose focus demands that the planning process be multidisciplinary, inclusionary, and have a high level of public involvement (Ahern, 1995), bringing diverse viewpoints and cultural values into the greenway planning and design process, and providing opportunities to raise public awareness and explore the best solutions among decision makers and stake holders on emergent environmental and social-economic issues. This is critical for maintaining cultural sustainability and long-term success for coastal urban greenways.

Conclusion

Global climate change and accelerated sea level rise is a growing threat to coastal cities across the world. Our case studies in Boston and Shenzhen provide insights and valuable lessons for adaptable greenway planning strategies to both face the challenges and mitigate the impacts. The City of Boston has gained greater control of its future by approaching climate change on both a macro and micro level, with both a short- and long-term view, and optimizing its open space assets including its greenway network to drive solutions that have impacts beyond flood protection. The City of Shenzhen, on the contrary, does not have the knowledge and resources, and is far from getting ready to react to the threats of sea level rise and other climate-induced changes at the scale being forecasted by scientists. The destruction of many wetlands is now one of the region's biggest climate challenges.

It is critical that we work together as a global community, sharing resources, experiences, and visions for resilient communities, as the impacts of climate change and sea level rise do not stop at property lines or national boundaries. Immediately, cities need to start adaptation planning and implementation while these interventions can have positive impacts; resilient greenway planning is critical to mitigating and coping with the changes ahead.

References

Ahern, J. 1995. Greenways as a Planning Strategy. Landscape and Urban Planning 33. Pp132.

Boston.gov. 2018. Transformative Plan to Create Resilient, Open Boston Harbor Unveiled. www.boston.gov/news/transformative-plan-create-resilient-open-boston-harbor-unveiled, accessed January 26, 2019.

City of Boston. 2017. Coastal Resilience Solutions for East Boston and Charlestown - Executive Summary. .www.boston.gov/sites/default/files/climatereadyeastbostoncharlestown_executivesummary_web.pdf, accessed January 28, 2019.

City of Boston. 2018. Climate Ready Boston. www.boston.gov/departments /environment/

climate-ready-boston, accessed January 24, 2019.

City of Boston. 2018. Climate Resilient Design Guidelines. www.boston.gov/departments/public - works/climate-resilient-design-standards-and-guidelines, accessed January 22, 2019.

City of Boston. 2018. Go Boston 2030. www.boston.gov/departments/transportation/go-boston- 2030, accessed January 22, 2019.

City of Boston. 2018. Imagine Boston 2030. https://www.boston.gov/departments/mayors-office/imagine-boston-2030. accessed January 24, 2019.

City of Boston. 2018. Resilient Boston Harbor. www.boston.gov/departments/environment/ resilient-boston-harbor, accessed January 22, 2019.

EPA. Why are Wetlands Important? www.epa.gov/wetlands/why-are-wetlands-important

accessed January 31, 2019.

Guangzhou Housing & Urban-rural Construction Bureau. 2010. Guidelines for Comprehensive Planning of Pearl River Delta Regional Greenway Network. pp 13.

Lacambra, Friess, Spencer & Moller. 2013. Bio-shields: Mangrove Ecosystems as Resilient Natural Coastal Defenses. The Role of Ecosystems in Disaster Risk Reduction. pp82.

Liu, K. et, al. 2016. Where Do Networks Really Work? The Effects of the Shenzhen Greenway Network on Supporting Physical Activities. Landscape and Urban Planning. Vol. 152, pp49-58. www.sciencedirect.com/science/article/pii/S0169204616300160#bib0025 accessed January 28, 2019.

Kimmelman, M. 2017. Rising Waters Threaten China's Rising Cities. www.nytimes.com/ interactive/ 2017/04/07/world/asia/climate-change-china.html accessed October 20, 2018

Martin, T. 2016. Greenways as Resilient Infrastructure: The Brooklyn Greenway Case Study. Landscapes and Greenways of Resilience - Proceedings of 5th Fábos Conference on Landscape and Greenway Planning - Landscapes and Greenways of Resilience. (Budapest, 01 July, 2016).

National Geographic (2017). Sea Level Rise. www.nationalgeographic.com/environment/global-warming/sea-level-rise/ accessed January 17, 2019.

NASA, 2017. Rising Seas. www.nasa.gov/goddard/risingseas accessed February 28, 2019.

NASA, 2018. New Study Finds Sea Level Rise Accelerating. climate.nasa.gov/news/2680/new-

study-finds-sea-level-rise-accelerating/ accessed February 18, 2019.

People.cn, 2018. Shenzhen Yantian Golden Coast Pier and the Great Meisha Park Severely

Damaged by Super Typhoon. gd.people.com.cn/n2/2018/0918/c123932-32071306.html,

accessed December 25, 2018.

Searns, R. 1995. The Evolution of Greenways as an Adaptive Urban Landscape Form. Landscape and Planning 33. pp65.

Shenzhen City Government. (2017). Shenzhen Urban Planning and Land Use "Thirteen Five" Master Plan. www.szpl.gov.cn/szupb/tzgg/201711/P020171123406575304097.pdf, accessed January 28, 2019.

Shenzhen National Land Resources Committee (2015). Shenzhen Greenway Network Special Plan. pp100.

UN Environment Programme. 2015. Press Release: Wetlands for Our Future: Act Now to Prevent, Stop, and Reverse Wetland Loss. www.unenvironment.org/news-and-stories/press-release/wetlands-our-future-act-now-prevent-stop-and-reverse-wetland-loss accessed February 3, 2019.

Xinhua News Agency. State Oceanic Administration: Climate Change results in Sea Level Rise. www.xinhuanet.com/politics/2018-03/19/c_1122560481.htm, accessed January 6, 2019.

Yangcheng Evening News. 2013. Shenzhen Land Reclamation for 30 Years with Landfill Lessons www.chinanews.com/sh/2013/08-06/5130406.shtml, accessed January 2, 2019.