

ABSTRACT

Title of Thesis: INFORM: ENGAGING CLIMATE ACTION
THROUGH DIDACTIC ARCHITECTURE

Juhi Goel, Master of Architecture, 2019

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of Architecture, Planning and Preservation

The climate is changing, and so must architecture. Climate change is a fundamental design problem of our time, and it requires us to critically examine and deviate from some of our established practices with regard to the building typologies, materials, systems and design approaches that we propagate. This thesis explores an alternative model for the way we build our future cities - one that is rooted in climate action. It examines the design characteristics of a high-rise timber tower in a dense urban setting, where it effectively acts as a Carbon Sink. It addresses a number of sustainable design practices within a mixed-use program that speaks to a varied audience. And in doing so, it employs didactic architecture - or architecture as a teaching tool - to educate its users about their consumption footprint and inspire them to participate in climate action on a scale that promises systemic change.

INFORM: ENGAGING CLIMATE ACTION THROUGH
DIDACTIC ARCHITECTURE

by

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Dedication

To my incredibly supportive family and friends for encouraging me to keep going.

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I would like to thank all the members of my Committee for their invaluable insight, support and guidance that has helped me grow as a designer and an environmentalist.

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Chapter 1: The Hidden Urgency of the Climate Change Crisis

Vital Signs of Climate Change

The Earth's climate has changed throughout history. Just in the last 650,000 years there have been several cycles of glacial advance and retreat, with the abrupt end of the last ice age marking the beginning of the modern climate era — and of human civilization. In the past, these climate changes have been attributed to very small variations in Earth's orbit that change the amount of solar energy our planet receives. However, the current warming trend is of particular significance because it is proceeding at a rate that is unprecedented over millennia — and most of it has occurred since the industrial revolution era of the mid-20th century¹.

It is crucial to recognize that the current climate change crisis is real, especially since the evidence for significant global warming and rapid climate change is abundant and compelling. The evidence comes from direct measurements of rising surface air temperatures and subsurface ocean temperatures and from phenomena such as increases in average global sea levels, retreating glaciers, and changes to many physical and biological systems.² The changes are not simply limited to systems outside of immediate human interaction, but have already begun to affect human health and safety with an increasing frequency of heat waves, more severe rain and snow events, higher sea levels causing coastal flooding, damage to agriculture and displacement of millions of people due to intensified natural disasters.³

¹ IPCC Fifth Assessment Report, Summary for Policymakers.

² "Climate Change Evidence: How Do We Know?" *NASA*. NASA, September 21, 2018. Last modified September 21, 2018. Accessed October 30, 2018. <https://climate.nasa.gov/evidence/>.

³ IPCC Fifth Assessment Report, Summary for Policymakers.

There is no time to question the legitimacy of the fact that our planet is in fact in a state of crisis. If no mitigating actions are taken at this time, severe and irreversible damage to the planet and its various ecosystems is inevitable.

Recognition of Human Causes

There is unanimous consensus among leading scientific organizations worldwide with more than 95 percent probability that human activities over the past 50 years have warmed our planet. The industrial activities that our modern civilization depends upon have raised atmospheric carbon dioxide levels from 280 parts per million to 400 parts per million in the last 150 years.⁴ This rapid rise in the presence of human-produced greenhouse gases (GHGs) in the atmosphere has caused an unprecedented expansion of the "greenhouse effect" — warming that results when the atmosphere traps heat radiating from Earth back into space, thereby causing much of the observed increase in Earth's temperatures over the past 50 years.

The crux of this issue is that humans have developed a voracious appetite for consumption through their lifestyle choices. This is especially true in the United States, where only 5 percent of the world's population consumes at least one-quarter of practically every natural resource. And because it is the only industrialized country in the world still experiencing significant population growth, this high rate of resource consumption is expected to continue⁵. Moreover, since the United States has

⁴ IPCC Fifth Assessment Report, Summary for Policymakers.

⁵ Yin, Sandra. "Lifestyle Choices Affect U.S. Impact on the Environment." *Population Reference Bureau*. Last modified October 2, 2006. Accessed November 1, 2018. <https://www.prb.org/lifestylechoicesaffectusimpactontheenvironment/>.

come to symbolize a lifestyle of comfort and success for the rest of the world, it is easy for others to fall prey to its dangerous consumption patterns.

It is important to recognize that climate change is a problem that requires a collective action at the global scale, because most GHGs accumulate over time and mix globally, and emissions by any agent - individual, community, company or country - affect other agents. Effective mitigation will never be achieved if individual agents continue to advance their own interests independently. Limiting the climate change crisis requires immediate, substantial and sustained action by humans across the globe to work on two parallel tracks - one, to significantly reduce greenhouse gas emissions in order to mitigate a worsening problem, and two, to adapt their habitats and lifestyles to respond to the inevitable risks of the damage that has already been done.

Problematic Perceptions on Climate Change

Now that it has been established that climate change is real and that humans have most definitely caused it, it becomes important to examine public perceptions on the issue to understand if people feel a sense of accountability towards remedying the problem. On a macro scale, public opinion about global warming and climate change has a crucial influence in informing national, state and local decision-making, policy, and education initiatives aimed at reducing the damage or preparing for the impacts. However, current public opinion suffers from huge disparities between an awareness of the problem of climate change and a sense of personal responsibility to take action. The reason for this catastrophic gap is surprisingly elementary - a critical lack of discourse.

In an annual effort, the Yale Program on Climate Change Communication provides data estimates of U.S. climate change beliefs, risk perceptions, and policy preferences at the state and local levels. As of 2018, the data maps reveal massive disparities between public acknowledgement of the issue, concern for the impacts and action against climate change. While an estimated 70% of people in the United States believe that global warming is real and happening now, a mere 41% believe that the issue will harm them personally. Moreover, only 22% Americans discuss global warming at least weekly⁶. Given this data, it becomes obvious that public apathy and lack of urgency to act against climate change stems from the missing sense of personal stake, which in turn grows out of a lack of awareness and discourse on human relationships with climate change.

Clearly, the first step towards changing public perceptions on climate change is to spread awareness and prompt discourse on the issue. What is crucial now, however, is an amplified sense of urgency that reflects how the crisis may have a much more direct impact on people than they tend to estimate, and that it may affect them sooner than they imagine.

The Tone of Discourse

While there are many ways to spread awareness on mitigating and adapting to climate change, the most effective strategy may constitute visceral moments of interaction that bring people close to the problem, push them to reflect on their own

⁶ Marlon, Jennifer, Peter Howe, Matto Mildenerger, Anthony Leiserowitz, and Xinran Wang. "Yale Climate Opinion Maps 2018." *Yale Program on Climate Change Communication*. Last modified August 7, 2018. Accessed November 1, 2018. <http://climatecommunication.yale.edu/visualizations-data/ycom-us-2018/?est=personal&type=value&geo=county>.

role in subscribing to toxic consumption cycles, and leave them feeling empowered and equipped to take immediate action. At its core, it is extremely important that the tone of this education and discourse not only amplifies the problem to communicate its looming threat to humanity, but that it also keeps people hopeful and motivated to take action.

In fact, a 2014 study conducted by Dr. Nicholas Smith, a social and environmental psychologist at the University of Westminster indicates that the emotions of worry and hope are among the strongest predictors of public support for action against climate change. Dr. Smith argues that while the increase in worry may be motivating some Americans to act on global warming, “hopeful Americans are more likely to discuss global warming with their friends and family and support policies to reduce global warming, such as regulating CO₂ (the primary greenhouse gas) as a pollutant, requiring utilities to use more renewable energy (e.g., solar, wind power), and funding more research into renewable energy and environmental research organizations”.⁷

This psychology of public perceptions and their impact on action against climate change is especially relevant in the volatile American political climate today. During the final years of the Obama Administration and the signing of the 2016 Paris Climate Agreement, there was an overall boost among the public in both hope and worry regarding climate change that sparked conversation, awareness and widespread action. However, from 2017 onward—coinciding with the Trump Administration—

⁷ Smith, Nicholas, and Anthony Leiserowitz. “The Role of Emotion in Global Warming Policy Support and Opposition.” *Risk Analysis*. Wiley/Blackwell, November 12, 2013. Accessed November 1, 2018. <https://onlinelibrary.wiley.com/doi/abs/10.1111/risa.12140>.

Americans have become significantly more worried and less hopeful about global warming, resulting in a drastic fall in public discourse, a loss of accountability and an apathy for the looming effects of the crisis⁸.

Against this political backdrop, it becomes crucial to generate opportunities for public interaction that restore the psychology of worry and hope among people in order to sponsor systemic and long-term action.

The Way Forward

Currently, there is a huge gap between public apathy towards the scale of human consumption and its effects on climate change, and the levels of public engagement required of climate action and resilience. At a time when adopting urgent mitigative and adaptive methods are key, there is still much to be done to educate people in terms of establishing the very legitimacy of climate change and the kind of dangers it poses, the role that humans play in continuing to feed the problem, and the ways in which they can begin to reverse their destructive patterns. This thesis explores the potential of didactic architecture to mobilize such awareness and drive people to action.

⁸ Ballew, Matthew, Jennifer Marlon, Edward Maibach, Abel Gustafson, Matthew Goldberg, and Anthony Leiserowitz. "Americans Are More Worried about Global Warming, and Show Signs of Losing Hope." *Yale Program on Climate Change Communication*. Last modified October 9, 2018. Accessed November 1, 2018. <http://climatecommunication.yale.edu/publications/americans-are-more-worried-about-global-warming-but-show-signs-of-losing-hope/>.

Chapter 2: Why Boston?

The city of Boston serves as a unique backdrop to address the topic of climate change awareness. Although Boston is one of the oldest cities in the United States, it has become one of the global leaders in sustainability and resilience efforts in the last few years. This can be attributed to three main factors.

Firstly, Boston contains a significant amount of green space compared to many other American cities. The city boasts a large park system known as the Emerald Necklace - designed by Franklin Law Olmsted - that spreads over 1,100 acres of different kinds of parks culminating in the largest green space, the Boston Common.⁹ These lush outdoor spaces are valued by Bostonians for a number of reasons, and provide an important association between the city's public and its efforts to conserve the environment. Secondly, Boston has a 47-mile long shoreline on the north east coast of the country that has made it susceptible to floods and storms in the past. It is no surprise then, that when the alarm of climate change is raised, Boston is high up on the list of vulnerable cities and quick to jump on crafting an action plan to address its future risks.

Finally, Boston is brimming with one of the most significant groups of actors in conservation and sustainability efforts anywhere in the world: college students. Nearly every campus in the city has some sort of environmental program, with goals ranging from implementing recycling on their respective campuses to ensuring all

⁹ Campbell, Casey. "Why Boston Is Leading The Nation In Sustainability." *Culture Trip*. Last modified September 18, 2016. Accessed November 4, 2018. <https://theculturetrip.com/north-america/usa/massachusetts/articles/why-boston-is-leading-the-nation-in-sustainability/>

cafeteria scraps are recycled or composted. Increasingly, many of these students – especially those from well-endowed institutions such as Harvard and MIT – go on to start businesses and organizations in these areas of interest, making the city a minefield for innovative green initiatives and startups. This energy across the city keeps it at the forefront of addressing sustainability and resilience.

One could argue that Boston presents the best-case scenario for an American city to have the resources and context to deal with climate change. And yet, there is a significant gap between the city’s aspirations and on-ground action that has been traced back to a lack of public awareness on the severity and urgency of the current climate change crisis. For this reason, Boston serves as a perfect and fitting context to test out this thesis.

Boston at Risk

Boston was ahead of most other American cities in planning for sea-level rise and the effects of climate change before catastrophic storms like Sandy or Harvey hit. Previously, king tides occasionally overtopped downtown wharves, and South Shore waterfront homes were repeatedly battered by winter storms. But now flooding in downtown Boston, the Seaport, and other neighborhoods is becoming a more regular and recurring phenomenon and is increasingly causing property damage, inconvenience and injury.¹⁰

According to the City’s most recent Climate Vulnerability Assessment Report, three major climate hazards will increasingly impact Boston as the climate continues

¹⁰ Ris, Bud. “Climate Change Is Here. Boston Has No Time to Waste.” *Bizjournals.com*. The Business Journals, May 2, 2018. Last modified May 2, 2018. Accessed November 4, 2018. <https://www.bizjournals.com/boston/news/2018/05/02/viewpoint-climate-change-is-here-boston-has-no.html>.

to change: (1) extreme heat, (2) storm water flooding, and (3) coastal and riverine flooding.¹¹ While Boston enjoys a richly diverse population, not all residents are equally able to prepare for, adapt to, and bounce back from these looming temperature and flood hazards. It is important that Boston also considers the social vulnerability of its population – the disproportionate susceptibility of some social groups to the impacts of hazards, including death, injury, loss, or disruption of livelihood – in addressing its response through climate action and resilience.

Primed to be a leading climate-adapted city of the world, Boston needs to drive its planning into action now more than ever before. While the city is already on the path toward resiliency, the real challenge will be to mobilize action at the scale needed by its various initiatives.

¹¹ *Climate Vulnerability Assessment*. Rep. *Climate Vulnerability Assessment*. Mayor Martin Walsh, 2016. Accessed November 4, 2018. https://www.boston.gov/sites/default/files/imce-uploads/2017-01/crb_-_focus_area_va.pdf.

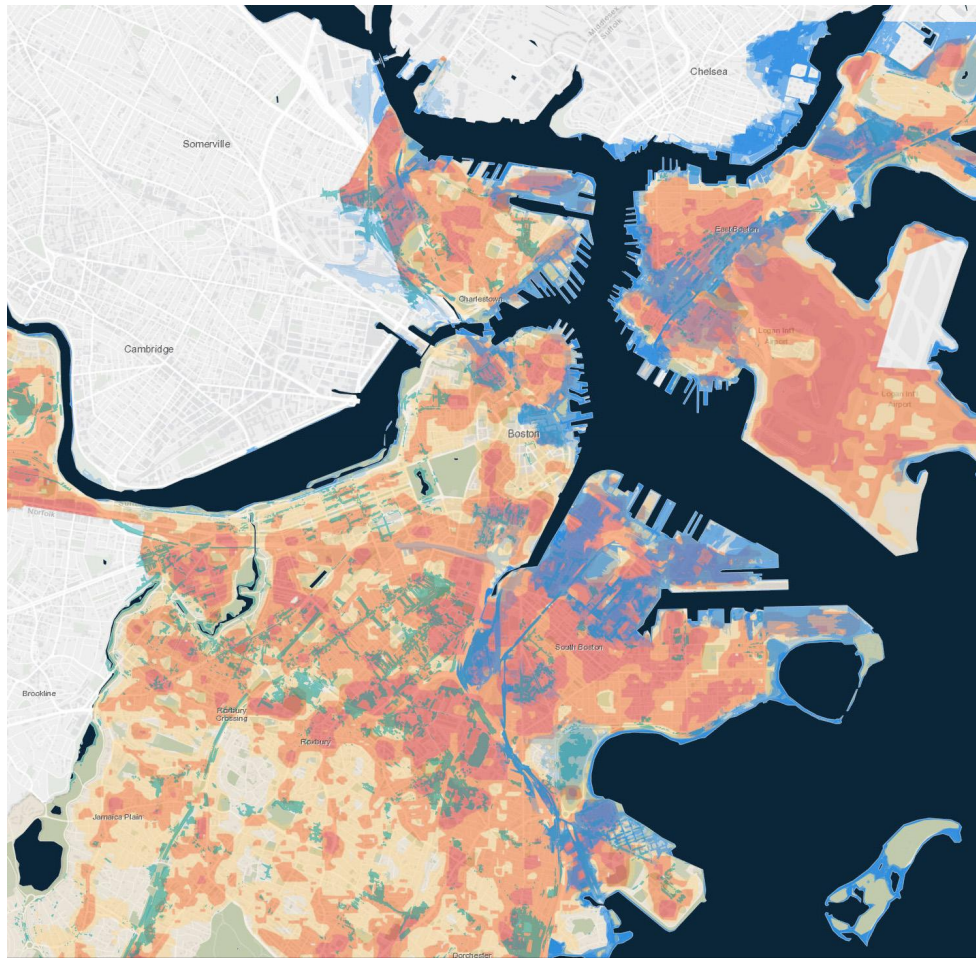


Figure 1: A map of the climate change risks to Boston, specifically with extreme heat marked in orange, and coastal and storm water flooding marked in blue (source: Climate Ready Boston, edited by author)

The Wake-Up Call

Under the proactive guidance of Mayor Martin Walsh, the City of Boston has implemented several plans and initiatives to leading the way on equitable climate resiliency. These initiatives can be used as important points of reference to program and design the Carbon Sink for sustainability and resilience. Some of these initiatives are introduced below:

1. **Imagine Boston 2030:** As Boston's first citywide plan in over 50 years, Imagine Boston 2030 serves as a platform to further identify initiatives that

will help the city prepare for climate change while expanding opportunities to all Bostonians. It focuses on enhancing the vibrancy of the city's neighborhoods, expanding these neighborhoods to find space for housing and jobs, building a resilient waterfront to address the city's flooding issues, and improving access to opportunity to historically underserved neighborhoods.

2. Climate Ready Boston: This initiative has set Boston's climate preparedness agenda by developing a detailed climate adaptation strategy to enable the city to thrive in the face of climate change. It presents a thorough analysis of Boston's climate risks and describes the initiatives the City and its partners should undertake to manage these risks. Climate Ready Boston presents five additional layers of initiatives to create a more climate-ready city: 1) a climate-projection consensus to underpin decision making, 2) empowered communities that are prepared for risks, 3) protected shores, 4) resilient infrastructure, and 5) adapted buildings. These initiatives are guided by principles that produce multiple benefits, leverage building and investment cycles, create layers of protection for the city, incorporate local involvement, and design for flexibility and adaptability.¹²

3. Resilient Boston Harbor: This initiative is focused on protecting the coastal community of Boston by creating resilient, accessible open spaces, and prepared buildings and infrastructure along the city's 47-mile shoreline.¹³

Resilient Boston Harbor has already identified four neighborhoods at flooding

¹² "Climate Ready Boston." *Boston.gov*. Last modified November 30, 2018. Accessed December 8, 2018. <https://www.boston.gov/departments/environment/climate-ready-boston>.

¹³ "Resilient Boston Harbor." *Boston.gov*. Last modified October 17, 2018. Accessed December 7, 2018. <https://www.boston.gov/departments/environment/resilient-boston-harbor#understanding-the-vision>.

risk – including the Downtown and North End District that serves as the site for this thesis – and made detailed design proposals to improve the preparedness of these neighborhoods through a “resilience toolkit”. This toolkit includes recommendations of an elevated harbor walk, reinforced seawalls, floodwalls, beaches and living shorelines, all of which are explored in Chapter 3: Didactic Sustainability and Resilience.

4. **Greenovate Boston:** While the last two initiatives focus on climate readiness, Greenovate Boston is the City's initiative to “get all Bostonians involved in eliminating the pollution that causes global climate change, while continuing to make Boston a healthy, thriving, and innovative city”.¹⁴ The initiative connects residents with energy efficiency tips and resources, and has already reached more than 40,000 Bostonians to date.
5. **The Boston Community Energy Study:** This initiative explores the potential for local energy generation, district energy and microgrids in the city and use tenant-specific energy usage data to accurately determine the energy needs of the city.
6. **Carbon Free Boston:** Carbon Free Boston is a daughter initiative of Greenovate Boston and leads the City’s efforts to reach carbon neutrality by 2050. The initiative will develop a shared, positive vision of a carbon-free future, study the options for achieving that future, find key stakeholders who have a deep understanding for the issues, and create a sense of urgency and willingness to make tough short-term decisions for the future. The project will

¹⁴ “Greenovate Boston.” *Greenovateboston.org*. City of Boston, n.d. Accessed December 7, 2018. <http://greenovateboston.org/>.

focus on these key sectors to reduce emissions: (1)electric power (2)buildings (3)transportation, and (4)waste. Currently, Carbon Free Boston is developing a database of models for Boston’s buildings, so that optimal energy conservation measures (additional insulation, heat pumps etc.) can be identified for each building type and fed into specific policies for building decision makers.

- 7. Zero Waste Boston:** Another subset of the Greenovate Boston initiative, Zero Waste Boston is the City's planning process to reduce waste, spur job growth, and achieve cost-savings by introducing the city to the circular economy. The plan will recommend goals and timelines for waste reduction and disposal cost savings for the commercial, industrial and institutional, and residential sectors that will be forced to reconsider their relationship with the materials they use. The circular economy component will open up a space for innovation as individuals and businesses find new ways to use and remake things, turning what was once deemed waste into valuable resources.

Why Focus on Consumption?

While the City of Boston has launched a comprehensive spectrum of initiatives to address both climate action and resilience, one of these particularly speaks to a much wider audience and requires the participation of the city as a whole: Zero Waste Boston. According to the Zero Waste Advisory Committee’s assessment, Boston residents, businesses and visitors dispose of approximately 874,000 tons per year, of which residential trash comprises 22% of total trash, while commercial trash is 78%. If the Zero Waste initiative is successfully implemented in entirety, its

greenhouse gas emissions reduction potential is equivalent to eliminating all passenger cars in Boston.

The biggest strength of Zero Waste Boston is that makes the public aware of their consumption habits and aims to address a change in destructive patterns, rather than a correction of existing outcomes. The initiative is gearing up to educate the public about materials that are especially wasteful in the area of Organics (32-34%), Construction, Demolition, Deconstruction Debris (17%), Glass (3%), Metals (3%) and Plastic (12%).

Further, the circular economy aspect of Zero Waste Boston would generate upto 1,172 potential new jobs in collection, processing and manufacturing of waste according to the Institute for Local Self-Reliance. In fact, developing circular markets in Boston – those focussed on repair, reuse, remanufacture, compost, and recycling – could be an important contribution the City can make nationally. Especially since China, a major market, may be stopping imports of all recyclables by 2020, Boston would be the first major city in the US developing a Zero Waste Plan in context of this new market reality. This could provide a platform to create a cohort of innovative Zero Waste business accelerators and incubators actively working towards rerouting waste, while the city as such begins to limit its consumption habits that are the root cause of climate change due to their high carbon costs.

The Carbon Sink as a Tool

The numerous initiatives launched by the city of Boston provide a wealth of information and resources that can help the shape the Carbon Sink into a building that

is not only about climate resilience on the Boston shoreline, but also about climate action which has to do with correcting current patterns that are resulting in environmental degradation and climate change. In considering specific programs for the Carbon Sink building, it is important to choose a topic that relates closely to the visiting public and speaks to their role in becoming a part of the change. With larger scale initiative such as Climate Ready Boston and Carbon Free Boston, the problem distances itself from immediately public grasp and internalization and becomes the responsibility of “the other”. The core idea of Zero Waste Boston, however, turns the climate change narrative back to the public and forces them to reflect on the environmental cost of our consumption habits as a society. Using this concept along with the opportunity for the public to start actively engaging in the circular economy could prove to be a powerful program for the Boston Carbon Sink with long lasting effects from a systemic shift in our ecological footprint.

Chapter 3: Didactic Sustainability & Resilience

The issue of climate change often sparks conversations on resilience, but it is perhaps equally or even more important to address continuing human trends in sustainability today than ever before. While there has been a sudden jolt of awareness about the need for climate resilience, there is nothing unexpected about why floods and storm surges on coastlines have become the new normal. These phenomena have been decades in the making: a direct result of human consumption, burning coal, oil, and natural gas to light and heat our homes, drive our cars, and power our economy. Therefore, design methods that attempt to tackle the larger problem of climate change must work on sustainability – or climate action – on a parallel track with building resilience. This Chapter explores some successful ways of approaching sustainability and resiliency in the Carbon Sink.

Sustainable Design Strategies

Of the many approaches to sustainability, there are four that may be particularly relevant to the Carbon Sink for different reasons:

1. **The Living Building Challenge:** This is one of the only mainstream design standards accepted today that is rigorous in its approach to sustainability. The primary focus of the Living Building Challenge is to design self-sufficient buildings that remain within the resource limits of their site. For instance, Living Buildings produce more energy than they use and collect and treat all water on site. The approach looks into the comprehensive aspects of a place, energy, water, materials, health & happiness, beauty and equity surrounding

architecture. In nearly every aspect of this approach, living buildings give more than they take, creating a positive impact on the human and natural systems that interact with them.¹⁵

2. **Biophilic Design:** Biophilic design is an approach to architecture that seeks to connect building occupants more closely to nature. Biophilic designed buildings incorporate natural lighting and ventilation, natural landscape features and other elements for creating a more productive and healthy built environment for people. In addition to its focus on health, this approach is also powerful on a psychological level since it helps users experience and learn from the natural environment while establishing an awareness of our place as humans within the greater natural ecosystem and drives us to value this ecosystem more.



*Figure 2*The Bosco Verticale project in Milan brings a vertical forest into two residential towers in the middle of the city (source: Nguyen Tan Tin, www.flickr.com)

¹⁵ “Living Building Basics.” *International Living Future Institute*. Last modified April 20, 2018. Accessed November 20, 2018. <https://living-future.org/lbc/basics/>.

3. **Carbon Neutrality:** The concept of carbon neutrality revolves around the offsetting of current anthropogenic greenhouse gas emissions with their uptake via biological processes.¹⁶ At its core, this approach analyses the carbon cost – including the life-cycle environmental cost – of every material and process used in a system (in this case, in the architecture and construction industry). Although certain metrics can turn out to be best-guess scenarios for the true carbon cost of construction materials and processes, the concept of carbon neutrality forces us to be extremely conscientious in our consumption.
4. **Minimalism:** The movement of minimalism is most prominent in Japan, where the influence of Zen Buddhism instills a desire for simplicity. In addition to its practical benefits of proposing a cheaper lifestyle and a safer environment in a country prone to earthquakes (and injuries from objects falling over), this culture of minimalism also serves as a great source of inspiration for limiting consumption and extending the life of materials¹⁷. Decluttered, simple and beautiful – these are the essential characteristics of Japanese minimalism that can be applied to an architecture that intends to teach a public to reduce its consumption for a more sustainable future.

¹⁶ “What Is Carbon Neutral?” *Institute for Sustainable Energy - Carbon Free Boston*. Boston University, n.d. Accessed November 20, 2018. <http://sites.bu.edu/cfb/resources/what-is-carbon-neutral/>.

¹⁷ Shamsian, Jacob. “32 Photos That Show How Obsessed Japan Is with Minimalism.” *INSIDER*. INSIDER, August 9, 2018. Last modified August 9, 2018. Accessed December 10, 2018. <https://www.thisisinsider.com/inside-japans-extremely-minimalist-homes-2016-6#its-all-about-having-only-simple-objects-12>.

Sustainable Material Options

1. **Cross Laminated Timber:** Cross-laminated timber (CLT) is a large-scale, prefabricated, solid engineered wood panel consisting of several layers of kiln-dried lumber boards stacked in alternating directions, bonded with structural adhesives, and pressed to form a solid, straight, rectangular panel. Lightweight yet very strong, CLT has superior acoustic, fire, seismic, and thermal performance. It is also fast and easy to install, generating almost no waste onsite.¹⁸ It can be used in structural systems, such as walls, floors and roofs since the panels serve as load-bearing elements, but it is also interchangeable with other wood products and building systems. Like other mass timber products, CLT can be used in hybrid applications with materials such as concrete and steel.¹⁹ Overall, the design flexibility and low environmental impacts of CLT make it a go-to material for sustainable construction. Structurally, CLT has mostly been used in low-rise and middle-rise construction, but recent advances in wood connectors are contributing to a growing market for the material in tall construction.

¹⁸ “Cross-Laminated Timber (CLT).” *Think Wood*. Accessed December 10, 2018. <https://www.thinkwood.com/products-and-systems/cross-laminated-timber-clt-handbook>.

¹⁹ “Cross-Laminated Timber (CLT).” *History of APA, Plywood, and Engineered Wood*. Accessed December 10, 2018. <https://www.apawood.org/cross-laminated-timber>.



Figure 3 Strong and stable, CLT can be used as walls, roofs, and floors in mid-rise buildings. (source: U.S. Department of Agriculture, Flickr)

2. **Charred Wood:** This material is generated by the process of lightly applying open flame to a wood plank to char the surface of the board. A centuries-old Japanese technique known as *shou sugi ban*, this process helps weatherproof and finishing the wood. More importantly, charred wood has found to be a major aid in carbon sequestration and air filtration.



Figure 4 Shou sugi ban or charred wood facade (source: Wikimedia Commons)

3. **Sheep's Wool:** Sheep's wool is growing in popularity as the most effective and sustainable building insulation in the world; it expands over time, doesn't absorb water and is easily renewable. It is not only non-toxic, but it actively absorbs VOCs from the environment.
4. **BamCore:** Bamboo sequesters carbon more efficiently than other trees and can be harvested 3-4 times as fast as the standard wood for lumber that we use today. In its structural integrity, bamboo has been compared to cured concrete in compression and has tensile strength comparable to steel. BamCore is a studless bamboo-based panelized structural system that eliminates about 90% of typical wood studs, headers and posts to reduce thermal bridging and air leakage, which saves operating dollars year after year.²⁰ BamCore's lifecycle analysis concludes that, over the course of 30 years, the carbon cost of shipping their material from South America to California to the east coast is less than that of building a traditional stick house, due to its superior thermal performance.
5. **Bark and Cork:** The combination of bark and cork provide a beautiful and sustainable option for exterior cladding. Bark is technically a waste material that is thrown away when poplars are harvested for plywood and trim. And although cork needs to be shipped from Portugal, it still a better solution to exterior cladding than cement-board on top of rigid foam insulation. Bark and cork together provide an integral exterior insulation envelope built into the cladding and help achieve passive house standards with grace.

²⁰ "Bamboo Building Materials and Construction." *Bamcore*. Accessed December 10, 2018. <http://bamcore.com/>.

6. **Hemp:** Hemp is one of the fastest growing plants and is great for features like ceilings, interior wall finishes, furniture, etc. A new bio-composite material known as Hempcrete is emerging in the American construction sector that combines hemp and lime to create light insulated construction blocks. It is a low density material and resistant to crack under movement thus making it highly suitable for use in earthquake-prone areas. Hempcrete walls must be used together with a frame of another material that supports the vertical load in building construction, as hempcrete's density is 15% that of traditional concrete.²¹



Figure 5 Hempcrete blocks serve as primary thermal and acoustic insulators when they encase a facade (source: Scott Lewis, Flickr)

As an on-going process, it will be important to survey and identify local sources in Boston that can contribute recycled objects and materials such as glass and

²¹ "Hempcrete." *Wikipedia*. Wikimedia Foundation, June 1, 2018. Last modified June 1, 2018. Accessed December 11, 2018. <https://en.wikipedia.org/wiki/Hempcrete>.

metal towards the construction of the building as well as towards interior furnishings and finishes.

Harbor Resilience Strategies

As part of the Resilient Boston Harbor initiative, the City of Boston has identified a ‘Resilience Toolkit’ of ways to protect the Boston shoreline through methods that also improve the quality of life for Bostonions throughout the year. These include some of the following strategies:

1. **Protective Waterfront Parks:** This strategy proposes a more gradual transition from the city’s hardscapes to the waterfront through the use of living shorelines, beaches, elevated waterfront “gateway” parks.²²
2. **Adapted infrastructure:** Elevated roadways, strengthened seawalls and flood barriers can ensure that existing infrastructure in the city is insured against rising water levels.²³
3. **Elevated Harbor Walks:** The Harbor Walk itself serves as a buffer between the city of Boston and the waterfront, and so extending and widening the harbor walk at the site could be beneficial to improving the area’s resiliency. A few different approaches can be used to design the Harbor Walk as a flood buffer: the use of a habitat strip along its water edge, a stepped design that

²² “Resilient Boston Harbor.” *Boston.gov*. City of Boston, October 17, 2018. Last modified October 17, 2018. Accessed December 11, 2018. <https://www.boston.gov/departments/environment/resilient-boston-harbor>.

²³ “Resilient Boston Harbor.” *Boston.gov*. City of Boston, October 17, 2018. Last modified October 17, 2018. Accessed December 11, 2018. <https://www.boston.gov/departments/environment/resilient-boston-harbor>.

allows for a more gradual and adaptable use of the amenity, or simply, an elevated Harbor Walk that anticipates the rise in water levels below it.²⁴

Opportunities for the Carbon Sink

The resources presented in this Chapter will begin to shape an integral part of the Carbon Sink's form, size, texture and spatial qualities. The biggest design challenge for this thesis, however, will be to implement these combined efforts in building sustainability and site resilience in a didactic manner, so that this project becomes a model for the way in which architecture addresses the current climate change crisis with a more comprehensive, long-term and systemic shift in mind.

²⁴ "Resilient Boston Harbor." *Boston.gov*. City of Boston, October 17, 2018. Last modified October 17, 2018. Accessed December 11, 2018. <https://www.boston.gov/departments/environment/resilient-boston-harbor>.

Chapter 4: Site Selection

Since this thesis is focused on generating widespread public awareness on the climate change crisis in Boston, it is crucial that its site be located in a neighborhood that has a large volume of visitors year-round, high foot-traffic around or through the site area and easy access to different modes of transportation. It is also important that the building is situated in an appropriate zoning area that caters to an audience that is willing to engage with its program.

From the standpoint of design intent, there are a few additional criteria that are important to the site selection. The Carbon Sink must have a high degree of visibility – either within the Boston mainland or across the river/harbor or both – in order to truly shine as a symbol for the city’s efforts in this area. Preferably, the site should also be located on a water edge so that the building may have the opportunity to interact with the natural features that are important to the city and therefore tie back into the context of Boston in a visceral way.

These criteria are evaluated against four sites in Boston - the Harbor Garage in North End, two sites in and adjacent to the Fort-Point Channel, and a site in Chelsea. The findings are numbered on a scorecard at the end that is used to arrive at a site selection.

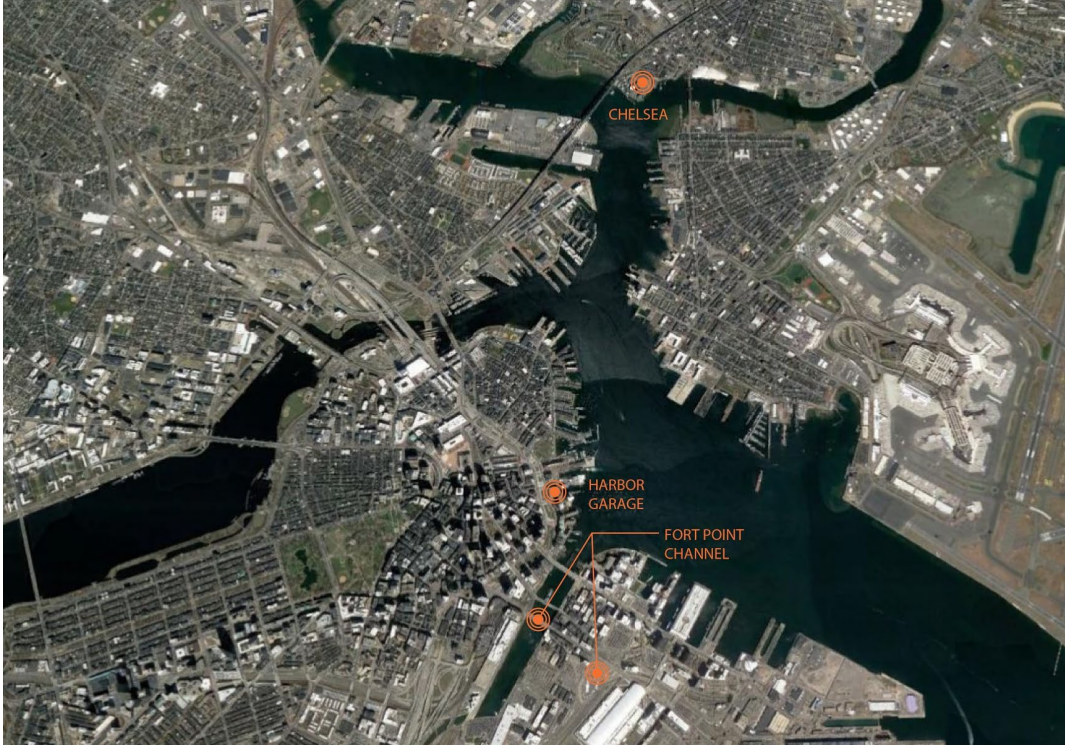


Figure 6: Sites selected for evaluation (source: Google Earth, modified by author)

Harbor Garage in Downtown Boston

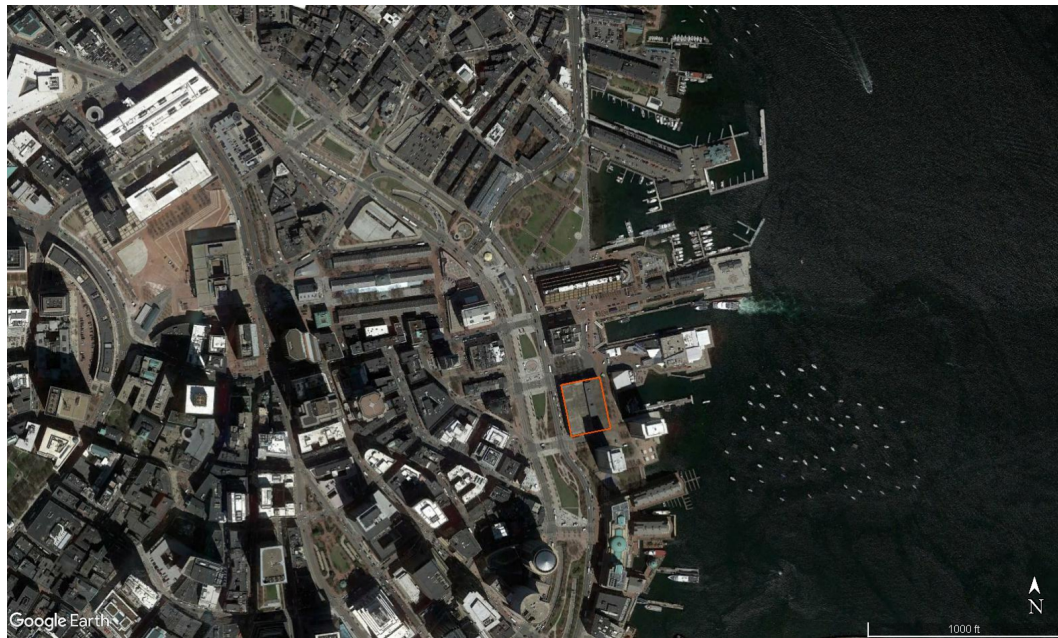


Figure 7: The Harbor Garage in context (source: Google Earth, modified by author)

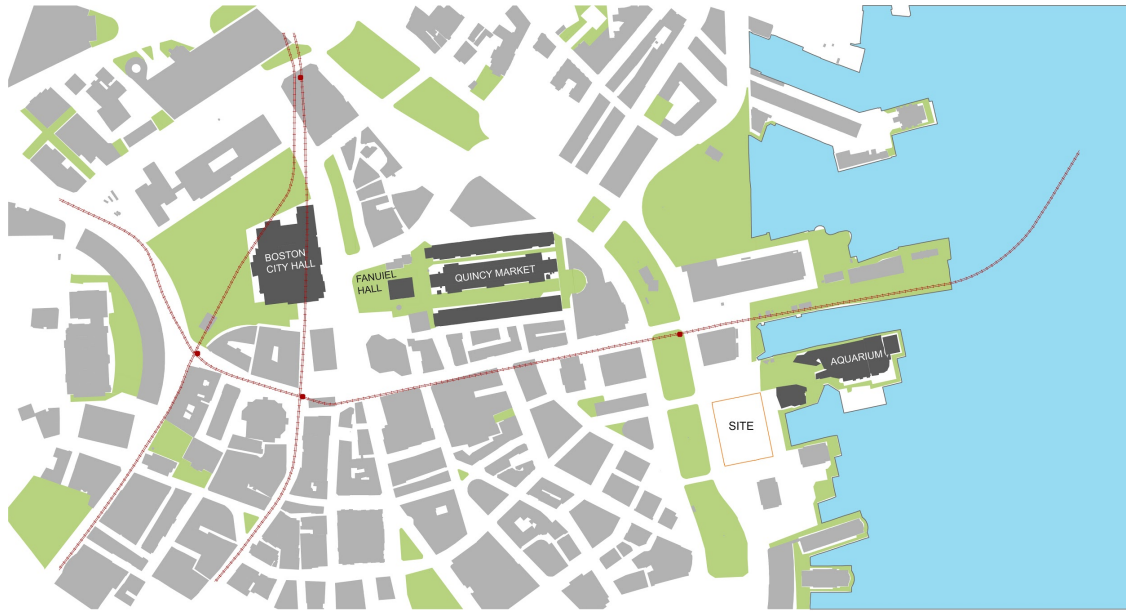


Figure 8: Important buildings, green spaces and public transit around site (source: author)

Pros:

Located adjacent to the famous New England Aquarium, this site and also the Downtown neighborhood in general already draws the largest volume of foot traffic from tourists and locals across the year. This is because the site is located where three prominent neighborhoods overlap: the Financial District that provides trickle-down foot traffic from working professionals looking to enjoy their evening, the North End ‘Little Italy’ Neighborhood that serves as a major recreational hub due to its restaurants and the famous Freedom Walk, and the Government Center that is a hub in itself of working professionals, locals on a chore, and tourists visiting the famous buildings in this district. In fact, the District has number of public institutional buildings as well as major recreational public spaces: the Boston City Hall, Faneuil Hall, Quincy Market and New England Aquarium are all a short walk away, as is the Christopher Columbus Park and the famous ‘Big Dig’ Greenway Park.

The site has excellent accessibility due to the presence of three public transit stops of different subway lines within a 10-min walk, and its location on a major road – Atlantic Avenue - that is also pedestrian and bike friendly. The site caters to a diverse variety of racial and income groups across Boston due to its affordable connectivity and public spaces.

Cons:

Although the site is situated in such a prominent location, its visibility as a symbolic building may be hindered by its proximity to the New England Aquarium and the shadows of the adjacent Harbor Towers when viewed from the water or other coasts. Further, the site has limited access to water despite sitting on the harbor edge because the inlet is relatively narrow here.

Verdict:

If this site is chosen, it will become important to optimize the visibility of the building from the mainland side where the site has a substantial presence. It will also be necessary to solve the building's response to its existing water edge, and its adjacency to the Harbor Towers and the Aquarium.

Fort-Point Channel & Seaport District

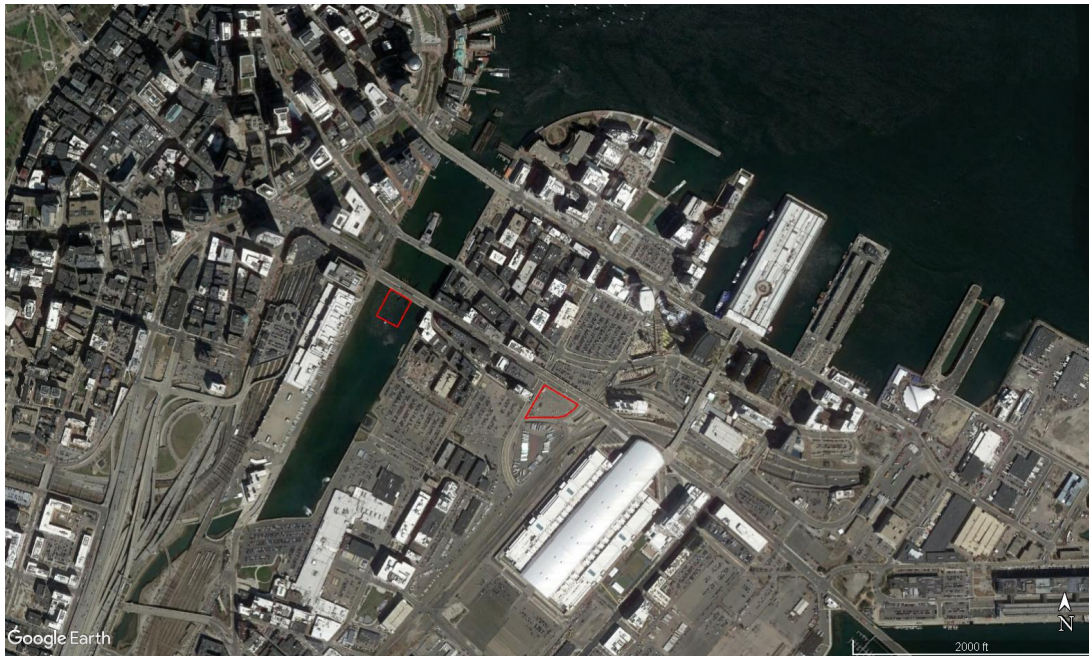


Figure 9: The Fort-Point Channel and Seaport sites in context (source: Google Earth, modified by author)

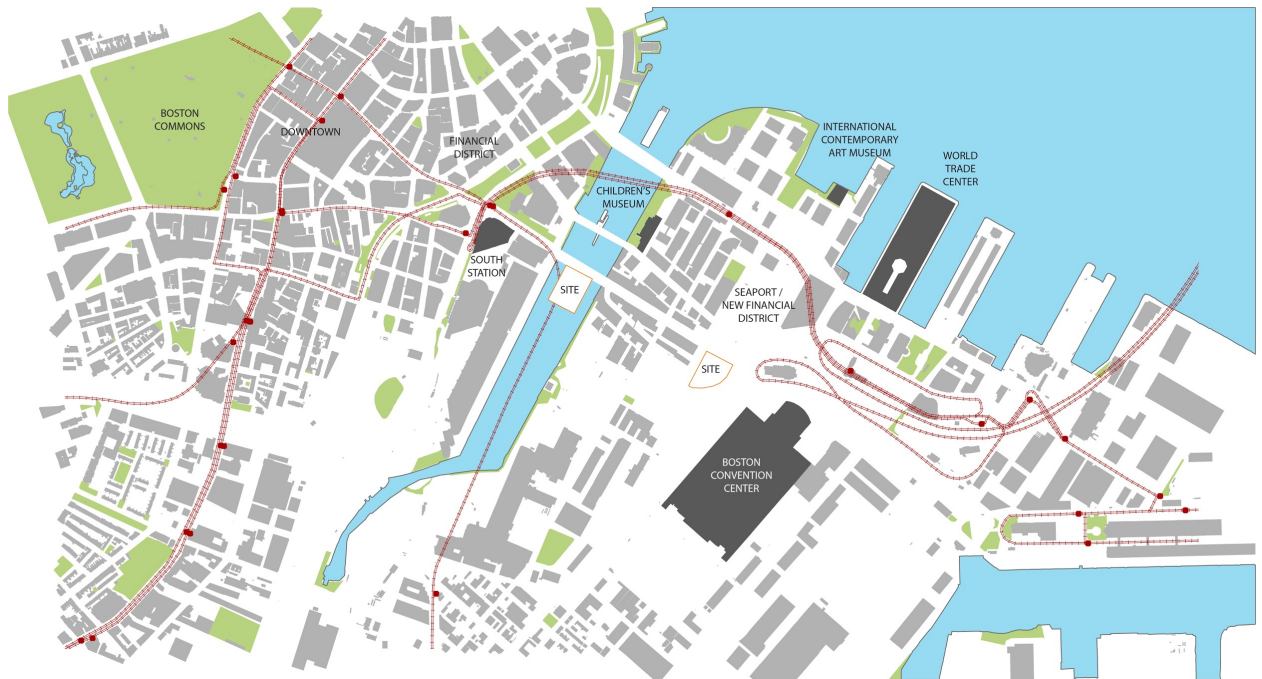


Figure 10: Important buildings, green spaces and public transit around site (source: author)

Pros:

The two sites identified on the Fort-Point Channel and Seaport district are three blocks away from each other and therefore have similar opportunities and challenges. There are also a few institutional buildings located here: the Tea-party museum and Children's Museum are sited at the channel and frequented by locals and tourists, while the International Contemporary Art Museum at the Seaport draws a number of visitors into the Seaport district. The World Trade Center and the Boston Convention Center serve as much larger scale focal points in the Seaport that may bring in a large volume of foot traffic all at once, although sporadically. In terms of visibility, the site could be located off of the bridge on the channel itself to present a new elevation of Fort Point Channel that is visible from both adjacent coastlines as well as boat cruises across the water.

Cons:

This area mainly caters to high-income working professionals in the Financial District to the left of the Fort Point Channel or in the Seaport area to the right of the Channel, and therefore lacks the kind of diversity of public that the Carbon Sink intends to reach out to. Although foot traffic is high here, it is due to the fast-paced requirements of these professionals that are either seeking restaurants for their lunch breaks or are commuting to and from public transportation. Therefore, there is not enough interest in this neighborhood to create an educational-institutional building. Finally, while the ridership for public transportation via South Station is high in the Financial District, there is no particular incentive for people to walk over and encounter the first site at the Fort Point Channel bridge unless they already know about it. The public transit

into the second site in the Seaport district is further limited to a bus service that is currently infrequent and inefficient, thereby restricting accessibility to this area.

Verdict:

If this site is chosen, the Carbon Sink would need to include a program use that would draw in more foot traffic – both from the existing influx of working professionals in the area as well from more diverse socio-economic groups in the city. It would also have to rely on administrative relationships with other organizations to be truly visible, unlike the Harbor Garage site which is visible simply due to the context of its location.

Chelsea



Figure 11: The Chelsea site in context (source: Google Earth, modified by author)

Pros: Due to its location on the edge of the coastline directly across the water from mainland Boston, East Boston and Charlestown, the site in Chelsea can have a

symbolic presence if designed to stand out. There is also a great opportunity here to improve existing site conditions and create a new institutional landmark in a low-income neighborhood where there is none.

Cons: Although the site may have a symbolic presence at the edge of the water, it is far enough from the other coastlines of Boston that it may not actually be very visible from the mainland. It will be seen most frequently by commuters driving on the Tobin bridge, but is physically distanced from the bridge enough that direct access to the site is limited. Further, public transit into this area is restricted to a commuter rail which is expensive and infrequent. Apart from the lack of other programs in this area that may draw a vast volume of foot traffic, the population of Chelsea by itself is unlikely to support the existing program planned for the Carbon Sink, and so the building may have a very limited outreach.

Verdict: If this site is chosen, there would have to be a major shift in the program to cater specifically to the population of Chelsea so that the building does not disrespect its context. Since the initial goal of this Thesis is to maximize outreach of education and advocacy on the current climate change crisis and changing consumption patterns, this relatively isolated site may not serve as the best fit for that purpose.

Evaluating the Site Scorecard

The analysis of the four potential sites in consideration is numbered on a scorecard against the criteria established earlier in this chapter. The Harbor Garage emerges as the best option for the site of the Carbon Sink, especially due to its accessibility to a diverse public.

Selection Criteria	HARBOR GARAGE	FORT-POINT CHANNEL	SEAPORT	CHELSEA
VISIBILITY as a symbolic building	4	3	2	1
PROXIMITY to other institutional buildings	5	4	4	1
ACCESSIBILITY from public transit	5	3	1	1
VOLUME OF VISITORS across site	5	3	3	1
DIVERSITY OF VISITORS around site	5	2	3	2
SIZE ALLOWANCE for program	5	3	4	3
ADJACENCY TO WATER	5	5	5	5
TOTAL SCORE	34	23	22	14

Table 1: Site scorecard from selection criteria (source: author)

Addressing Environmental Justice

Although the site option in Chelsea fares low on the site selection matrix, it offers an important point of reflection as to the intersection of climate change with

relatively isolated, low-income communities. This brings up the question of environmental justice, which is different from the initial intention conceived of the Carbon Sink, but a topic that is extremely important to address in the area of climate change. Boston has a history of racial and economic inequities that make the city's communities of color and low-income areas the most vulnerable to climate change, and it is important that any efforts to combat climate change are committed to helping these communities.

Sparked by the site selection process, the conversation on climate justice will add to the original program conceived in this Thesis. The new programmatic components of this Thesis will now consist of a main Carbon Sink located in the Harbor Garage as well a number of smaller, local and satellite Climate Action Centers located in the low-income vulnerable neighborhoods of the city. As originally planned, the main Carbon Sink will comprise of a large exhibit component highlighting the dangerous relationship between human consumption patterns and climate change as well as work spaces for sustainability initiatives and climate research, and it will cater to local, national as well as international crowds frequenting downtown Boston. The satellite Climate Action Centers will address local neighborhood concerns regarding climate change and resilience through educational programs, organizational partnerships and an emphasis on neighborhood-level advocacy in fighting consumption and pollution.

Both the main Carbon Sink and the individual Climate Action Centers will be linked in their efforts and will inform locals about the presence and progress of the other units, driving a sort of collaborative competition for sustainable resilience

across the city. This way, a larger network for climate action will begin to connect the different parts of Boston together to mobilize large-scale systemic change while attacking specific local issues. This thesis will focus on the design of the main Carbon Sink at the site of the Harbor Garage and provide a “programmatic toolkit” for a typical neighborhood-based Climate Action Center.

Chapter 5: Site Analysis

The Neighborhood

The site of the Harbor Garage is located at an intersection of Boston's most active neighborhoods; although it is technically in Downtown Boston, it lies close to the edge of the North End District, Government Center as well as the Financial District. Due to this premier location, the site is close to some of the most important landmark buildings and areas of the city: particularly the Faneuil Hall Marketplace, the Greenway and – its neighbor – the New England Aquarium. Each of these offer a valuable context to the program of the Carbon Sink, especially in terms of the nature and volume of foot traffic that they bring into the neighborhood.

Faneuil Hall Marketplace

Faneuil Hall is a designated landmark known for its historic meeting hall which was the site of several speeches, and for its marketplace since 1743. Immediately behind this building is the famous and lively Quincy Market, full of food and beverage vendors along a main corridor and clothing and accessory stores above and on the periphery. The area attracts many tourists, with Faneuil Hall alone drawing more than 20 million visitors per year. In 2008, it was rated number 4 in America's 25 Most Visited Tourist Sites by Forbes Traveler. It is two blocks away from the Rose Fitzgerald Kennedy Greenway.²⁵

²⁵ "Faneuil Hall." *Wikipedia*, Wikimedia Foundation, 11 Dec. 2018, en.wikipedia.org/wiki/Faneuil_Hall.

The Greenway & Its Role

The Rose Fitzgerald Kennedy Greenway is a linear park located in several Downtown Boston neighborhoods. Since 2008, the 17-acre Greenway sits on land created from demolition of the unsightly elevated John Fitzgerald Expressway under the “Big Dig” project. It consists of landscaped gardens, promenades, plazas, fountains, art, and specialty lighting systems that stretch over one mile through the Chinatown, Financial District, Waterfront, and North End neighborhoods.²⁶

The New England Aquarium

An immediate neighbor of the Harbor Garage, the New England Aquarium is located on the Central Wharf in downtown Boston between Atlantic Avenue and the Rose Fitzgerald Kennedy Greenway on one side and the waterfront on the other. The Boston Harborwalk goes around the perimeter of the Aquarium. In addition to the main aquarium building, the New England Aquarium also includes the 6-story high Simons IMAX Theatre with about 428 seats for its audience²⁷. This part of the aquarium is the closest building to the site selected for this thesis.

With more than 1.3 million visitors a year, the Aquarium is one of the premier visitor destinations in Boston, drawing large volumes of local and tourist foot traffic into the area. It is also a major public education resource for the region, and is currently working on a new and extended masterplan featuring a new “Blueway” to

²⁶ “Rose Fitzgerald Kennedy Greenway.” *Wikipedia*, Wikimedia Foundation, 9 Dec. 2018, en.wikipedia.org/wiki/Rose_Fitzgerald_Kennedy_Greenway.

²⁷ “New England Aquarium.” *Wikipedia*, Wikimedia Foundation, 6 Sept. 2018, en.wikipedia.org/wiki/New_England_Aquarium.

improve public outreach in the areas of environmental conservation and climate resilience. This is covered in further detail in the last segment of this Chapter that focuses on the current political context of the Harbor Garage site.

The Harbor Garage Site

As it stands today, the Harbor Garage is the closest parking structure to the New England Aquarium and one of the main garages on the Downtown Waterfront. Measuring about 200-ft by 270-ft, the building is a 80-ft tall, exposed concrete structure with 1,560 parking spaces over 7-stories. The Garage was designed by the firm of I.M. Pei and built in the 1960s, and has been part of a redevelopment discussion since 2007.

Accessibility:

The site is easily accessible by foot, bike, car as well as public transit. Due to its adjacency to the Faneuil Hall/Quincy Market area, the North End, Government Center, and the Financial District, this site is extremely pedestrian friendly.

According to Walk Score – an online database that measures the walkability of any address based on the distance to nearby places – this area of Boston is a “Walker’s Paradise” scoring 96 percentile on its walkability to nearby amenities that span dining, drinking, entertainment, shopping, groceries, errands, parks and schools. The site’s Bike Score is also relatively high at 83 percent, because of the frequency of

bike paths, plazas and parks in the area as well as a calm traffic flow with a number of crosswalks stemming from the adjacent Greenway.²⁸

The site has direct street access on three sides, with its fourth side facing the harbor. The longer edge of the site faces Atlantic Avenue which consists of a lane of parking, a bike lane and two high-volume lanes of one-way traffic. Atlantic Avenue is separated by the Greenway from John Fitzgerald Surface Road which brings in traffic in the opposite direction, and both these main roads converge at the famous Charlestown Bridge which connects Boston to Charlestown and Cambridge. The site is also flanked by Milk Street and India Street – which converge into State Street and connect up to the Faneuil Hall area.

The most attractive aspect of this site's accessibility, however, is its relationship to the city's far-reaching public transit network, the MBTA or Massachusetts Bay Transportation Authority. The closest subway stop – the Aquarium station on the MBTA's Blue Line – is a 3-minute walk from the Harbor Garage. All other subway lines connect to the Blue Line, and also have their own stops only a short walk from the Aquarium, including the State stop on the Orange Line which is an 8-minute walk, the Government Center stop on the Green Line which is a 10-minute walk, and the South Station stop on the Red Line which is a 10 to 15-minute walk from the Garage. There is no doubt then, that this site has some of the best accessibility in the entire city that already draws in significant quantities of pedestrians, bikes, cars and commuters from across Boston.

²⁸ "Walker's Paradise: Downtown Boston." *Walk Score*. Accessed November 10, 2018. <https://www.walkscore.com/score/boston-ma>.

Weather

Boston has warm and humid summers, while winters are cold and stormy, with occasional periods of heavy snow. Average temperatures range from 73 °F during the hottest weeks in July to 29 °F during the coldest ones in January. Spring and fall are usually cool to mild, with varying conditions dependent on wind direction. Prevailing wind patterns blow offshore – primarily from the west – towards the Atlantic Ocean to minimize its influence on the city’s temperature. However, areas along the coast often see more rain than snow because the warm air from the Atlantic is able to raise precipitation temperatures, and so snowfall increases dramatically as one goes inland from the coast.²⁹

The micro-climate in the Harbor Garage site is affected by its location on the waterfront, the presence of the Greenway along its inner edge, as well as its neighboring buildings. The Harbor Towers cast a shadow on the Garage during the day, making the site cooler than it would be with direct access to sunlight.

Views

While the Harbor Garage is located on the waterfront, it is overshadowed by the buildings on either side when viewed from the water. To its right is the New England Aquarium, which dominates the waterfront because of its architecture, its cultural significance and its position as one of Boston’s top landmarks. To its left are the Harbor Towers, two Brutalist-era residential towers about 40-stories high designed by the famous architect I.M.Pei. Both the Aquarium and the Harbor Towers

²⁹ “Boston.” *Wikipedia*. Wikimedia Foundation, December 6, 2017. Last modified December 6, 2017. Accessed November 4, 2018. <https://en.wikipedia.org/wiki/Boston>.

are located further out towards the harbor, and together with their height and architecture, they make the site of the Harbor Garage a challenging nook to highlight as an important building on the waterfront. For similar reasons, only half the site allows for views towards the water and these are framed by elements of the two buildings flanking the Garage. Going forward, it will be important to incorporate the proposed Blueway into this view corridor and optimize the design of this side of the Carbon Sink for the opportunities and challenges that this edge presents.



Figure 12 Ground View from the Harbor Garage to the water edge with the Aquarium and Harbor Towers as framing elements (source: Google Earth, edited by author)

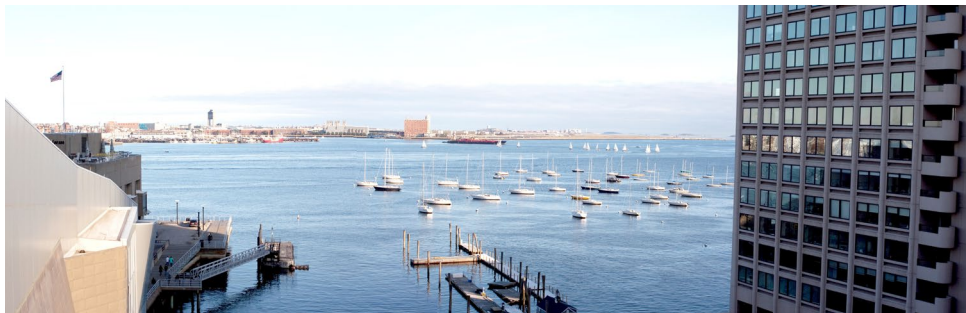


Figure 13: Seventh Floor View from the Harbor Garage to the water edge with the Aquarium and Harbor Towers as framing elements (source: author)

The inner face of the Harbor Garage presents more opportunities than challenges. The adjacency of the longer edge of the site to the Greenway allows for a large void of space in front of it that makes the site of the Harbor Garage extremely visible from anywhere on a long stretch of the Greenway and the streets on its opposite side that lead up to Faneuil Hall, City Hall and Downtown. The curve of the Greenway before and after it meets the Harbor Garage further extends the view corridors to and from the site, with the Greenway itself serving as a landscaped foreground to the building. This layout presents the opportunity to capture a wide panoramic view of Boston from the site in a way that may lead the occupants to reflect back onto the context of their city.



Figure 14: View of the Harbor Garage from the Greenway (source: Google Earth, edited by author)

Zoning & Land-Use

The Harbor Garage site is currently zoned as a Commercial site like a majority of the area in the Downtown district. The New England Aquarium and its associated IMAX

theater that are both adjacent to the garage are zoned as Institutional buildings while the Harbor Towers on the other side of the garage are zoned as Condominiums. For the purpose of this project, it will be assumed that the site of the Harbor Garage will be approved for Institutional zoning like the New England Aquarium.

However, the Boston Planning & Development Agency has recently signed off on a major rezoning of 42 acres of waterfront in downtown Boston, including 22 acres of filled tidelands³⁰. Under the rezoning, 50 percent of the Boston Harbor Garage redevelopment has to be open space. This is discussed further in the Political Negotiations section of this chapter.

Political Negotiations on Site

In an ongoing controversy, the Chiofaro Company – the development firm that has owned the Boston Harbor Garage since 2007 – has proposed to redevelop the site with a 600-ft tall two-tower mixed-use complex with an ice rink as part of a year-round open space. The proposal includes a 55-story residential tower with 120 condos and up to 300 hotel rooms, and a 45 story office building comprising 700,000 square feet of space. If built, these proposed glass buildings would “spill onto the Rose Fitzgerald Kennedy Greenway on one side, and Boston Harbor on the other with view corridors of the water and the city from every angle”.³¹ However, this proposal has faced serious opposition from both neighbors of the Harbor Garage – the Harbor

³⁰ Acitelli, Tom. “Proposed 600-Foot Waterfront Tower Takes Big Step Forward.” *Curbed Boston*. Curbed Boston, March 3, 2017. Last modified March 3, 2017. Accessed November 10, 2018. <https://boston.curbed.com/2017/3/2/14796656/boston-harbor-garage-tower-chiofaro-waterfront>.

³¹ Grillo, Thomas. “Harbor Towers’ Residents Reject Chiofaro Waterfront Project.” *Bizjournals.com*. The Business Journals, July 23, 2014. Last modified July 23, 2014. Accessed November 14, 2018. https://www.bizjournals.com/boston/real_estate/2014/07/harbor-towers-residents-reject-chiofaro-project.html?page=all.

Towers as well as the New England Aquarium - providing valuable insights to their concerns with the site.

An opposition letter from the Harbor Towers letter states that the massive size of this project would bring major shadows, wind and traffic to the Greenway, Atlantic Avenue, the John Fitzgerald Surface Artery, the harbor, the marinas and the neighborhood. The residents agree that the garage is not attractive and does not represent the best use of the space, but they feel that Chiofaro's proposal presents an overwhelming and unfitting leap in height, density and massing. Clearly, these are important parameters to keep in mind in the schematic design proposal of the Carbon Sink.

The New England Aquarium is more willing to accommodate Chiofaro's proposal, but only if its two major demands are met. Understandably, the Aquarium wants a guarantee that the Chiofaro Company will underwrite the institution's financial survival amid what could be three years of construction on the Harbor Garage site that is located right on the approach to the aquarium. Aquarium officials are concerned that the institution currently operates on razor-thin margins, and work on turning the garage into a tower full of residences, retail, and offices could "tip it permanently into the red".³²

The second demand of the New England Aquarium presents a big change in the masterplan of the current site with a program that could be extremely useful to the agenda of the Carbon Sink. The Aquarium has asked for a 1,000-foot perpendicular

³² Acitelli, Tom. "New England Aquarium to Harbor Garage Builder: We Need a Guarantee." *Curbed Boston*. Curbed Boston, April 24, 2017. Last modified April 24, 2017. Accessed November 14, 2018. <https://boston.curbed.com/2017/4/24/15405262/boston-harbor-garage-tower-new-england-aquarium-deal>.

extension of the Rose Kennedy Greenway, dubbed the ‘Blueway’ into Boston’s waterfront where the Aquarium is currently situated. The latest master plan calls for a public promenade that will feature broad sightlines from the Rose Kennedy Greenway to the aquarium and waterfront, and offer a cohesive design to expand the public’s access to this area. It will bring the Aquarium’s environmental mission out into the public realm through transformative outdoor exhibits, and serve as a model for strategic resiliency planning on the harbor.³³ The proposal presents a great opportunity for the Carbon Sink project to share the ‘Blueway’ with the Aquarium since the two institutions have a common intention to educate the public about climate change and spur their participation in climate action and resilience.

The Way Forward

There is no doubt about the strong potential of the Harbor Garage site to successfully implement the climate awareness agenda of the Carbon Sink. With its current location in a bustling recreational, commercial and tourist district with a high degree of accessibility, diverse foot traffic, visibility and proximity to some of the most famous spaces in the city, the site is already set up to speak to a vast majority of the city’s public.

The ongoing redevelopment plans for the site present valuable parameters for the Carbon Sink’s relationship with its neighbors. The redevelopment proposal begins to inform the potential massing, scale and height for the site in a city where density is important, but the concerns regarding these implications could also inform the built

³³ Flaherty, Holli. “The Blueway: Our Vision for a Transformative Waterfront.” *New England Aquarium*. Accessed November 14, 2018. <https://www.neaq.org/about-us/mission-vision/blueway/>.

form on the site. Further, the current demands of the Aquarium regarding the 'Blueway' present a new opportunity to extend the program of the Carbon Sink beyond its initial constraints and think about the public spaces that this building could utilize as an amenity to tie into. These findings from this site analysis will therefore play a major role in shaping the program and massing of the Boston Carbon Sink.

Chapter 6: Program Explorations

The programmatic elements of this Thesis are aimed at informing, enhancing and optimizing Boston's efforts to become a leader in sustainability and resilience as a response to climate change. The program will attempt to narrow the gap between this aspiration and on-ground action – that exists primarily because of a lack of public awareness of the severity and urgency of the problem – by promoting education and discourse at various levels of interaction with the building. In essence, this building will not only aim to serve as a carbon sink with its materials, but also with its programmed spaces.

The Carbon Sink will therefore consist of three broad categories of spaces – (1) **green incubators** or offices used by professionals, students and climate scientists and researchers committed to investigating solutions to climate change, (2) **residential areas** used by residents committed to living responsibly, and (3) **the green alley** used by the public to experience and tour through the didactic features of the building while also using some of its commercial amenities. There will be a visible overlap of certain spaces between these categories to inspire different groups of people and increase their participation in the different action areas of the building. The programmatic breakdown of each of these categories can be found below.

Green Incubators

The more private programmatic elements will include a climate research institute that continues to update predictions, evaluate progress and identify at-risk opportunities for action, as well as incubator workspaces for city-wide initiatives,

start-ups and student programs that are actively working towards solutions in the areas of building and commercializing renewable power generation, sustainable transportation, energy efficiency, battery storage, industrial waste recycling, water conservation and more. These two action areas will share a number of resources between them since they will be working towards a shared goal.

1. Conference / Meeting rooms / Classrooms

There will be 10 flexible rooms that can be used as conference rooms or meeting rooms by the incubator businesses, organizations and full time researchers at the Carbon Sink. These can also double up as outreach and educational classrooms that provide a link between school programs visiting the public exhibits and those who are more involved with the Carbon Sink’s efforts so that the public is drawn into these efforts.

2. Permanent Offices

The action area of the Carbon Sink will house up to 30 full-time research and advocacy professionals with their own office spaces.

3. Co-working Open Office

Permanent designated desk in a shared open office for sustainability startups.

4. Co-working Lounges

Access to an open spot or “hot desk” in the common area additional lounge seating.

5. Resource library

A small library of the Carbon Sink’s research-relevant books, digital media and materials will be made available to everyone involved in the action area.

6. Labs

The Labs at the Carbon Sink will provide spaces to incubators and organizations focused on solutions that help reduce consumption and waste generation or innovate new methods and products by which materials can have a second life. Flexible lab space will allow any technology-based startups to develop their initial research into prototyping, and prepare for commercial development. Wet labs will provide tools and equipment to startups working in areas of green chemistry, advanced materials, water, and energy storage need to conduct their experiments.

7. Kitchenette

8. Service Spaces

Residential Areas

The residential segment of the building will consist of a combination of one, two and three bedroom apartments in order to serve a diverse and mixed-income resident pool. A typical program mix for apartments in the building may be in the following range:

- 40% 1 bedrooms
- 30% 2 bedrooms
- 10% 3 bedrooms
- 20% shared amenities

The shared amenities may take the form of an urban gardening balcony or terrace on every floor or a larger sustainable design driven amenity that every few floors that

also acts as a community space. This will be determined through the design exploration phase of the Thesis.

The Green Alley

The public exhibit component of the Carbon Sink is intended to serve as the main point of attraction that will draw the larger public into the discussion on climate action. Through its programmatic subdivisions, it will teach visitors about the impact of their consumption patterns, spark personal reflection on the urgency of action and demonstrate to the visitors how it is transforming some of these patterns in order to affect the scale of systemic change that is required to combat climate change. Some of the main spaces that could serve well in the Green Alley are outlined below.

1. Entry

Information desk and coat check

2. Green Café & Restaurant

The Green Alley may have a café or restaurant to serve organic and locally grown dishes to residents and visitors to the building. These may be located to activate the ground plane of the building and/or draw visitors to its upper levels as well.

3. Organic Grocery Store

Unlike a typical grocery store which encourages more consumption, the Carbon Sink's groceries will come with a significantly lower carbon footprint and be served by the urban agriculture on site as well as within a sustainable transportation radius in the city.

4. Reflection Pond

The nature of this space has to be calming but also empowering as it serves as a transition into the climate action, programs and facilities of the Carbon Sink.

5. Waste Drop-off Center

The Carbon Sink will also be focusing on reducing and reusing waste, and so a waste drop-off component in the program will help the public actively participate in the initiative every time they visit or, in some cases, draw people who are dropping off their waste into the building. This space will require a loading dock with sustainably designed waste channels for batteries, e-waste, packing materials, compost, etc. The design of this space will exhibit ways in which materials from the Zero Waste Boston Initiative (and others) can be reduced, substituted, repaired and repurposed through the concept of the circular economy. It will also have an attached space for some amount of sorting and processing of waste that can later be used by the Green Incubators or the Green Alley.

6. Breakout lounges

Workshops and tours may be conducted for parents, local residents or commuting professionals to showcase the more expressive and didactic aspects of the architecture that can teach them about their local environment. The Green Alley should therefore be equipped with substantial public seating and lounging areas.

7. Service spaces

The exhibits will need support spaces for equipment - mechanical, electrical, and storage based. The building will also have to provide restrooms for an average capacity of at least 1500 visitors per day, and other utility rooms.

8. Outdoor Resilience Exhibits

Boston's resiliency plan outlines specific recommendations on resiliency infrastructure that can also improve the public realm. These options include extending the Harborwalk — the public's walking path around the harbor— over the water, strategically filling the harbor to create more expansive public space, and developing floating shorelines with native vegetation or integrated seawalls that create places for gathering while providing increased protection from flooding.³⁴ The Carbon Sink could both provide for and take advantage of these resources through outdoor exhibits and conservation efforts that also fuel this resiliency plan.

Programmatic Relationships

The different programs of this building will be designed to interact with each other, so that the Carbon Sink takes a net-zero approach to its waste, power, water, food and overall footprint. For example, residents living in the building may bring their trash down to the waste sorting facility to separate and discard their waste there. While the waste processing center is part of the Green Alley and will be working towards sorting waste for recycling and reuse, the ideas, strategies and innovations on

³⁴ Abbott, Kathy. "As Weather Warms, Don't Lose Urgency about Seaport Resiliency." *Bizjournals.com*, The Business Journals, www.bizjournals.com/boston/news/2018/04/18/viewpoint-as-weather-warms-dont-lose-urgency-about.html.

how to generate a circular economy for this waste will be actively occurring within the Green Incubators of the building. This way, the topic of waste is threaded through all the users of the building and also becomes a didactic outcome for visitors watching these interrelationships in action. Such programmatic overlaps are intended in various other aspects of the building and will be explored in further detail through the design process.

Chapter 7: Precedent Study

Selection Criteria

Considering the scale and complexity of the program proposed in the Carbon Sink, it becomes extremely important to study any precedents that may relate to the programmatic relationships of the project, its focus on spatial narrative, the importance of site interaction and an applied methodology of didactic sustainable design. This chapter examines three precedents based on the aforementioned criteria and evaluates each of them to draw inspiration and/or offer a critique of design decisions as they may apply to the Carbon Sink.

Precedents and Selection Criteria	Programmatic Relationships	Spatial Narrative	Sustainable Design	Interaction with Site	Notes
California Academy of Sciences, San Francisco	•		•		
Lemvig Carbon Sink, Denmark	•			•	Unbuilt. Study based on competition entry.
The National Aquarium Masterplan, Baltimore	•	•		•	Study based on proposal for future updates to aquarium.

Table 2: Summary of precedents and their selection criteria (source: author)

California Academy of Sciences

Architect: Renzo Piano

Location: San Francisco

Date of Completion: 2008

Area: 410,000 square feet (100,000 square feet of public space)

Program: The California Academy of Sciences is one of the few institutes in the world that combines exhibition space, education, and conservation and research facilities all beneath one roof. The exhibits comprise an African natural history section, separate planetarium and rainforest exhibits within their own glass dome structures, an underground aquarium and an exhibit hall with rotating topical displays. The Academy conducts research in over 12 scientific fields with a staff of over 50 professional educators and PhD-level scientists, supported by more than 100 Research and Field Associates and over 300 Fellows. Through a “public lab” space, the Academy exhibits its ongoing research to the general public to bridge the gap between private initiatives and public awareness. Additionally, the Academy can accommodate private events with seated parties of up to 1,000 people.³⁵



Figure 15 California Academy of Sciences (source: Wikimedia Commons)

³⁵ “California Academy of Sciences.” *California Academy of Sciences*. Accessed October 20, 2018. <https://www.calacademy.org/>.



Figure 16 Indoor Rainforest at the California Academy of Sciences (source: Wikimedia Commons)

Sustainability features: Designed by award winning architect Renzo Piano, the California Academy of Sciences sets a new standard for sustainable architecture as the world's first "Double Platinum" museum. Supported by 95% of recycled steel, 68% insulation from recycled blue jeans, powered in part by 60,000 photovoltaic cells generating 213,000 kilowatt-hours of energy, and topped with a living roof, the building is the epitome of energy-efficient design. The building uses 30% less energy consumption than the federal code requirement by optimizing the use of natural light and ventilation for both research as well as exhibit spaces.³⁶

Key takeaways: The California Academy of Sciences is successful in blending the program of a private research institute with that of a largely public museum, through

³⁶ Azzarello, Nina. "Renzo Piano's California Academy of Sciences." Web log. *DesignBoom*, July 24, 2013. Accessed October 20, 2018. <https://www.designboom.com/architecture/renzo-pianos-california-academy-of-science/>.

the use of an intersecting “public lab” where the public can view on-going private research. The project provides some valuable insights on how to create didactic micro-habitats within a man-made structure that is both high-performing and biophilic. That said, while the exhibits at the Academy comprise of mutually detached spatial experiences, the Boston Carbon Sink will seek to weave its exhibit component into a linear coherent narrative.

Lemvig Klimatorium

Architect: 3XN

Location: Lemvig, Denmark

Date of Completion: Currently in design phase; scheduled to open in 2020.

Area: Unknown

Program: The Lemvig Klimatorium is a beacon project of the Coast to Coast Climate Challenge (C2C CC) in Denmark which aims to secure the country’s natural assets from the negative impacts of climate change.³⁷ Once built, the Klimatorium will specifically focus on collecting and sharing knowledge about water in a programmatic framework that will combine the areas of science and education, climate tourism and innovative businesses to work towards a common goal: solving Denmark’s climate challenges. The building will be used for educational exhibitions on climate change, conferences, concerts and events, and has the potential to become a new local meeting place, as it also includes a café and lounge space.³⁸

³⁷ “About Lemvig Carbon Sink.” *Klimatorium*. Accessed October 20, 2018. [https://www.visitnordvestjylland.com/In-int/lemvig/about-lemvig-Carbon Sink](https://www.visitnordvestjylland.com/In-int/lemvig/about-lemvig-Carbon-Sink).

³⁸ “About Lemvig Carbon Sink.” *Klimatorium*. Accessed October 20, 2018. [https://www.visitnordvestjylland.com/In-int/lemvig/about-lemvig-Carbon Sink](https://www.visitnordvestjylland.com/In-int/lemvig/about-lemvig-Carbon-Sink).

Site Interaction: The Lemvig Klimatorium will be situated at the city’s waterfront to pay tribute to the area’s nature and its local fishing culture. As a response to its site, the building will invite its guest in through a wooden entrance shaped like a wave, referencing a ship’s hull, the fjords within the country and the waves of the sea.³⁹ This seamless relationship between the building facade and the site create a sort of “climate landscape” for the project.

Key Takeaways: The Klimatorium will be using the Quadruple Helix innovation model in its program to focus on the relation between university, industry, government and civil society in a way that is similar to the symbiotic programming intended for the Boston Carbon Sink. As it moves forward in its design phases, it may serve as an important programmatic precedent since it will be the first official “Klimatorium” in the world.

National Aquarium, Baltimore

Architect: Studio Gang

Location: Baltimore, Maryland

Date of Completion: Proposed in 2015 as a masterplan for future updates

Area: 360,000 sf with 37,000-sf urban wetland

Program: The Strategic Master Plan for the National Aquarium focuses on improving the visitor experience and reinforcing the organization’s commitment to environmental conservation and education at various scales. The plan coordinates the architectural experience of indoor and outdoor exhibits with educational labs and

³⁹ Angelopoulou, Sofia Lekka. “3XN Wins Competition to Design a New Waterfront Carbon Sink in Lemvig, Denmark.” Web log. *DesignBoom*, September 5, 2018. Accessed October 20, 2018. <https://www.designboom.com/architecture/3xn-waterfront-Carbon-Sink-lemvig-denmark-09-05-2018/>.

classrooms through a redesigned circulation sequence to enhance visitor flow through the amenities. This sequence takes visitors on a programmed journey through the various ecological zones of the Chesapeake watershed, the United States' largest estuary and among the most fragile. The plan also proposes hub-like lounge spaces to engage with the site's local ecology in a casual setting.⁴⁰

Site Interaction: At the urban scale, the plan suggests connecting the Aquarium's current facilities, separated by a former ship slip in Baltimore's Inner Harbor, with a new urban wetland that will speak to the Aquarium's conservation efforts. The wetland will unify the exhibits on both piers: while Pier 3 would offer an expansive tour of global "Hope Spots," treasured places on the planet that are worth protecting, Pier 4 would become the domain of the Chesapeake Bay Watershed. The design of the wetland itself is based on the geometry of Chesapeake Bay tidal meanders to put the entire site into its context.⁴¹

Key Takeaways: The changes and additions proposed in the Aquarium Masterplan provide valuable insights into achieving a connected narrative within a large comprehensive exhibit and educational space through a strategically programmed use of the site (as a new preserved wetland in the case of the Aquarium). The Boston Carbon Sink could also draw from the "circulation corrections" made within the Aquarium building to provide a better visitor experience.

⁴⁰ "National Aquarium Strategic Master Plan." *Studio Gang*. Accessed October 25, 2018. <http://studiogang.com/project/national-aquarium-blueprint>.

⁴¹ "National Aquarium Strategic Master Plan." *Studio Gang*. Accessed October 25, 2018. <http://studiogang.com/project/national-aquarium-blueprint>.

Conclusion

The three precedents presented in this chapter offer valuable lessons in their programmatic relationships, spatial narratives, sustainable design techniques and site treatment. The follow recommendations synthesize the applications of these learnings with the context of the Boston Carbon Sink, and may be used as design guidelines for the project going forward.

1. The visitor experience of the Boston Carbon Sink should be designed as a promenade, but with the option to detach and engage with different sustainable design features throughout the building.
2. The Carbon Sink must not only engage its surrounding site with its program, but draw from its locational advantages to make it a substantial component of the narrative, even if that requires an adjustment of the story being told.
3. It is important that the aesthetic of the narrative prioritizes the communication of the building's climate action agenda, so that the architecture evokes the desired emotional engagement from its occupants.

In addition to these design guidelines, the design process for the Boston Carbon Sink could continuously benefit from referring to the spatial details of the precedents discussed in this chapter. It is important for the success of the Carbon Sink project to critically evaluate any relevant design decisions that were made in the past, and build on them for a better architecture.

Chapter 8: Design Proposal

This Chapter presents the final design characteristics of the Boston Carbon Sink - the high-rise timber tower that addresses a number of sustainable design practices within a mixed-use program that speaks to a varied audience. It highlights the didactic architecture features of the building that successfully educate its users about their consumption footprint and inspire them to participate in climate action on a scale that promises systemic change.

Program Layout

After considering a variety of programmatic combinations, the final design proposes the following program distribution in the Carbon Sink:

1. A ground floor or plaza level of green commercial spaces
2. Four floors of “green incubator” office spaces
3. Thirty-five floors of mixed-income residential apartments
4. A “green alley” public promenade through multiple floors of the building
5. Four levels of underground parking

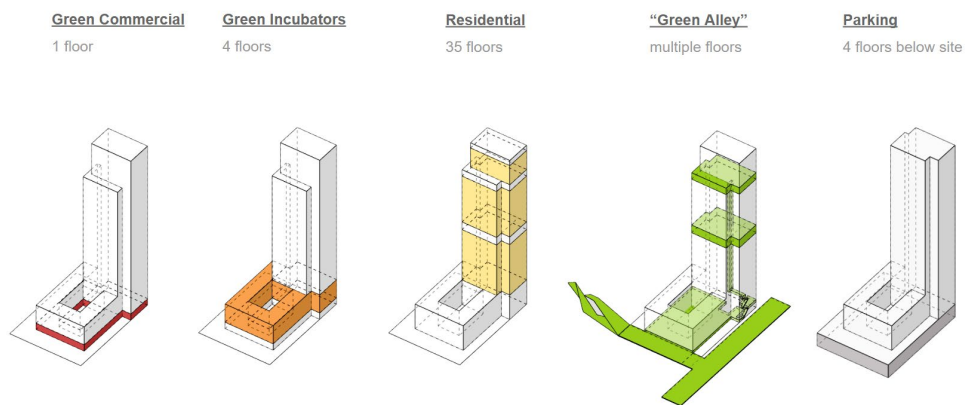


Figure 17: Final programmatic distribution in building (source: author)

The location, adjacencies and spatial relationships of these programs are illustrated in Figure. The next few sections of this Chapter take a closer look at the design characteristics of each of these programs.

Site Design

The urban design at the base of this project converses with the neighboring New England Aquarium and the proposed Blueway while creating new destinations along the harbor and also drawing foot traffic into the Carbon Sink itself. Since the site is primarily approached from the north – by public transit, vehicular drop-off and foot traffic coming from other landmarks around the site – this warrants the location of a vast public plaza at the junction with a combination of hardscapes and landscaping.

The circulation through the plaza leads foot traffic to four destinations: (1) the New England Aquarium, (2) the Blueway promenade, (3) the Fish Cove with public seating overlooking fish-farming activities on the harbor and (4) the courtyard entrances into the Carbon Sink building. The paths to either of these destinations are guided by “cloches” or miniature greenhouses that are harvested to contribute to the organic grocery store inside the Carbon Sink. These cloches on the plaza are open to the public, serving as outdoor didactic spaces that teach about urban agriculture as people navigate the plaza to go to either of its destinations.

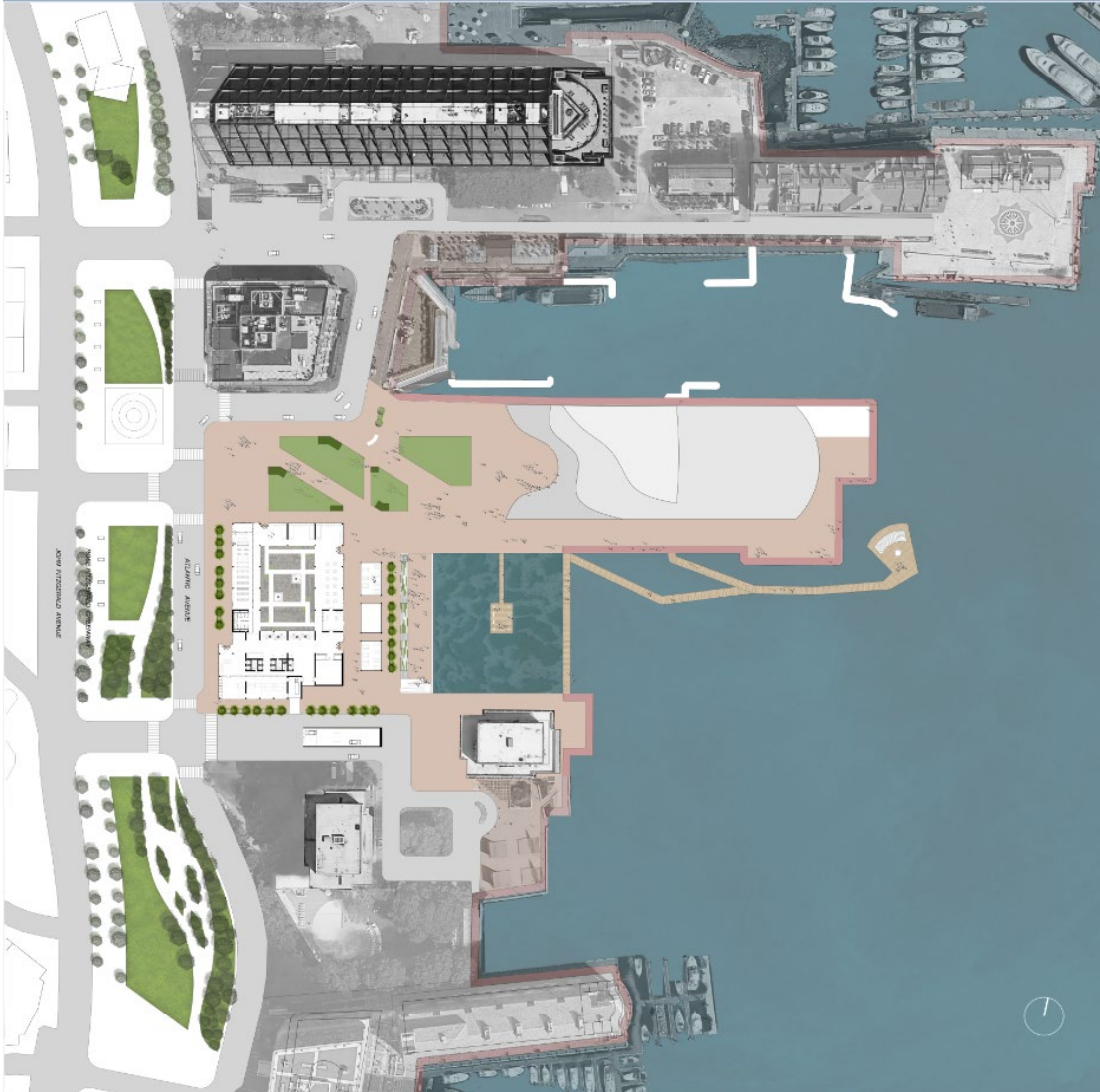


Figure 18 The site design of the Carbon Sink lends itself to interacting with the New England Aquarium and the Blueway promenade while creating new destinations. (source: author)

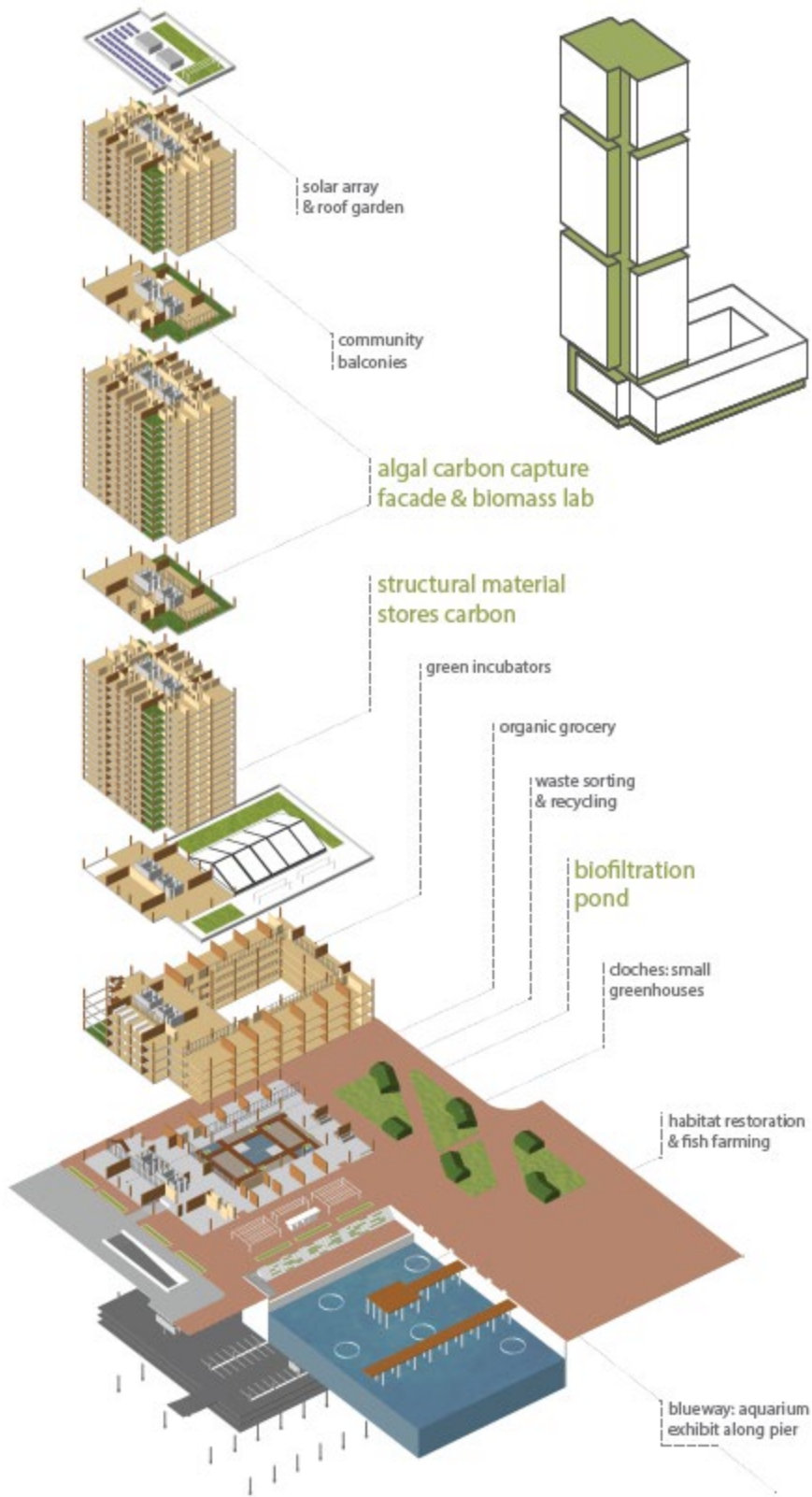


Figure 19 An exploded axonometric drawings highlighting the sustainable design features of the building; the same features that become a part of its Green Alley experience starting at the plaza level. (source: author)

Architectural Experience

The main entrance of the Carbon Sink is located at the north façade of the courtyard, inviting the occupant through a threshold into an indoor-outdoor bio filtration pond surrounded by sustainable commercial programs at the plaza level and four floors of green incubator offices above. The green commercial spaces at the plaza level comprise of an organic grocery store facing Atlantic Avenue to activate the street experience of this building, and a food court and organic restaurant to the north and east respectively that activate interactions between the outdoor plazas and the building's interiors.

The bio filtration pond thus acts as an oasis of reflection in the middle of all this activity. As the first major sustainable design feature on the Green Alley, the pond uses natural elements to filter the greywater output of the building, actively contributing to its climate action agenda while serving as a didactic tool for those seeking to learn more about our water treatment.

As one navigates the paths of the bio filtration pond or walks further along the grocery store, they are greeted by the main reception lobby of the Carbon Sink. This lobby consists of three sets of elevators serving the vertical circulation outlined earlier in this Chapter: two public elevators serving the Green Incubators and the Green Alley, four private elevators serving the residential floors of the building and two elevators that take both residents and the public down to the underground parking garage. In order to receive and coordinate this diverse group of users, the lobby provides substantial lounge seating and circulation porosity.

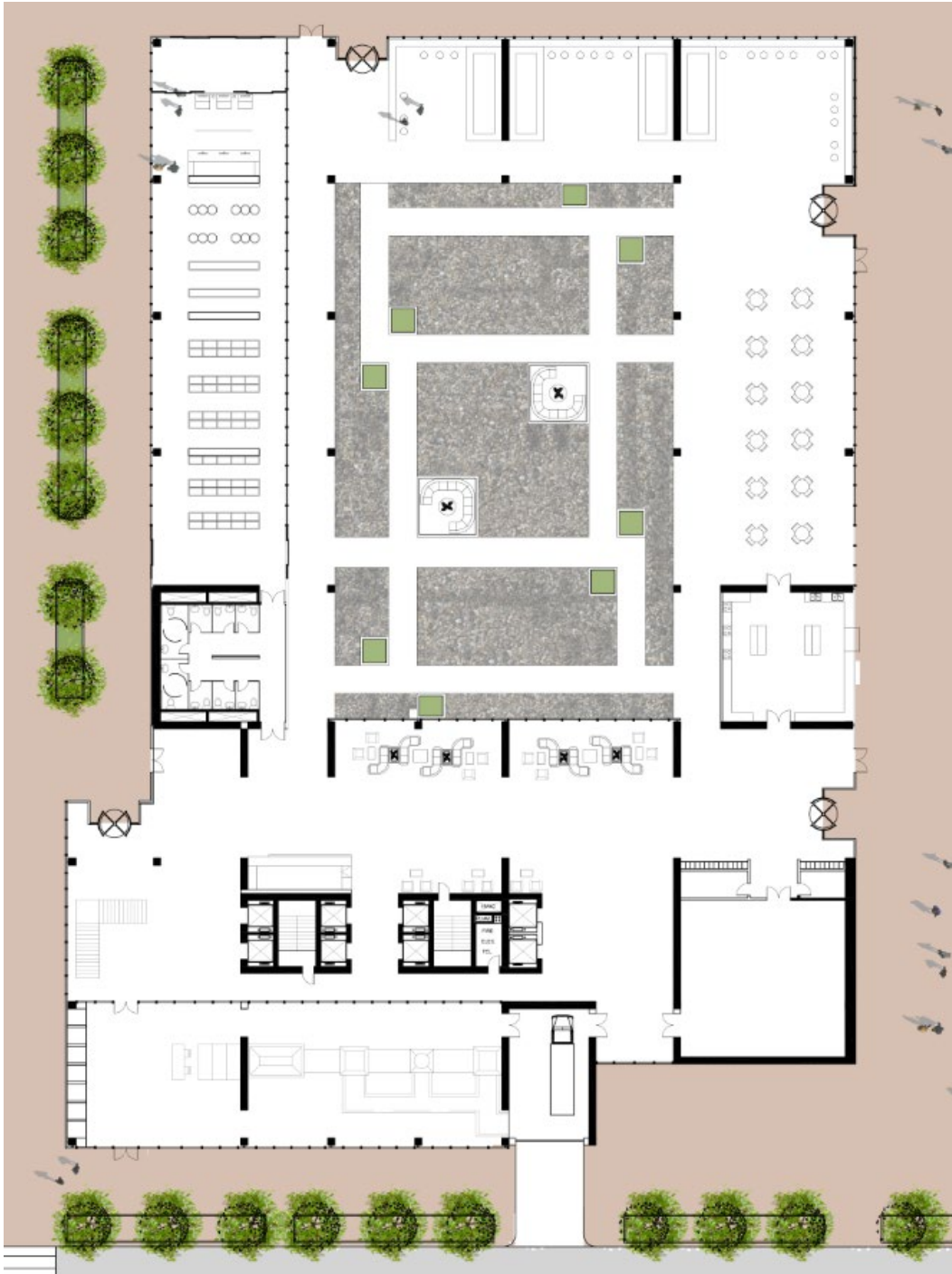


Figure 20 Plaza Level Plan (source: author)



Figure 21 Courtyard view from the North entrance of the Carbon Sink (source: author)



Figure 22 Lobby view from the Atlantic Avenue entrance of the building, with the waste center to the right of the public elevators (source: author)

Finally, the lobby also serves as a threshold into the waste drop-off and sorting center in the building, where residents and visitors alike can participate in the building's waste management practices. The waste center is transparent wherever possible to make the public aware of the building's consumption and its celebration of a circular economy or a reusing and repurposing culture, thus serving as another important didactic stop through the building.

The next four floors of the building serve as the office component of the Carbon Sink; the Green Incubators that house a number of small start-ups and organizations working on different kinds of climate action initiatives. Due to the flexibility desired by these spaces, the typical floor plan of the Green Incubators consists of modular open plan segments that can adapt to different office layouts as well as a number of meeting and conference rooms of different sizes all arranged along the courtyard form of the building. To the south of the elevators, each of these incubator floors is equipped with a prototyping lab which can be adapted to a chemical, physical or biological lab based on the requirements of the incubators occupying the Carbon Sink.

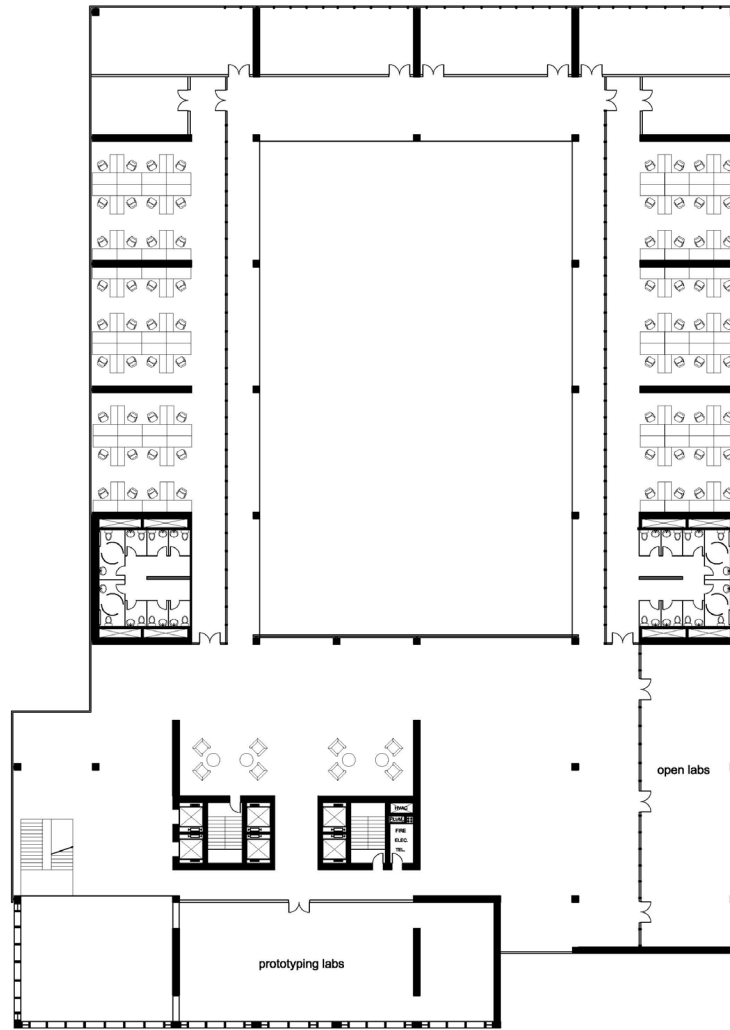


Figure 23 Typical Green Incubator Floor Plan (source: author)

The residences in the Carbon Sink are accessed by their own set of elevators to ensure privacy – either directly from the lobby level for the first fifteen floors or from the sky lobbies that are first accessed by express public elevators. Each residential floor consists of one 3-bedroom apartment, two 2-bedroom apartments and four 1-bedroom apartments in a single-loaded donut plan. Each floor also allows for semi-public balconies that allow for shared interactions while residents come together to invest their time in composting small-scale urban agriculture.

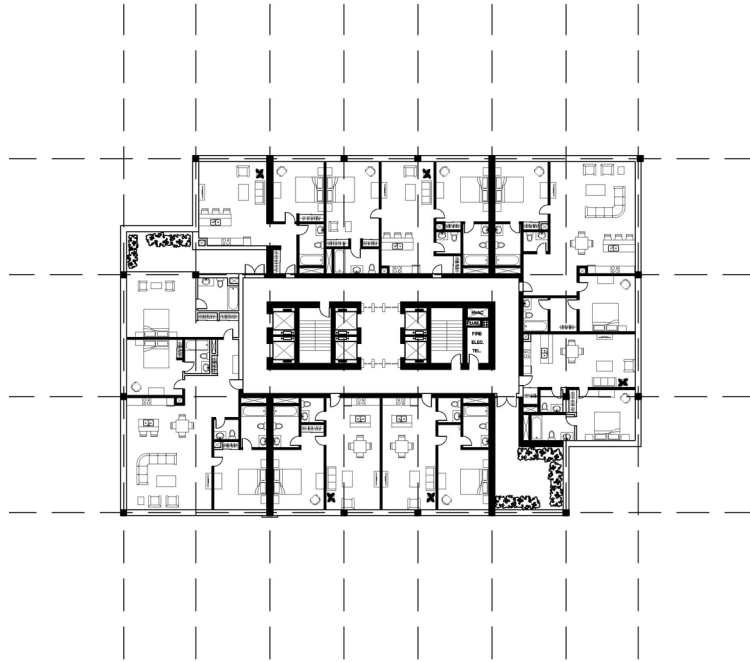


Figure 24 Typical Residential Floor Plan (source: author)

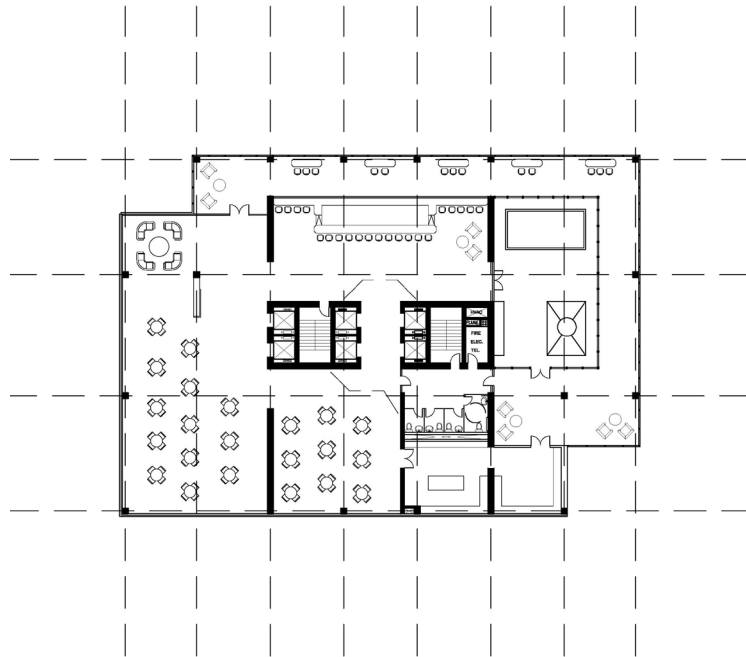


Figure 25 Sky Lobby Floor Plan (source: author)

For the residents using the express elevators and for the public visiting the Green Alley of the building to study its didactic features, the sky lobby serves as a crucial component of the Carbon Sink’s architectural experience. The sky lobby consists of an organic restaurant with panoramic views of the city’s skyline and the Boston Harbor, through the lens of an algal carbon-capture façade. The façade consists of 18-inch thick glass panels filled with translucent green microalgae that are bubbled in with carbon dioxide exhaust from the building’s mechanical systems. The microalgae not only capture and digest this carbon, but they also generate heat in the process that can be reused by the building’s systems. They then turn into biomass, and are collected and processed on a periodic basis within a designated biomass lab on each sky lobby level.

Equipped with this carbon capture façade system, the sky lobbies at the Carbon Sink truly act as the lungs of the building, and can be programmed to absorb carbon from the rest of the city.



Figure 26 The Carbon Sink restaurant serves as a major draw to the public seeking to visit, especially because of its unique algal carbon-capture facade (source: author)

Structural Approach

At 42 storeys tall, the Carbon Sink is a unique timber tower that is yet to be built in the real world. Therefore, this Thesis adopts a structural model recently published by the architecture firm SOM that makes an informed deduction as to how this building might come together. Following the model, the Carbon Sink will be a hybrid timber structure, consisting of a concrete core that pushes out reinforced link beams and perimeter spandrel beams at every floor. These concrete beams then hold 8-inch thick structural cross-laminated timber (CLT) floor panels that are typically sized at 8ft wide by 40ft long. The timber floor panels make up a solid structural floor for glulam columns and CLT shear walls to rest on, so that most structural elements of the building still consist of mass timber, effectively making it a carbon sink.⁴²

⁴² Timber Tower Research Project. *Skidmore, Owings & Merrill, LLP*. May 6, 2013. Accessed March 14, 2019.

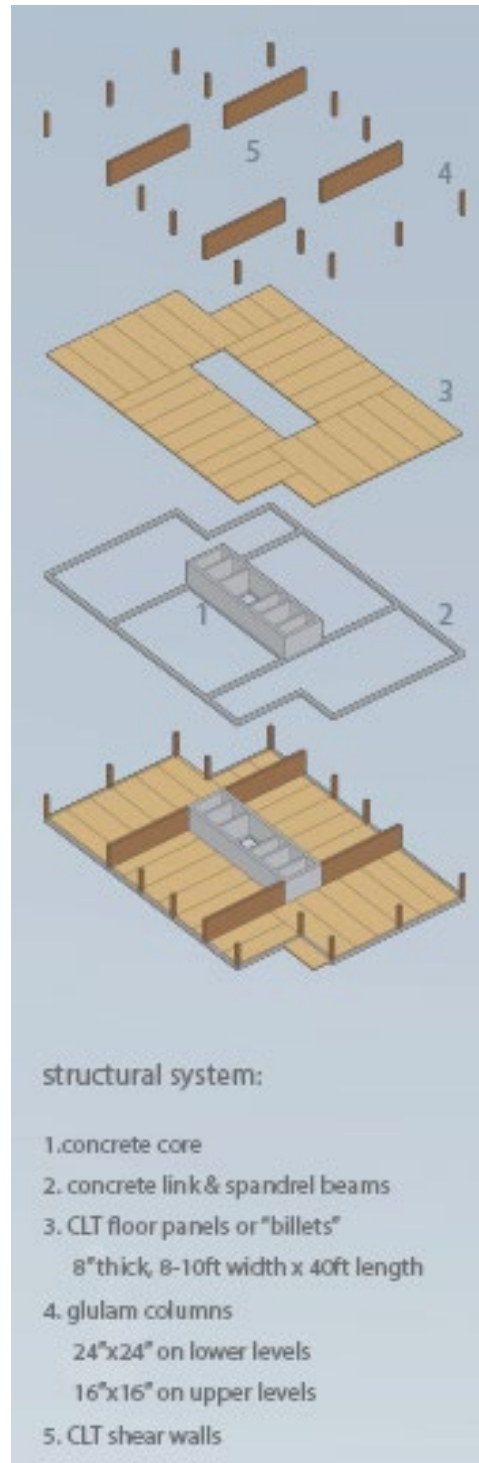


Figure 27 Exploded axonometric of hybrid structural system (source: author)

Façade as a Symbol

In order for the façade of the Carbon Sink to stand as testament to its name, it was necessary for its aesthetic to not only celebrate the novel use of mass timber in its architecture, but to also highlight the unique programmatic elements brought about the green alley in the building, especially where algal carbon capture panels were used. The Carbon Sink strategically showcases these algal bio-façade at its green alley floors, contrasting the green micro-algae panels against the textured exterior wood panels that address the rest of the building skin.

At the residential segments of the building, the façade utilizes vertical louvres along the living room edges of its apartments, addressing the sun's glare from its eastern and western angles while also providing a distinctive reading for the building. Along the bedroom portions of the residential floorplate, the façade assumes an alternating pattern between solid exterior wood panels and operable window panels to provide an adequate combination of privacy and daylight to these spaces. This mosaic is also extended to the green incubator program of the building, where the courtyard building assumes the alternating pattern of solid and void.

Against the backdrop of downtown Boston – primarily composed of steel, concrete and glass - the Carbon Sink therefore stands as a symbol of change. It not only incorporates sustainable design materials and systems, but showcases them to the public realm through its façade, provoking public discourse on climate action.



Figure 28 The facade acts as a didactic tool for the building, highlighting its sustainable features and serving as a symbol for its efforts (source: author)

Conclusion

In a rapidly urbanizing world with an enormous demand to house and shelter billions of people in the upcoming decades we must find solutions for our urban environments that have a lighter climate impact than today's structural materials. This Thesis proposes a model that allows us to be surrounded by building materials and systems that are manufactured by nature; and serve as a constant inspiration for us to engage in the conversation on sustainability that is critical today. With its design proposal, this Thesis has the capacity to address major challenges of climate change, urbanization, sustainable development and world housing needs through a new didactic architecture; one that is rooted in climate action.

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