8-15-2023

Incorporating Climate Change Resiliency into Urban Planning: Green Infrastructure in Boston and Copenhagen

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August 15, 2023

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Introduction

Flash flooding across the United States East Coast from intense summer storms has become a recurring threat and is only predicted to worsen with climate change (Davis, 2023). But water management in cities is not a new problem. Dealing with water in cities is a core aspect of urban planning and development. The earliest cities were structured around the movement of water for sanitation, drinking, and power (Brown et al., 2009), and infrastructure for water management has been designed based on the typical annual patterns for precipitation and climate. However, climate change is leading to extreme rainfall events, flooding, heat waves, and more intense storms (Ran & Nedovic-Budic, 2016). These impacts are also only predicted to increase with continued global warming (IPCC, 2022).

Cities face a unique challenge in dealing with climate change. High levels of impermeable surfaces lead to less infiltration of precipitation and widespread flooding. Extreme rainfall events and greater flood risks are predicted to impact conventional stormwater systems (Reu Junqueira et al., 2022). Furthermore, the urban heat island effect also enhances the increased temperatures caused by climate change (Wilby, 2008).

Natural climate solutions provide an opportunity to meet these challenges. The UN 2030 Agenda for Sustainable Development emphasizes the maintenance of urban green spaces to reduce vulnerability and exposure to climate change risk at low adaptation costs (Sturiale & Scuderi, 2019). Specifically, green infrastructure utilizes natural infiltration processes to improve

water quality, increase green space, enhance biodiversity, and reduce the urban heat island effect (EPA, 2023). Green infrastructure minimizes flood risk by reducing the load put on existing stormwater infrastructure through increased infiltration and runoff storage (Jia et al., 2015). Using green infrastructure combined with traditional methods of handling large volumes of water can increase the environmental and health benefits (Reu Junqueira et al., 2022). In cities, this can include parks, public green spaces, private gardens, bio-retention cells, permeable pavement, and street gardens (Haase et al., 2017).

As a result, climate resiliency planning requires cities to evaluate and update existing structures for stormwater management. My paper examines this process of incorporating climate resiliency into urban planning. I asked the following questions: How are Boston and Copenhagen working to integrate climate resilience principles into existing institutional structures for stormwater management? Specifically, what are the barriers to the adoption of green infrastructure? And finally, how can climate adaptation facilitate meaningful community engagement and climate justice?

Methods

To answer these research questions, I conducted a comparative policy analysis between two case studies: Copenhagen, Denmark and Boston, Massachusetts, USA. These cities share common challenges with climate change in that water management plays a key role in adaptation. Both cities will likely see increased flooding, extreme precipitation, and heat waves (Climate Ready Boston, 2016; “The CPH 2025 Climate Plan,” 2012). In addition to facing similar challenges, Copenhagen and Boston are both relatively progressive cities positioned as leaders in sustainable urban planning (Biodiversity Information System for Europe, 2020). As a

result, case studies of Copenhagen and Boston provide a unique opportunity to analyze urban climate change resilience policy, as challenges for incorporating resiliency and justice principles would likely be larger in other places.

I conducted qualitative research, including semi-structured interviews and site visits to green infrastructure projects. Research on specific green infrastructure projects also allowed me to explore the challenges associated with constructing and maintaining green infrastructure. I completed 14 interviews with experts from different stormwater management and climate adaptation backgrounds. Participants were recruited by email from publicly available contact information. I spoke with city officials, water utility providers, architects, and academics from each city to get a holistic perspective on green infrastructure projects and climate adaptation. Prior to each interview, I provided consent information to interview respondents. Each interview lasted thirty or more minutes. I began each interview by asking participants to describe their experience with climate adaptation and green infrastructure. Based on their response, I used a guide with follow-up questions related to general themes of the evolution of green infrastructure use in the city, challenges with implementing projects, and aspects of community engagement. Recordings of interviews were uploaded to Panopto, a software that creates transcripts. Common themes from the participant's views and experiences informed the three main components of the paper. First, I answer how green infrastructure is being utilized in each city and incorporated into existing structures, then I outline the main challenges identified, and finally, I discuss the opportunities for community engagement.

How is green infrastructure being utilized in cities and incorporated into existing structures?

Stormwater management is a critical component of urban planning. Both Boston and Copenhagen have incorporated traditional stormwater infrastructure techniques into development. However, the use of green infrastructure for climate adaptation is relatively new. In Boston, the use of green infrastructure existed prior to major climate adaptation efforts and is now being scaled up in the process of expanding the city's resiliency. Whereas in Copenhagen, the use of green and blue infrastructure became popular as a part of the climate adaptation planning process in 2012.

Green infrastructure was first introduced to Boston in 1879 as part of the Emerald Necklace, which is a network of parks and parkways that stretches across the city, making it the first piece of green infrastructure in the United States (Emerald Necklace Conservancy, 2023). A Boston engineer explained how since 1879, Boston stormwater management mainly consisted of gray infrastructure intended “to collect water as quickly as you can” and “get it out to the river.” In 2012, the city’s water utility provider, Boston Water and Sewer Commission (BWSC), entered a consent decree with the Conservation Law Foundation and the EPA, which legally required the use of green infrastructure to treat stormwater pollution (Marks, 2014). BWSC conducted green infrastructure demonstration projects to meet these water quality requirements (Marks, 2014). As a result, a BWSC employee who has been working with them for over 45 years described how “the first time we were doing green infrastructure was really for stormwater quality purposes.” The city began incorporating climate resiliency planning a few years later, in 2016 with the first Climate Ready Boston report. The initial report was then followed by coastal resiliency planning and neighborhood-specific adaptation work. The election of Green New Deal Mayor Michelle Wu in 2021 and her appointment of Kate England as Boston’s first Green Infrastructure Director led to a new focus on the role of stormwater management for climate resiliency.

Interview respondents from Boston outlined how these changes have led to a transition from the original goal of green infrastructure for water quality purposes to one that incorporates its co-benefits for climate resiliency. A Boston city official explained how Boston has adoption a broader definition of green infrastructure to "meet many current challenges beyond just water quality and localized stormwater flooding." When asked about the definition of green infrastructure, they explained:

> If you ask Boston Water and Sewer and other stormwater professionals what green infrastructure is, you're going to get a very stormwater-centered definition… And that's not incorrect. It's just a limited definition of green infrastructure as an approach to improving out water quality in our ecosystems and making our cities more resilient.

The consent decree that requires a focus on water quality drives BWSC's stormwater-centered definition and may have delayed the overall acceptance of nature-based solutions for climate change. Despite this, a Boston city official who has worked on Boston's energy and environment policy for over 15 years remarked that within the last decade, green infrastructure is "becoming a preferred alternative for folks who are engaged in climate work."

Expanding the definition of green infrastructure has allowed Boston City Hall to market it to different departments to meet multiple needs. A Member of the Mayor's cabinet outlined the plan of "integrating green infrastructure into everything the city does" and making it "the normal way of doing things." Specifically, this aims to create small, distributed infrastructure projects through policies set for other departments. Another member of Climate Ready Boston explained that now the city is looking back on plans to incorporate stormwater flood management into existing coastal resiliency projects and hopes to have that be the norm for future projects. The

city is also planning to start mapping larger-scale flood management projects where green infrastructure would have a regional impact.

For Copenhagen, the use of blue and green infrastructure became a priority following the 2011 Cloudburst. In that event, six inches of rain fell in less than three hours, leading to extensive flooding across Copenhagen and over $1.04 billion USD in damage (Gerdes, 2012). The cloudburst led to the development of Copenhagen's Climate Adaptation Plan in 2011 and the subsequent Cloudburst Management Plan in 2012, which prioritize nature-based solutions (Negrello, 2023). The Copenhagen interviews all identified this as a key transition point for the city. A city planner described how "climate adaptation would become the backbone for city development." Similarly, a professor at the University of Copenhagen explained that since then, "any time you think about, like renovating a place, you also think about how climate adaptation and stormwater management fits into that." The city focused on specific neighborhoods vulnerable to flooding. The neighborhood of Østerbro was redeveloped to be the first climate-adapted neighborhood (Appendix A, Figures 1-4). The city has completed large-scale projects for water management in Østerbro, including the traffic circle Skt. Kjelds Plads, which reworks the flow of traffic and incorporates green retention surfaces with 586 native trees (Negrello, 2023; Appendix A, Figure 2).

While ambitious, the implementation of these distributed cloudburst projects across the city had to be re-evaluated from its initial plan. A Copenhagen municipal official explained that the city ran into an issue with how one project would then alter the movement of water throughout that area:

> We started adding cloudburst projects into existing urban projects. And then we realized we cannot disconnect the water connection… How one project implemented in one area affects water in the rest.

So instead, the municipality changed the approach to creating a holistic plan for the city. The shift to larger-scale planning supports research on the integration of green infrastructure in cities and how water pathways are interconnected within the larger urban landscape (Reu Junquiera et al., 2022). In addition, the original plans implemented following the cloudburst were focused on managing a 100-year flood event. However, new regulations from the state are now requiring the city to shift its planning goals to instead focus on smaller flood events that are more in line with socioeconomic budgets. A water utility employee explained that "in the future, I think we will not see the projects that will handle a 100-year rain event anymore," which "will result in much fewer and smaller projects."

When adopting green infrastructure alternatives, there are options for small-scale or large-scale techniques. Reu Junqueira et al. (2022) find that converting and distributing small green infrastructure areas along the catchment maximizes their benefits. Utilizing green infrastructure for climate adaptation does not mean that cities must clear large areas for redevelopment. Alternatively, green infrastructure can be highly efficient when strategically placed in catchment areas within existing structures like sidewalks, roads, and bike lanes. While both cities are considering nature-based solutions for stormwater management, Copenhagen and Boston are moving in different directions in relation to the scale of green infrastructure. Copenhagen began with large-scale projects for large amounts of rainwater in response to the cloudburst. However, more recently, there has been a shift towards smaller-scale projects.

Alternatively, Boston began with smaller projects and is now considering how to plan for large stormwater management.

Furthermore, these interviews highlighted the importance of having a structure in which water management and stormwater are ingrained in development. For Copenhagen, the use of green infrastructure emerged from collective action following a specific event. This solidified stormwater management as a priority for all subsequent city projects rather than an afterthought. Whereas in Boston, the use of green infrastructure by BWSC was not initiated internally. Instead, a landscape architect working in the Boston area explained how "you quickly find that they were forced to do it. They didn't do it because they value the river or they're good people or whatever it is."

Through conversations with experts on the process of incorporating green infrastructure into urban planning in each city, themes emerged about the potential for systemic change and the role of policy windows. The rapid adoption of an ambitious plan in Copenhagen was likely due to the policy window created by the 2011 Cloudburst. A professor at the University of Copenhagen described this effect in how policy windows "often open and radically change the kind of landscape." Prior to the cloudburst occurring in Copenhagen, the climate adaptation plan had already been proposed and was waiting for approval. As a result, when the cloudburst occurred, the plan could move forward quickly. Cities must have people working on these goals so that when the opportunity arises, the measure can move forward.

Challenges of cooperation

Institutional Structures

To understand green infrastructure policy adoption and use in both cities, I examined challenges with implementation. My initial hypothesis was that challenges would include funding, space, public support, and cooperation. Instead, a common theme across interviews was that horizontal collaboration was the predominant challenge for urban planning. While funding and space were concerns raised for both cities, the driver behind these challenges seemed to be rooted in the collaborative nature of solving them.

A key difference between Boston and Copenhagen in the capacity for coordination on climate adaptation and flood management was in the institutional structures in place. In Boston, BWSC is a subdivision of the Commonwealth of Massachusetts. A member of a conservation nonprofit explained how this creates a "quasi-independence" in which BWSC does not have to listen to the Mayor's office. The division with BWSC is exacerbated by the fact that they do not own land in the city and have a separate budget. As a result, all projects must be in collaboration. A Boston architect describes this challenge in how BWSC "need to rely on these other agencies or other municipalities in the private sector as well to each do their part." Like most cities, there is also the added challenge of limited space and multiple entities with overlapping jurisdictions. As a result, an EPA Director described how:

> You have different branches responsible for different things, even talking to each other, it's not as integrated… Everyone has kind of their defined roles and responsibilities and people are very hesitant to cross over.

Alternatively, in Copenhagen, the board of HOFOR, the water utility provider, is appointed by the municipality. As a result, the city can set goals for stormwater management and adaptation projects, which HOFOR is required to implement. A HOFOR employee describes how as a result, they "have a very close collaboration with the Climate Change Department" in

which “we have the same goals, and we are working on the same projects.” The utility's role in climate adaptation was also expanded through national regulations, making it easier for them to make “top-down decision making around what needed to happen for private property owners.” Furthermore, when other departments in the city have a project, they must screen it with the Climate Adaptation Plan, and they must coordinate if there is an overlap. A city Copenhagen employee described how this means planners meet in the early stages of planning and that any conflict between entities in the city is ultimately decided upon by the city council.

Ideological Divides

Ideological divides between groups further exacerbate the separation between entities in the city with differing priorities and valuation systems. Within urban planning, “urban greenspaces and their ecosystem services are often undervalued” (Gill et al., 2007). In Boston, this is exemplified in the disagreement over how to value of green infrastructure co-benefits. A representative from BWSC explained that:

> We’re focused on the mechanics of rainfall, infiltration, etc. The City of Boston is focused on the beauty…They don’t care how effective the green infrastructure is. They just want it to look pretty.

Another BWSC staff member stated, “While the city maintains green infrastructure could have co-benefits… We’re saying fine, but we don’t want to have to pay for that piece of it.” However, a common sentiment expressed in other interviews from Boston was the idea that an older generation of city planners would retire soon and open spaces for people with this focus on climate resiliency and adaptation. A Boston city official explained how BWSC are, “old school engineers who, you know, don't really see the co-benefits of green infrastructure as super important.” And therefore, it can be hard to “convince people to work on green infrastructure”

and “explain all the co-benefits.” Part of this divide stems from different mandates. A staff member from BWSC commented, “Don’t get me wrong. I get the heat island effect. All of that stuff. But from our standpoint, from the commission’s money standpoint. I need the phosphorous out.” A Boston city official described their perception of this divide:

> “I think one of the challenges is also just like administratively like we are a separate entity from the Boston Water and Sewer Commission. And while we do work closely with them, we have somewhat different mandates.”

As a result, the Mayor's office aims to work with BWSC to update their existing plans for stormwater management with more nature-based solutions.

Varying levels of support for nature-based solutions also stem from differences in education about the role of green infrastructure. A Boston landscape architect explained that from an engineering perspective, stormwater management “is very formulaic and engineers like final answers… so when working on a nature-based approach, it’s harder to do that.” More fundamentally, a city official describes how among city staff:

> “We still have this huge gap that needs to be filled in terms of people's knowledge about and understanding of you know, green infrastructure, climate change, resilience, all of these really kind of key concepts.”

In Copenhagen, while the water utility provider is more integrated within the municipal structure, there is still a disconnect between municipal planning and water management priorities. A HOFOR employee described this divide:

> Municipal planning has the tendency over the last long period just to make plans for how the city should look. And yes, green and blue are of course, the words that they use a lot. But then again, when it comes to the water then it kind of gets to be our problem.

Furthermore, the division between entities stems from meeting other requirements for projects. The officials working for the city and utility discussed challenges relating to meeting permit requirements for water quality and getting approval for projects. For the cloudburst projects, HOFOR is working on "the necessary permits for a project [that] have been dragging on for four years. So, it will be finished maybe not until 2030. But we're still trying." While environmental regulations are key for protecting the quality of water in the city, these requirements have not been updated with new monitoring technology, making it difficult to get permits.

Systemic Change and Long-Term Maintenance

Professionals from each city both highlighted challenges with incorporating the maintenance of green infrastructure projects and climate adaptation into existing structures. Allocating responsibility particularly complicated when green infrastructure co-benefits engage multiple sectors in the development of projects.

In Boston, there is still the need for new systems and a unified group that can take responsibility for climate adaptation projects. Currently, green infrastructure projects involve multiple sectors, but it is unclear who is responsible in the long run. The creation of a Green Infrastructure director with a designated budget in 2022 was an important step in designating authority for projects in the city. The new Green Infrastructure director also created maintenance contracts for new projects to address the issue of long-term responsibility. However, BWSC employees expressed ongoing concerns with the maintenance of nature-based solutions as opposed to underground "low maintenance" gray infrastructure. Another expert from Boston expressed that "maintenance and obligations is inertia" and "will eventually become systemic and expected as they will roll into the business of being the city." Similarly, a Boston employee

who works with municipalities on adopting green infrastructure explained, “we're so early on working on green infrastructure that the cost of maintaining these structures hasn't been incorporated into municipal staffing and resources.”

In Copenhagen, the municipality is responsible for the maintenance of parks whereas hydraulic maintenance is taken care of by HOFOR. In terms of funding projects, updated regulations expanded the range of climate adaptation projects HOFOR can fund using sewage discharge fees. A HOFOR employee described that project responsibility is broken down into such detail that “it takes us quite a spreadsheet to continue to divide these expenses.” However, Copenhagen has had the benefit of working on climate adaptation in urban planning for a longer period, which has streamlined this process. When asked about working through issues of collaboration, a Copenhagen municipal official described the importance of “learning by doing and by organizing informally.” In particular, he highlighted the role that interdisciplinary work plays in nature-based solutions, which require collaboration and “forces professionals to open up and make a partnership… by giving up some of your needs.” The theme of collaboration was also underscored by a professor in Copenhagen who described the importance of “working across siloes” and “imagining a future where we can focus on the interdependency we have to nature and to each other.” Similarly, a Copenhagen architect described the importance of reaching people entrenched in their beliefs and how “learning the language and where they are coming from, and listening is more important than trying to impose.”

Interviews from both cities stressed how challenges with the implementation of projects for green infrastructure tend to be tied to issues of horizontal cooperation for urban planning. These results reflect findings that urban green space planning is restricted by “established planning paradigms, multi-level legal frameworks, siloed institutions, and former investments”

(Hansen et al. 2022, p. 4), which can lead to a limited capacity for transformation (Wolfram, 2018; Macdonald et al., 2020). Despite this, lessons from Copenhagen emphasize the importance of inter-departmental collaboration over shared goals and establishing systems for climate adaptation work.

Opportunities for Community Engagement

The third theme I focused on for my interviews was how green infrastructure is being designed and implemented within communities and the intersection of climate justice principles. Existing literature highlights how green infrastructure has the potential to provide co-benefits for social health and inclusivity through increased access to green space in communities (Haase et al., 2017). However, when increased green space is adopted as a form of market-driven projects that cater to higher-income residents, this can lead to the displacement of lower-income households through the process of green gentrification (Anguelovski et al., 2016; Rue Junqueira et al., 2022). A connection between added green space and an increase in price and location assessment of housing has been observed in research on green gentrification (Haase et al., 2017).

These challenges raise the question of how to add green spaces without preventing the displacement of existing residents. A professor I spoke with from the University of Copenhagen described how:

> We need to actually ask how do we provide affordable housing and green infrastructure together hand in hand so that we have healthy green communities that support justice and inclusive and equitable approaches to climate resilience.

She explained that while gentrification occurs in Denmark, it is lessened by the welfare state. When asked about issues of gentrification, an architect from Copenhagen stated that the municipality can prevent this price increase through regulation. However, she argued that:

> There is no interest in Denmark to regulate the market to prevent increasing housing prices… because the Danish state has a lot of its revenue from property value tax. A lot of gentrification is due to a very aware decision-making. It doesn't just happen if you put in a park or green areas. It is supported.

Concerns with gentrification were much higher in Boston, which has an extensive history of segregation in which communities are denied equal access to city resources and green spaces. Disparities in the allocation of green spaces across the city have led to a focus on addressing the resulting heat island effect. A member from Climate Ready Boston noted "how can we give special attention to and address a lot of those injustices through this work is a huge priority." Boston began its first National Green Infrastructure Certification Program in order to create a "green infrastructure jobs pipeline." A representative from Mayor Wu's cabinet explained that their goal is "Requiring the workforce to be from your communities and from your neighborhood," which not only helps employ Boston residents but also increases the quality of work.

Part of the suggested solutions to preventing green gentrification also stems from ensuring that added green spaces are done in a way that involves the community. A professor at the University of Copenhagen described how "issues of justice and recognition, environmental racism get brought in and we start thinking about the technical to the social in quite serious ways." In light of this, she then reflects on the importance of incorporating different kinds of knowledge.

Denmark's public education has focused on climate change for decades. As a result, Denmark has a culture where people are engaged and want to take ownership of climate adaptation initiatives. A planner who works with both HOFOR and the municipality described the HOFOR program for school kids where they come in and do a full planning and negotiation cycle for the proposed climate adaptation project in their neighborhood. The focus on education intends to create a more positive atmosphere and engagement around climate adaptation in the city.

A representative from the municipality explained their goal of "co-creating as much as possible" with "organized local citizen engagement throughout some informal organizations." A HOFOR employee described how for climate adaptation and water management projects, the city recognizes that these tend to take longer as they are still new, so there needs to be a longer community engagement process, especially in areas with high renter turnover. He also outlined how the city will often create tools and workshops for citizens which lay out the constraints of a project through which they often come to a similar conclusion as the city. They recognize that this citizen engagement process leads to more acceptance than just presenting the solutions. A Copenhagen city official described this importance: "The best solutions are also where the citizens feel not only like a part of planning but also because they feel partial ownership" which gives it a "local touch." However, community participation in the planning process can be a challenge. There is the fundamental issue of connecting the technical domain with meeting the needs of residents (Negrello 2023). A Copenhagen City Official describes this in "how to combine work together with professionals on one side and amateurs on the other side so that they also can complement each other" (Copenhagen City Official). Furthermore, interview

participants from both cities explained that the rising popularity of green infrastructure and added green space from residents has increased the challenge of incorporating this input.

In Boston, a concerted effort has been made to engage communities in climate resiliency work. A city official working with Climate Ready Boston described how "if you do not bring the community in early, your public process that you try to throw in at the end becomes very painful and very long and very difficult." Instead, the city has worked to:

> Focus a lot on meeting people where they are and meeting people in spaces that they're already going to. Like neighborhood organization meetings and things like that to share information.

Within Boston, the city official described how there is an existing network of people they have worked with who are engaged in the process: "I think it's good because it holds us accountable what are we doing and what is our progress." However, this perspective is not necessarily shared by all entities responsible for green spaces in the city. A BWSC employee described how "the public is going to want to see surface features, but are those best for me? They're much higher maintenance." Another city official described the plans for stormwater management created by BWSC as being "largely made in a vacuum without any input from the city and definitely without any input from the public." For the widespread involvement of residents to be successful, it must be a priority for all responsible entities within the city. However, community input is often not valued as highly as traditional scientific knowledge, which contributes to the exclusion of it from planning (Danielsen et al., 2018).

Even with widespread awareness of green gentrification, cities must also incorporate these considerations into the planning and development of climate adaptation projects. Green infrastructure implementation should be in areas with a greater proportion of socio-economic

disadvantaged residents, less access to green space, and greater flood risk (Junqueira et al. 2022). To do so, cities must acknowledge existing inequalities within modeling systems. (Junqueira et al. 2022). A Boston city official described how "I think every neighborhood of Boston has an environmental justice community included within it." The widespread need for climate justice work across the city raises the question of prioritizing project locations. When speaking about this process of prioritizing environmental justice communities, a former member of Boston's climate action department stated:

> We're going to prioritize environmental justice communities. That sounds great, but are you asking to prioritize the place where environmental justice communities work? Are you going to prioritize the way that they travel? You know, the public transportation systems they work through? … So, decisions are going to have to be made. Those decisions should be prioritized through an environmental justice lens. But there's going to be some winners and losers and that's going to hurt the city.

While the city is aware of green gentrification and the need to prioritize EJ communities, there is still concern that people will be left out of these conversations. There needs to be accountability regarding how residents are engaged in this process. This means Boston and Copenhagen must go beyond hearing the voices of residents who are already involved in green space advocacy. Instead, to create spaces that are designed for diverse usage, cities must consider different opinions and contrasting views in planning (Ernston 2013).

From the interviews, representatives from both cities expressed the importance of engaging with communities in designing projects. Copenhagen has had success in creating a culture that is largely supportive of climate adaptation work through educational efforts. However, issues of gentrification are not a priority for climate adaptation, partly due to a

stronger welfare state than in the US. As a result, Boston has taken more steps to address issues of green gentrification due to existing inequalities in the city. Boston would also benefit from expanding its educational efforts on climate adaptation and stormwater management.

Looking Forward in Each City

Climate adaptation and the need for immediate action highlight the weaknesses of existing urban planning structures. Flood risks are inherently uncertain, which challenges urban planning processes and structures that tend to be centered around the present (White & Haughton, 2017). The response to the Copenhagen cloudburst exemplifies the tendency for policy to focus on current challenges as opposed to future risks. The policy window allowed for immediate action to prepare for a 100-year flood and led to large-scale projects that focused on managing high-intensity flooding. However, this past summer, the city dealt with unprecedented drought. A professor at Copenhagen described how "we went full-on taking water away and getting it out. Instead of thinking about how do we retain water to have a more balanced system that accounts for droughts and accounts for flooding." When I spoke with representatives from Copenhagen, they discussed the emerging need to redesign the system for droughts and wildfires.

Incorporating climate change adaptation also means updating existing structures. In Boston, multiple interview respondents referenced how state laws that prevent building into the water have created a "restrictive barrier on stormwater management in the urban context." A representative from Climate Ready Boston described how this was one of the biggest challenges for moving forward with climate resiliency in the city. As a result, things that make sense technically and for the community are not acceptable through the permitting process. Instead, cities must deal with drastic changes and new decision-making. However, urban planning relies

on systems that once established, “can be increasingly hard to change over time (Macdonald et al 2021, p. 146). Preparing for climate risk requires structures that can deal with change quickly.

Incorporating green spaces as a part of climate adaptation in cities is a process that requires time. As interviews from both cities revealed, co-benefits green infrastructure can meet the needs of multiple city entities, which requires systems thinking (Hansel et al., 2022). As a result, green space planning occurs through collaboration with the residents and horizontally across city entities, creating a complex “network of government agencies, non-governmental organizations and public-private partnerships” (Macdonald et al. 2020, 144). Consequently, solutions for green space adaptation cannot be universal. Location specific solutions are essential for creating meaningful green spaces while also preserving the existing urban space. Furthermore, the values behind adding green space must also be evaluated. As a professor from the University of Copenhagen asked:

> What kind of political goals do we have, how is growth and value understood in a society? And then how does that impact the way in which green infrastructure is realized and managed and governed in our societies?

Redevelopment for the sake of urban renewal and profit will lead to the displacement of low-income residents. A Copenhagen architect I spoke to outlined how without any values behind development or requirements for green space, they become an “unnecessary expenditure” for developers. The city then must solve the lack of green space after the area is developed. To prevent this, measures must be taken to ensure that co-benefits of health are valued within the economic analysis for urban planning. Furthermore, it is more efficient for green infrastructure requirements to be incorporated into development from the start.

Conclusions

In Boston and Copenhagen, there are different timelines for how green infrastructure and nature-based solutions are being incorporated in each city. Interviews with individuals involved in the process gave me insight into the motivation behind green infrastructure adoption and how that influences the speed of acceptance and cooperation. Furthermore, each city is exploring the role that green infrastructure can have in community engagement. Incorporating residents into climate adaptation projects raises questions of climate justice and green gentrification and whether either city is doing enough. These conversations touched on the values at the core of urban planning for climate change and how cities struggle to deal with rapid change using systems designed for stability.

Responding to climate change is a dynamic process that challenges the static tendency of urban planning and policymaking. Copenhagen and Boston are in the process of imagining a stronger, more resilient city to the effects of climate change. A key part of this is the use of green space in both mitigation and adaptation. In particular, both cities are exploring the role that green infrastructure alternatives will play in stormwater management and climate change. Discussions with experts in each city emphasize that planning for climate change will require ambition in the willingness to change the status quo of bureaucracy and policymaking. With communities in cities facing more extreme impacts from climate change, their needs must be prioritized – especially environmental justice communities that benefit from climate resiliency projects but are at risk of displacement. As a result, green infrastructure and, more broadly, nature-based solutions to climate change in cities will require work across different city entities and within the community. With limited time to act, lessons from cities that have undertaken these steps are key to informing the critical climate action of other cities.

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Appendix A

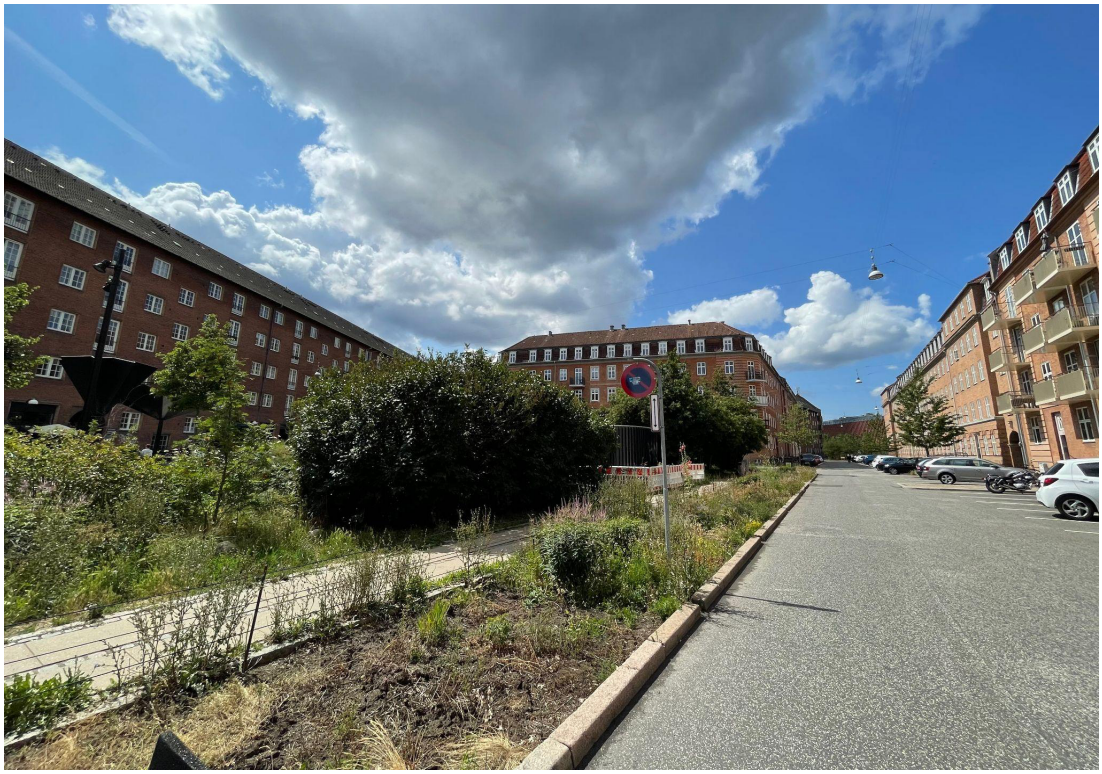

Figure 1: *Climate-adapted square in Østerbro, Copenhagen.*

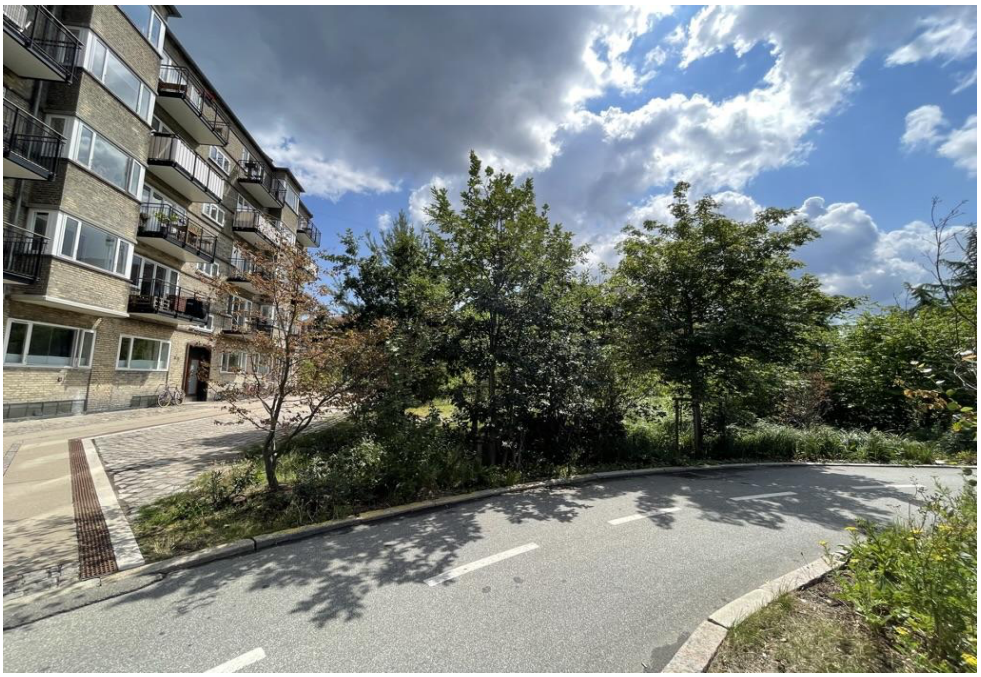

Figure 2: Bioretention area in Copenhagen's climate adapted neighborhood, Østerbro

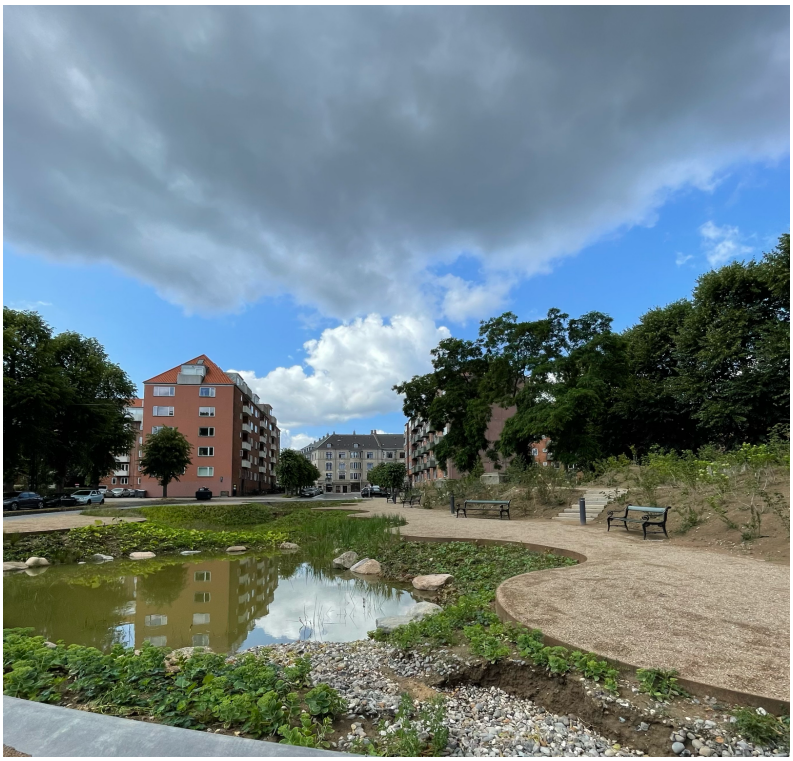

Figure 3: Carl Nielsens Allè. A rainwater basin in Østerbro, Copenhagen.

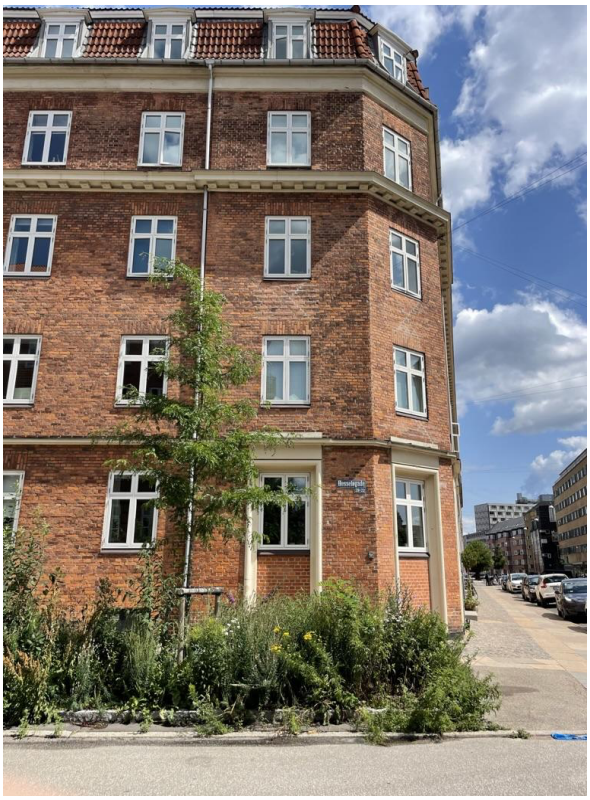

Figure 4: Curbside bioretention area in Copenhagen's climate adapted neighborhood, Østerbro

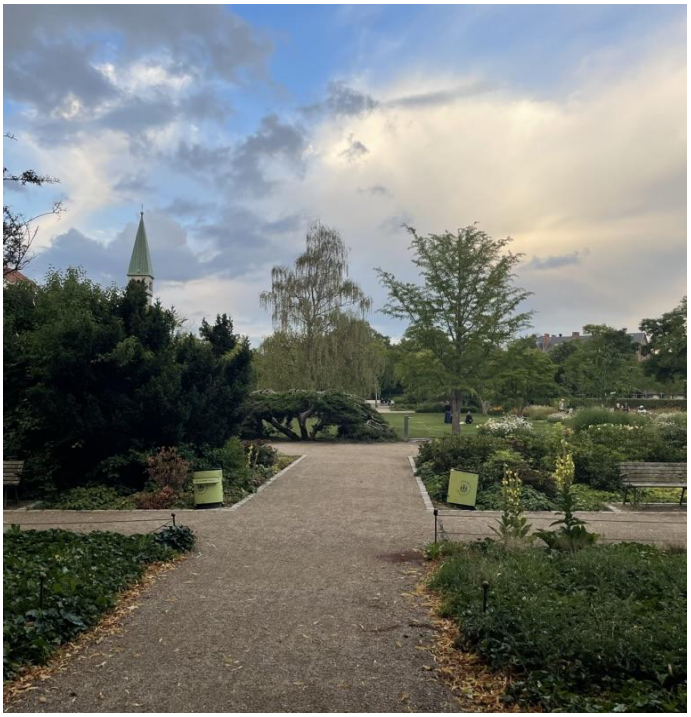

Figure 5: Enhaveparken in Copenhagen. Climate Park that can hold 22,600 m3 of water.

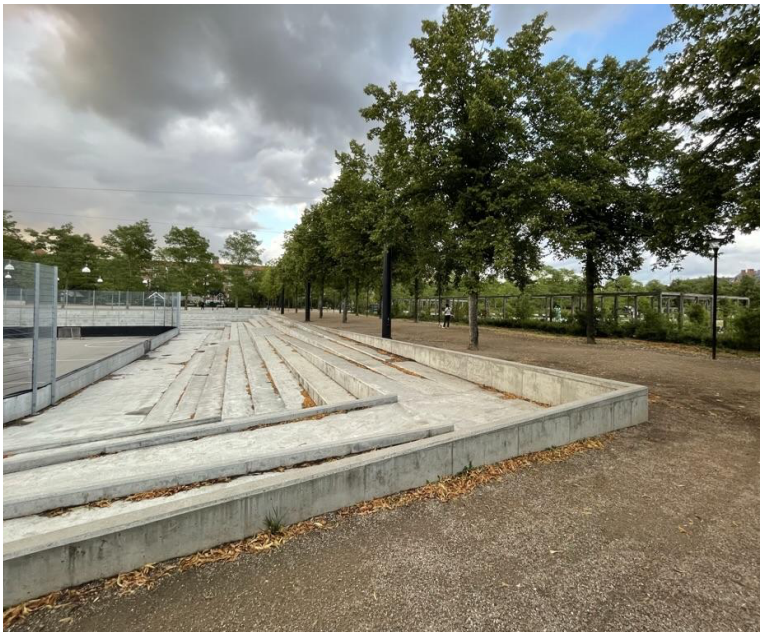

Figure 6: Recreational area that also functions as a retention basin in Enghaveparken. Copenhagen