

The Role of Open Government Data in Boston's Climate Adaptation Process

By

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Submitted to the Department of Urban Studies and Planning
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Abstract

This thesis asks the question, what is the role of open government data? Has the open aspect of open government data democratized participation to create more insightful, just, equitable, and inclusive action or research? Studying open government data use is important because more efforts can be made to replicate successes and bridge gaps between reality and perceived benefits. To examine this question, this thesis uses Boston, Massachusetts as a case study.

The City of Boston is a leader in municipal climate adaptation, and has worked with a diverse set of private, public, non-governmental, and academic actors to create and implement resilience initiatives for their climate adaptation plan Climate Ready Boston. Boston's open data initiative and its context in the broader national open government data environment hints at potential influence of open government data on Climate Ready Boston. In this thesis, I study traces of open government data in Climate Ready Boston's ecosystem of actors to understand the role of open government data in climate adaptation. Two network maps were produced to identify the relationships and information exchanges in an attempt to trace the role and presence of open data. The results suggest current minimal usage of open government data in Climate Ready Boston, and that Boston climate adaptation could benefit from increased collaboration between academic institutions and local nonprofit organizations to create valuable insights from open government data.

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Part I: Introduction

Open government data may play an influential role in the climate change adaptation planning. Although a substantial amount of literature on open government data exists, there has been acknowledged lack of literature on the impact of open government data. In this thesis, I investigate the role of open government data in Climate Ready Boston, the City of Boston's climate adaptation plan. The introduction is organized into two parts: background and purpose.

1.1 Background

The background section introduces climate change action in the context of Boston's existing climate adaptation plans, introduces open government data in the national and Boston context, and connects Boston's climate adaptation action to open government data.

Boston climate adaptation context:

Climate change action consists of multiple layers of initiatives targeting a complex multifaceted problem space. Climate action ranges from ecological intervention, social reprogramming, risk assessment, climate science assessment and prediction, and it requires inter-organizational coordination, co-benefit considerations, and strong considerations for vulnerable populations. Numerous climate action plan guidelines exist in the literature, but many of them emphasize that holistic climate action plans must be cognizant of social vulnerability and equity issues with climate adaptation (Rosenzweig et al., 2018; C40 Cities Climate Leadership Group, 2020). Climate change action can be broadly categorized into climate mitigation and climate adaptation. Climate mitigation aims to slow or reverse climate change primarily by controlling greenhouse gas emissions. Climate adaptation aims to prepare for the climate effects that are occurring now and will inevitably occur in the future, such as sea level rise, temperature

increase, and increased extreme weather occurrences. It is important to understand how cities prepare for the impacts of climate change in order to identify key processes or innovations that holistically improve the outcomes of climate adaptation.

The City of Boston is facing severe threats from climate change. A winter storm combined with high tides in 2018 flooded streets and Aquarium metro station with icy sea water (Garfield, 2018). Extreme temperatures are expected to become more frequent in addition to coastal flooding like the winter 2018 flood event: “By 2050, Boston’s summers may be as hot as Washington, DC’s summers are today ... At the end of the century, between 10 and 20 percent of Charlestown, East Boston, Downtown, and South Boston will face flooding at high tide, even when there is no storm” (City of Boston, 2019e, p. 9).

The City of Boston under Mayor Martin Walsh released *Imagine Boston 2030*, the first comprehensive citywide plan in over fifty years. It incorporated a climate action plan in response to alarming climate projections and recent extreme climate events (City of Boston, 2018a). The *2014 Climate Action Plan (CAP) Update* renewed the city’s climate vision to reduce greenhouse gas emissions and increase climate resilience (City of Boston, 2014). Two initiatives were created to further operationalize CAP goals: Carbon Free Boston identified the specific and measurable steps that Boston must take to reach carbon neutrality by 2050, and Climate Ready Boston (CRB) recommended 39 initiatives to prepare the city for the impacts of climate change.

The *Climate Ready Boston Final Report* (CRB final report) was released in December 2016 by the Environment Department’s Climate Ready Boston team and it recommended 39 initiatives to prepare the city for extreme heat, stormwater flooding, coastal and riverine flooding (City of Boston, 2016a). The CRB final report consists of three main sections: climate projection consensus, climate vulnerability assessment, and climate resilience initiatives. Each section

contains the work of city departments, agencies, community partners, academic institutions, private consultants, and regional actors. The climate projection consensus established a common set of sea level rise, temperature increase, precipitation projections which all City of Boston activities must take into account. The climate vulnerability assessment used the agreed upon projections to calculate the expected risk. The climate resilience initiatives established five overarching layers: Updated Climate Projections, Prepared and Connected Communities, Protected Shores, Resilient Infrastructure, and Adapted Buildings. Each layer consists of one to three strategies, and each strategy consists of two to seven initiatives.

Open Government Data to improve governance:

One new government innovation that may play a role in climate adaptation is open government data. The release of government data has become an increasingly adopted initiative in governments and government agencies of all shapes and sizes around the world. In this thesis, “open government data” (OGD) is defined as existing and continually produced government data freely available in open formats and ways that enable public access and facilitate exploitation. “Government” in this thesis broadly includes all scales of government and government agencies, for example the City of Boston, Massachusetts Department of Transportation (MassDOT), the Metropolitan Area Planning Council (MAPC), US Census Bureau, US Geological Survey, and so on. “Freely available in open formats” refers to machine-readable data (spreadsheet, geospatial) that can be freely downloaded without limit. “Enable public access and facilitate exploitation” refers to web-based platforms including but not limited to online data portals, often accompanied by application programming interfaces (APIs) that allow for direct and automated access to the dataset for software applications.

Over the past decade, governments have implemented OGD initiatives in a variety of ways with varying levels of openness, varying in implementation/effectiveness of data portals, the frequency at which data is released, and the type of data released (Geiger & Lucke, 2012). The rapid adoption of OGD is driven by perceived benefits around increasing government transparency and accountability, generating economic value, better allocating public resources, democratizing agenda setting, and empowering citizens on a local level by facilitating more informed decision making, and new forms of social mobilization (Gonzalez-Zapata & Heeks, 2015; Zuiderwijk & Janssen, 2014a). However the actual impacts of OGD have not been studied extensively, in part because OGD usage is so difficult to tract. Though many governments now host their own open data portals, there is little literature on the external impact of open governmental data, and whether OGD actually results in its perceived benefits. Of the studies that have assessed the impact of open government data, most have done so by sampling a few projects in case studies, from which some generalizations on impact are synthesized; however, the authors acknowledge the anecdotal and limited scope of their investigation.

The United States federal government under President Obama's administration in 2013 developed Project Open Data, which has now evolved into the <https://www.data.gov/> open data portal. In 2018, the federal government enacted the Open Government Data act, which requires all "federal agency data to be accessible and requires agencies to plan to develop statistical evidence to support policymaking" (Ryan, 2019).

On the municipal scale, the City of Boston has also passed its own open data policy. Effective since July 2015, the City of Boston Open and Protected Data Policy requires the city's Chief Information Office (CIO) to create a data catalog, and to release "public record" labeled data on Boston's open data platform. For determining which data to publish, the "CIO shall work with Departments and prioritize for publishing those datasets that are public records, are frequently

requested by the public, are associated with the City's policy priorities, and are appropriate for disclosure" (Walsh & Franklin, 2015, p. 10). Boston's open data portal "Analyze Boston" (<https://data.boston.gov/>) currently has 159 datasets, covering a variety of subjects ranging from public safety, permits, and environment (City of Boston, n.d.-b). One example of OGD from Analyze Boston is the City Hall Electricity Usage dataset which measures and updates electric power load at City Hall (1 City Hall Square) every 15 minutes.

Analyze Boston contains data from many city agencies including Boston Maps, Public Works Department, and Environment Department. See Table 1 for the top 10 city agencies that post the most datasets and their most viewed dataset. The top two most viewed datasets are "Employees Earnings Report" (29,505 views) reporting payroll data for employees published by the Office of Human Resources and "Property Assessment" (29,090 views) reporting property or parcel ownership with value information published by the Assessing Department. Relating to climate, 12 datasets are tagged "climate-ready-boston", of which 11 are tagged "flooding". The flooding datasets are geodata showing area of potential coastal and riverine flooding under various sea level rise scenarios (9-inch in 2030, 21-inch in 2050, 36-inch in 2070s) and storm and tide conditions (1pct annual flood, high tide). The other dataset is "Climate Ready Boston Social Vulnerability" (297 views) which is the dataset used in the vulnerability assessment for *Climate Ready Boston Final Report*.

Table 1 Top 10 Boston city agencies by number of datasets published on Analyze Boston with example dataset with the most amount of views.

Boston City Agency	# of Datasets	Example dataset (views)
Boston Maps	89	Streetlight Locations (1855)
Public Works Department	9	Street Sweeping Schedules (8668)
Department of Innovation and Technology	6	Short Term Rental Eligibility (3760)
Boston Transportation Department	5	Traffic-Related Data (6007)
Environment Department	5	Building Energy Reporting and Disclosure Ordinance BERDO (3228)
Boston Police Department	4	Crime Incident Reports Since August 2015 (23699)
Inspectional Services Department	4	Approved Building Permits (18470)
Office of Budget Management	4	FY21 Operating Budget (943)
Archives and Record Management	3	Requests Satisfied by Archives and Records Management Statistics (948)
Boston Planning & Development Agency	3	Economic Indicators (3650)

Synergies between climate action needs and open government data:

A cursory review of the existing US and Boston data portals show that environment related OGD is available and plentiful across different scales of government and spatial granularity. The availability of environmental data indicates the opportunity to explore the impacts open government data on climate change governance.

This thesis attempts to assess the impact of OGD in within the constrained scope of Climate Ready Boston’s activity by applying a top-down investigative search methodology. A focused investigation on the impact of open government data on climate change governance will reveal the presence or absence of benefits: for example (1) improvement of policy-making processes, (2) creation of new insights in the public sector, and (3) new (innovative) services and policies,

by investigating the presence of OGD products in the conception and development of currently enacted climate initiatives. This method of inquiry can capture the character of OGD influence on one important policy area, such that urban climate change governance actors can get a sense if, and which OGD mechanisms are successful.

1.2 Purpose

In this thesis, I study the traces of open government data in Climate Ready Boston's ecosystem of actors to understand how open government data makes climate adaptation better. I choose Boston as the focus city of study because of it is an international leader in municipal climate action, and because there are indications of open government data penetration, ranging from the existence of the city's open data portal (Analyze Boston), to the Metropolitan Area Planning Council's (MAPC) data-driven, smart growth initiative. My research question is two-fold:

- What role does open government data play in Boston's climate adaptation action?
- How has open government data created more insightful, just, equitable, and inclusive climate adaptation action in Climate Ready Boston?

The first question builds a broad understanding of OGD influence in the network of Climate Ready Boston stakeholders and lays the groundwork for answering the second, more specific question on the equity aspect of OGD influence.

An "open government data consumer" is any entity (government, private corporation, academic institutions, social organizations, community-based organizations, individuals, etc.) that incorporates open government data into an "open government data product" which includes but is not limited to a research paper, blog, interactive tool, data visualization, or digital application. Different data products play different roles sometimes simultaneously: they can generate

actionable insight, improve operations as a tool, provide evidence-based backing, and raise awareness for an issue.

I propose a theoretical model for open government data flows, from which I base my investigation strategy. This open government data flows model is similar to a life cycle assessment for OGD. It traces OGD from the source, to data consumers, to data products, to government action. I trace backwards from Climate Ready Boston initiatives by examining online published documents and conduct interviews with city officials and other involved actors. In the interviews I ask about known open government data products or instances when OGD played an important role in Climate Ready Boston process. From reading reports and conducting interviews, I identify the different products created from OGD, the means through which the OGD products play in shaping action, and the stakeholders that produce OGD products. These data are compiled into stakeholder network map which maps out the ecosystem of stakeholders and to the degree which they are connected to Climate Ready Boston activity. From the stakeholder network map, I trace flows of open government data across stakeholders and their OGD products.

This research is important because an understanding of effective OGD uses can help cities understand what datasets and how data is made available to the public are important in generating actionable insights for climate adaptation planning. Findings may emphasize the value of “openness” and information transparency in social goals, such as equity, justice, democracy. This research could help governments more strategically release datasets and generate knowledge for stakeholders on what kinds of OGD products are the most influential in climate adaptation action. This thesis could identify any other important but unaccounted for OGD enabled stakeholders in Climate Ready Boston. It also adds to the body of OGD impact research as well.

The thesis is organized as follows: First, the literature review details the motivation and impact open government data, challenges in climate adaptation action, and it elaborates the proposed theoretical model of OGD flows into Climate Ready Boston. Then, the method details the investigative approach, followed by the results chapter which will contain the stakeholder network map, the OGD flow map, and descriptions of influential open government data products. The discussion and the conclusion elaborate findings and expand on the lessons learned along the investigative journey.

Part II: Literature Review

The purpose of an overview of the literature is threefold. The first section will review open government data broadly by identifying motivations and noting findings from several impact assessments. These open government data impact assessments demonstrate that different investigative approaches reveal different findings, even when the research questions are similar. The second section will review the importance of holistic climate adaptation policy and identify overlap between the perceived capability of OGD to improve climate governance to be more equitable, inclusive, and just. Finally, I propose a theoretical model for open government data flow from source to climate adaptation initiative which provides rationale for the investigative methodology used in this thesis.

Perceived Benefits of Open Government Data:

All papers reviewed in some way mentioned the perceived benefits of open government data. The literature generally categorizes the perceived benefits into three categories which are (1) political and social, (2) economic, and (3) operational and technical, compiled into Appendix A adapted from Janssen et al. (2012) , and Gonzalez-Zapata and Heeks (2015). Firstly, political and social benefits concern governmental duty to be transparent, to provide citizens access to public data, to increase accountability, to improve of governance and public services, and to assist in the creation of new knowledge, and to facilitate citizen empowerment. Secondly, the authors of this literature believe that OGD has exploitable economic value and can create jobs, opportunities, services, and new investments. Third, the authors point to operational and technical benefits are improved internal efficiency through reduction of repeated work, improved cross-agency communication, etc.

Commonalities across governments for the most important perceived benefits can be seen by reviewing the findings of several studies. Gonzalez-Zapata and Heeks (2015) noted that in the Chilean government, the improvement of bureaucratic operations and the perceived social and political benefits, such as improvement in policy agenda setting, were the most important factors for OGD implementation. Janssen (2012) interviewed various OGD stakeholders in the Netherlands and found that “economic growth and contributing to public values (transparency and accountability) are the overarching arguments for stimulating open data.” For both studies in Chile and the Netherlands, two governments of different capacities and locations, a highly important factor for OGD implementation were the perceived political and social benefits.

Even though political and social benefits were among the most influential factors of OGD implementation, studies in which interviews were conducted found that participants were, to varying degrees, skeptical of whether this benefit was actually realized based on the way OGD was being implemented at the time of the respective study. In interviews conducted with various Dutch public officials at the managerial level and the administrative level and users of public data, “those with higher level positions often focused on the benefits, whereas the persons in charge of realizing the benefits had a much more nuanced view” (Janssen et al., 2012). Additionally, in the interviews with Chilean government officials, “there was sometimes acknowledgment that appearance of this perspective [democracy and citizens’ empowerment and participation] was what mattered: ‘as a country, one of our greatest assets should be to have the image of a transparent country’”. Additionally, the primary stakeholders were politicians, public officials, public sector practitioners, and international organizations; and the secondary stakeholders were civil society activist, Information and Communications Technology (ICT) providers, funding donors, and academics. Noticeably missing from the list of identified stakeholders were the local private sector, multinational firms and investors, and citizen-users (Gonzalez-Zapata & Heeks, 2015). From another study by Zuiderwijk and Janssen (2014b),

they found that several “dark sides” of the implementation of OGD from the supplier (government) side, in which there was “little attention for public value and solving societal problems”, “unclear responsibility and accountability”, and that “not citizens but others profit from open data”. There seems to exist a gap between perceived benefits and actual motivations during implementation.

Additional studies have found that the structure of open data platforms and supporting initiatives that facilitate citizen learning and data literacy are necessary to achieve some of the social, political, and economic benefits. Ruijter et al. (2017) suggested though research has shown that OGD fails to foster democratic processes, a context-based approach to open government data design facilitates collaboration between public administrators and citizens to produce useful data. Lee and Chu (2018) also point out that the impact of open government data in Taiwan is not significant, but they see potential for OGD usage if governments take a user-centered approach to provide useful data to citizens. Susha et al. (2015) found that the adoption of OGD by businesses depend on the innovativeness of the company and its expertise and skills, and facilitating conditions are influential drivers for adoption but they are not given enough attention.

Studied impact of OGD:

In the following section, studies on the impact of open data in general will be discussed as there was a lack of studies on the specific impact of OGD, which has been widely acknowledged by the literature (Susha et al., 2015; Zuiderwijk & Janssen, 2014b); however, the projects evaluated in the studies included ones that utilized OGD, so findings can be reasonably applied to an OGD context. Different impact studies have found varying degrees of impact of OGD.

Open government data has created substantial value in the academic research community and will increasingly continue to generate new insights. A tremendous amount of earth and climate

related data and information are available from the U.S. Federal Government, namely from agencies whose primary purpose to monitor earth data such as the National Oceanic and Atmospheric Administration. In a paper linking data to actionable science in climate data analysis, Tilmes et al. (2015) stated that “linking such information across the breadth of interagency holdings can increase understanding of the complexity of those holdings and their inter-relationships and allow a more cohesive presentation of all of the material.”. Government agencies that monitor earth systems constantly generate valuable data for climate science research.

Open government data has a strong impact in academic research. Yan and Weber (2018) in their paper “Mining Open Government Data Used in Scientific Research” used a web-scraping technique on electronic journals to gather papers that contained the mention of open government data. They found thousands of papers that used OGD and were able to breakdown the use of OGD by research area. The second most prominent research area was environmental science, with 448 papers, after medicine, followed by 412 papers on social sciences (see Table 2).

Table 2: Top 10 research areas that use OGD, adopted from Yan & Weber (2018)

Research Areas	Count
Medicine	557
Environmental Science	448
Social Sciences	412
Computer Science	242
Agricultural and Biological Sciences	178
Engineering	145
Earth and Planetary Sciences	144
Biochemistry, Genetics and Molecular Biology	80
Energy	76
Business, Management and Accounting	45

This is evidence that OGD significantly drives scientific research, especially climate change research, and is rich in potential impact especially as governments become more open and publish more data. The structure and distributive nature of academic research publishing lends itself to analysis (for example scraping from public journals), however other uses of OGD (for example from NGOs and individuals) and the resulting outcomes are still unclear.

Yoon and Copland (2019) identified the social impact of data on local communities, including “resolving local problems from data-driven decisions, realizing unknown problems or correcting misrepresented problems, changing community data practices, strengthening community identity and enhancing the community’s data skills.” Open data has shaped the policies and protocol for decision making at a local level, and actually served to either correct misrepresented community problems or bolster existing intuition with quantitative data. Open data also helped promote community awareness of issues. Their study found that community governance has gained legitimacy from using open data as a decision-making tool, and that in effect, problems addressed were more relevant to the local community. However, it was observed that that literacy skills were not equitable within and across communities, which limited holistic engagement in the data system.

From a study done by the GovLab action research center based at New York University, “open data has improved governments, empowered citizens, contributed solutions to complex public problems, and created new economic opportunities for companies, individuals and nations” (Verhulst & Young, 2016). The authors of the GovLab report also recognized that the most effective data projects with the most the positive impacts were featured, and they came up with a list of recommendations to transform single success stories to the broader narrative of data projects.

Broader scoped impact assessments of open government data on process-centric changes to government conducted by Lee and Chu (2018) and Mergel et al. (2018) were surprisingly less positive. Lee and Chu asked 4235 OGD-users to rate on a scale of 1-5 “strongly disagree” to “strongly agree” the most common perceived benefits for OGD. Questions on the questionnaire included “OGD leads to more transparency for government” and “Presently, I think that with OGD, the public services have contributed to greater inclusion for marginalized groups in our society”. They found that users’ perspective on OGD impact was low. Mergel et al. conducted interviews with fifteen city managers responsible for the implementation of open data policies and found that product-centric outcomes for external innovation were more dominant over the process-centric outcomes for changing government procedures or promoting a culture of innovation.

It is worth noting the differences in methodology and differences in findings across impact studies. In Yoon and Copland’s (2019) paper which found that community-utilization of data led bottom up actions and initiatives, they took an interpretive qualitative approach and conducted “semi-structured phone interviews with 45 participants from data intermediaries and local community organizations.” Yan and Weber (2018) found substantial OGD use in medical, environmental science, and social sciences academic papers in scraping journals for open government data attribution. Yet, in Lee and Chu’s (2018) impact assessment, they were only able to assess OGD users’ perceptions of impact by asking broad, sweeping questions. They took the survey results as an indicator of actual impact, which could conflate public perception with reality. Mergel et al. (2018) interviewed high-level managers in charge of implementing open data initiatives, which again does not directly analyze the data products or the cascading impacts of data products which can produce process-centric outcomes. The thesis methodology is influenced by Yoon and Copland’s interview method and with Yan and Weber’s exhaustive search method through existing documents. My investigations are constrained by a context-

specific, limited scope of action within city government, while maintaining liberally inclusive definition of open government data and open government data product.

Municipal climate change action considerations:

Many networks of cities and researchers focused on addressing climate change have released frameworks for climate action planning. In most of these frameworks, inclusivity and equity are important components to comprehensive climate action. The Second Assessment Report of the Urban Climate Change Research Network (UCCRN): Climate Change and Cities (known as the ARC3.2) is a publication by 100 scholars from 50 cities across the world that addresses climate risks, adaptation, mitigation, and policy mechanisms relevant to cities. ARC3.2 aims to inform the development and implementation of effective urban climate change policies and proposes Five Pathways to Urban Transformation (the five pathways). The fourth pathway “focus on disadvantaged populations” is important because the urban poor, the elderly, women, minorities, recent immigrants and other marginal populations most often face the greatest risks due to climate change (Rosenzweig et al., 2018). C40 Cities network has created a resource center to provide climate action resources for cities, emphasizing the need for inclusive planning and equitable impacts. C40’s Climate Action Planning framework found on the resource center website states four key components of climate action planning one of which is inclusivity and benefits. The inclusivity and benefits component states that climate action plans should engage with the community to inform them of benefits and should establish ways to ensure equitable distribution of these benefits to the city’s population (C40 Cities Climate Leadership Group, 2020).

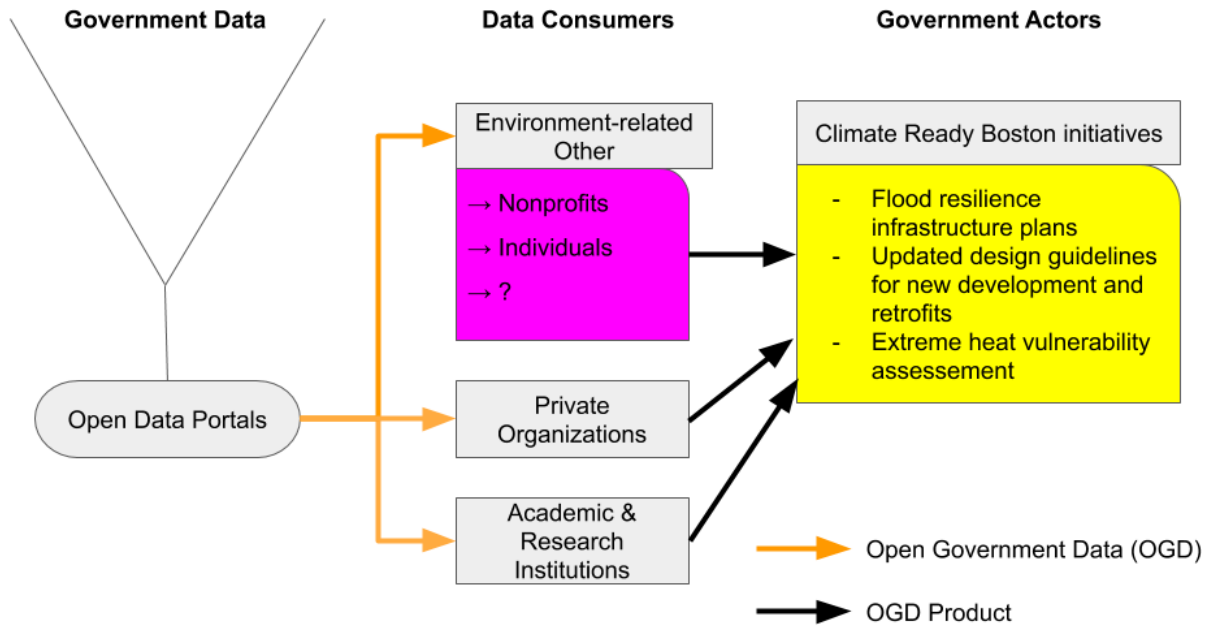
It is necessary in climate action planning to consider disparate climate vulnerabilities for disadvantaged populations and equitable outcomes because disadvantaged populations are more vulnerable to climate hazards and climate investment may drive gentrification and displace

these populations as well. Inclusive and equitable planning increases overall capacity of cities to reduce risk and manage climate hazards (C40 Cities Climate Leadership Group, 2020; Rosenzweig et al., 2018). Open government data's purported political social benefits such as increasing transparency, accountability, knowledge creation, citizen participation, and better policy agenda setting hints at the synergy between OGD advantages and needs for equitable climate action planning.

Theoretical Framework for OGD flows into Boston Climate Action Planning:

To survey the “other” stakeholder landscape in the climate change policy, I formulate a theoretical causal model of the pipeline from open government data to planning action, shown in Figure 1. First, government data is released on open data portals, transforming it into open government data. Then, the OGD is used by data consumers including private organizations, academic and research institutions, and other. These data consumers generate data products as outputs, which then inform Boston's climate adaptation plans. I will work first backward by interviewing climate adaptation officials and examining published executive planning reports. This methodology will confirm the validity of the model and will add complexity to the current understanding OGD impact mechanics.

Figure 1: Proposed theoretical model of open government data flows, from data portal to data consumers, to local policy and action



Part III: Method

I used a multi-pronged investigative approach to build an understanding of the role of open government data in Climate Ready Boston, which consists of a complex network of many diverse stakeholders.

I gathered information from unstructured and semi-structured interviews with MIT Department of Urban Planning and Studies (DUSP) members, city officials, and other organizations involved in Climate Ready Boston. I then gathered information from online research, which contributed substantially to the construction of the stakeholder network maps and the open government data flow maps. This method of investigation was specific to my situational context and the sociopolitical context of Boston, and I strategically adapted my information gathering methods as I accumulated information.

My goal was to create network maps that would elucidate the different dimensions of open government data in Climate Ready Boston by displaying the types of OGD used, the types of OGD products produced, the influence of different types of products, and who produced these OGD products. First, I mapped the stakeholder connections in CRB. Second, I identified open government data products and their range of influence in the CRB network produced in the first step. This OGD flow network map shows the presence of open data products, the type of product present, the reach of the product, and the stakeholders that were primary consumers of OGD and producers of OGD products. In addition to creating the network maps, online research was used to supplement any gaps in my methodology to find evidence of OGD. I detail each approach in this section.

Interviewing various sources to build a network map

Following the theoretical OGD flows model and learning from the success of Yoon and Copland's (2019) interview method to pinpoint open data impact in community based organizations, I conducted interviews primarily to uncover CRB stakeholders that use open government data, and secondarily to gather academics' and practitioners' perception of OGD influence in municipal climate action. Preliminary online research returned reports that lacked specificity or accreditation to parties that produced the research and the plans for initiatives, which further necessitated interviews.

I conducted unstructured and semi-structured interviews with MIT Department of Urban Studies and Planning professors, knowledgeable students, and the coordinator for Climate Ready Boston. Some of the interviewees had more experience working in the Boston climate context; others were experts on urban science and were based in the Boston area; others contributed to the broader national context of municipal climate change processes. Open ended questions were asked because I wanted the interviewees to rely on their perception of who the key actors were in the Climate Ready Boston network or their perception of open government data in climate change action. The questions for city officials asked them to describe their understanding of the stakeholder network. A follow up question asked them to describe if any non-traditional entities have influenced CRB action. I then asked them about whether they have seen examples of open government data used to make CRB more equitable, inclusive, or just. Appendix B has a list of conducted interviews and a general set of interview questions asked.

The interviews focused my investigation and reduced the search through the large and dispersed group of city reports. Speaking to professors, fellow students, and city staff built my intuition on climate adaptation activity in Boston, accelerated and focused certain avenues of

investigation into several community-based organizations, and decreased the search for non-traditional actors. I was fortunate enough to draw from the rich local knowledge of the urban planning community at MIT, many of them teaching about urban data or the climate crises, and others who had been organizing lectures. I was also able to obtain contacts with some of the groups for interviewing.

Reviewing Online Sources

I reviewed many online sources, which included published municipal documents and information on several city of Boston webpages as well as appendices methodology sections, external reports, and academic studies. The online research was conducted to build a network of actors that participated in Climate Ready Boston activities. Through this built network of actors and the reports and findings it produced, a second network map was constructed to trace the flow of open government data and document the different forms of information open data took, for example a spatial map, graph, or novel insight.

The Climate Ready Boston Progress Tracker on the city of Boston website listed all the climate resilience initiatives created in the CRB final report, and it provided me with a list of search areas for reports corresponding to each initiative (City of Boston, 2016a). For example, initiative *5.4 Conduct a harbor-wide flood protection system feasibility study* was completed with the University of Massachusetts Boston release of the *Feasibility of Harbor-wide Barrier Systems* report in March 2018 (Kirshen, 2018).

In total, I reviewed 14 projects connected to Climate Ready Boston. Each project was accompanied by a mixture of reports, websites, presentations, and methodology sections. Table 3 contains the list of all the online documents that contributed to the network maps.

Table 3: Projects/reports connected to Climate Ready Boston used in this thesis.

Project	Supporting reports, documents
Climate Ready Boston (CRB) Final Report	<ul style="list-style-type: none"> • <i>Climate Ready Boston Final Report</i> (City of Boston, 2016a) • <i>Approach and Methodology for Asset Data Collection and Exposure and Consequence Analysis</i> (City of Boston, 2016b)
Climate Projection Consensus for CRB Final Report	<ul style="list-style-type: none"> • <i>Climate Change and Sea Level Rise Projections for Boston: The Boston Research Advisory Group Report</i> (BRAG Report) (Douglas et al., 2016)
Boston Harbor Flood Risk Model	<ul style="list-style-type: none"> • <i>MassDOT-FHWA Pilot Project Report: Climate Change and Extreme Weather Vulnerability Assessments and Adaptation Options for the Central Artery</i>
Coastal Resilience Solutions for East Boston and Charlestown	<ul style="list-style-type: none"> • <i>Coastal Resilience Solutions for East Boston and Charlestown</i> [Final Report] (City of Boston, 2017)
Coastal Resilience Solutions for South Boston	<ul style="list-style-type: none"> • <i>Coastal Resilience Solutions for South Boston</i> [Final Report] (City of Boston, 2018c)
Updated Climate Projection Consensus for Greater Boston Communities	<ul style="list-style-type: none"> • University of Massachusetts Greater Boston Research Advisory Group (GBRAG) website (University of Massachusetts Boston, n.d.)
Feasibility of Harbor-wide Barrier Systems Preliminary Analysis	<ul style="list-style-type: none"> • <i>Feasibility of Harbor-wide Barrier Systems Report: Preliminary Analysis for Boston Harbor</i> (Kirshen, 2018)
Boston Planning and Development Agency (BPDA) Article 37 Green Building and Climate Resiliency Guidelines	<ul style="list-style-type: none"> • BPDA Climate Resiliency Guidance and Checklist (Boston Planning & Development Agency, 2017)
BPDA Coastal Flood Resilience Guidelines	<ul style="list-style-type: none"> • <i>Coastal Flood Resilience Design Guidelines</i> (Boston Planning & Development Agency, 2019)
Boston Public Works Department (BPWD) Design Standards and Guidelines for Public Rights Of Way	<ul style="list-style-type: none"> • <i>Climate Resilient Design Standards and Guidelines for Protection of Public Rights-of-Way</i> (Boston Public Works Department, 2018)
Resilient Boston Harbor Vision Plan	<ul style="list-style-type: none"> • Resilient Boston Harbor website (City of Boston, n.d.-c) • City of Boston News “Transformative Plan to Create Resilient, Open Boston Harbor Unveiled” (City of Boston, 2018d)
Climate Ready Downtown and North End Vision	<ul style="list-style-type: none"> • Climate Ready Downtown and North End website (City of Boston, n.d.-d) • Climate Ready Downtown and North End community open house #1 & #2 presentations (City of Boston, 2019a, 2019c)
Climate Ready Dorchester Vision	<ul style="list-style-type: none"> • Climate Ready Dorchester website (City of Boston, n.d.-e) • Climate Ready Dorchester open house #1 presentation (City of Boston, 2019d)
Moakley Park Vision Plan	<ul style="list-style-type: none"> • Moakley Park Vision Plan website (City of Boston, n.d.-f) • Moakley Park community open house #2 & #3 presentations (City of Boston, 2018b, 2019b)

From these online documents I compiled two lists corresponding to each network map. The first was a list of actor organizations involved or mentioned in each project. In the list, each row contained the name of the organization, scale (local, state and regional, national, global), type (government, private, nonprofit, community), report/project name (e.g. *Coastal Resilience Solutions for East Boston and Charlestown* [Final Report], (City of Boston, 2017)), and role in the project (project team, consultant team, community advisory group, etc.). This meant that if one actor worked on multiple projects, for example the Boston Green Ribbon Commission, there would be a corresponding number of rows with that actor's name. If this actor worked multiple times with another actor, their connection would be stronger, and they would be located near each other. See Table 4.1 below for a sample of data that was used to generate the stakeholder network map.

The compiled list of actors does not necessarily represent the entire CRB ecosystem because it is limited by the number of sources I reviewed, but it captures relationships as presented in important published documents. This methodology does not capture informal actors well, a gap that I attempted to fill with interviewing.

The second was a list of sources each report used as supporting evidence for the open government data flow map. For each report reviewed, a list of referenced sources was recorded. Table 4.2 below shows for a sample of data that was used to generate OGD flow map: the flood map information was taken from the Boston Harbor Flood Risk Model (BH-FRM) commissioned by). In this case, the primary consumer (column "degree" in Table 4.2 = 0) of open government data is the Boston Research Advisory Group for the *Climate Change and Sea Level Rise Projections for Boston: The Boston Research Advisory Group Report* (BRAG report) (Douglas et al., 2016). Their OGD product is BRAG report findings. The CRB final report used the BRAG report findings, meaning the CRB final report is a direct OGD product consumer

(column “product” in Table 4.2 = BRAG) and an indirect OGD consumer (City of Boston, 2016a). The “n-1 source” column contains the most immediate source that was cited for the corresponding row’s report, which would be the BRAG report for the CRB final report row.

This top-down, branching methodology cannot capture the influence of open government data if that detail is omitted in reports, or all the actors in the network as mentioned earlier. In order to capture a better picture of open government data, I examined a few organizations in more detail on their websites. I also conducted an open search for OGD products.

Table 4.1: Sample of data used to generate Climate Ready Boston stakeholder network map

Name	Scale	Type	Report	Committee
A Better City	local	nonprofit	CRB Final Report (2016)	Infrastructure Advisory Committee
A Better City	local	nonprofit	Coastal Resilience Solutions for South Boston (2018)	Supporting Stakeholder Outreach
A Better City	local	nonprofit	Coastal Flood Resilience Design Guidelines	Acknowledgments
All Aces Inc	local	private	Climate Ready Dorchester Vision	Project Team
Alternatives for Community and Environment	local	nonprofit	CRB Final Report (2016)	Community Advisory Group
Andrew Square Neighborhood Association	local	nonprofit	Coastal Resilience Solutions for South Boston (2018)	Supporting Stakeholder Outreach
Arcadis	global	private	CRB Final Report (2016)	CRB Project Team
Arcadis	global	private	Coastal Resilience Solutions for South Boston (2018)	Consultant Team
Arcadis	global	private	Feasibility of Harbor-wide Barrier Systems	Project Team

Table 4.2: Sample of data used to generate open government data flow network map

Degree	Report	Product	n-1 Source
0	The Boston Research Advisory Group Report (2016)	BRAG	
1	CRB Final Report (2016)	BRAG	The Boston Research Advisory Group Report (2016)
1	Coastal Flood Resilience Design Guidelines	BRAG	The Boston Research Advisory Group Report (2016)
2	Coastal Resilience Solutions for South Boston (2018)	BRAG	CRB Final Report (2016)

Network Graph Creation:

The list of actors generated from reviewing online sources was mapped using a force directed graph using D3.js JavaScript library. For the first stakeholder network map, the nodes represented the stakeholders and 14 report-projects. The edges represented collaboration so if a stakeholder worked on the project, the links connected these two nodes. The network map was necessary to show the propagation and transformation of open government data from a primary consumer to end users. In the second OGD flows map, the nodes represent either OGD related projects, OGD consumers, or both. Appendix C contains a detailed methodology for the network map creation process.

Part IV: Results

This chapter summarizes the findings from the stakeholder network map. Then the findings on open government data flows in Boston's climate adaptation planning is reviewed. The research reveals five clear open government data products present in Climate Ready Boston projects. For each of the five open government data products, I explain the datasets used, the actors that produced the product, and the propagating influence the product has had across the Climate Ready Boston network.

Stakeholder network map of Climate Ready Boston:

Figure 2 is the stakeholder network map of Climate Ready Boston. The radially arrayed pink nodes represent published reports, the other nodes represent relevant groups. The stakeholders that were only involved in one project are congregated to the radial periphery of the map. The stakeholders connected to multiple projects are congregated within the ring of reports shown in Figure 2. The map visually illustrates that local and regional government agencies are the primary group of stakeholders in CRB and have influence in multiple projects, followed by nonprofit organizations and private firms. The degree of involvement of a stakeholder is determined by the number of projects they have contributed to. For example, the Boston Environment Department is heavily involved in CRB, contributed to 10 out of 14 projects, because they CRB team is part of the Environment Department. The Boston Planning and Development Agency (BPDA) is also heavily involved in CRB because they deal with new zoning taking into account new flood projections and they set new flood resilient design guidelines for new and old buildings.

Several non-government stakeholders have a reoccurring presence in the CRB network. The University of Massachusetts Boston, specifically the School for the Environment, is the primary

academic institution partner, and they provide much of the scientific research necessary for action, leading the Boston Research Advisory Group scientists in creating a climate projection consensus, and other assessments. But besides UMass Boston, the numerous academic institutions in Boston are have minimal presence. Climate Ready Boston projects also involve a core group of private consultants, and a more variable group of design firms that vary across different CRB projects. For example, Arcadis, a Netherlands-based global design, engineering, and management consultancy, has been involved on city-scale projects such as the Climate Ready Boston Final Report, Feasibility of Harbor-wide Barrier Systems, Resilient Boston Harbor Vision Plan, and also neighborhood-level projects, such as Coastal Resilience Solutions for South End, and Climate Ready Downtown and North End planning. The Woods Hole Group, a private environmental, scientific, engineering consultancy based in Woods Hole, Massachusetts, has also produced influential flood risk models for CRB, and is involved in multiple projects. Urban design firms such as Stoss Landscape, ONE Architects, and Sasaki are involved in three or fewer projects. Lastly, several nonprofit organizations dominate the share of nonprofit involvement in CRB. The Boston Green Ribbon Commission is a group of business, institutional, and civic leaders in Boston working on Climate Change. Along with the Barr Foundation, these two stakeholders sponsor projects and research for Climate Ready Boston. Other important nonprofit stakeholders are Boston Harbor Now, a nonprofit co-managing the Boston Harbor Islands National Park and establishing the Boston Harborwalk, A Better City coalition of business, and LiveableStreets Alliance for better transportation systems.

Many place-based nonprofits are only involved in initiatives near their geographic neighborhood. This can be seen in figure 2, that many of the green nodes that connect to only one report are neighborhood level planning, including the Coastal Resilience Solutions for East Boston and Charlestown, Coastal Resilience Solutions for South Boston, and Moakley Park Vision Plan. This network map did not reveal non-traditional stakeholders.

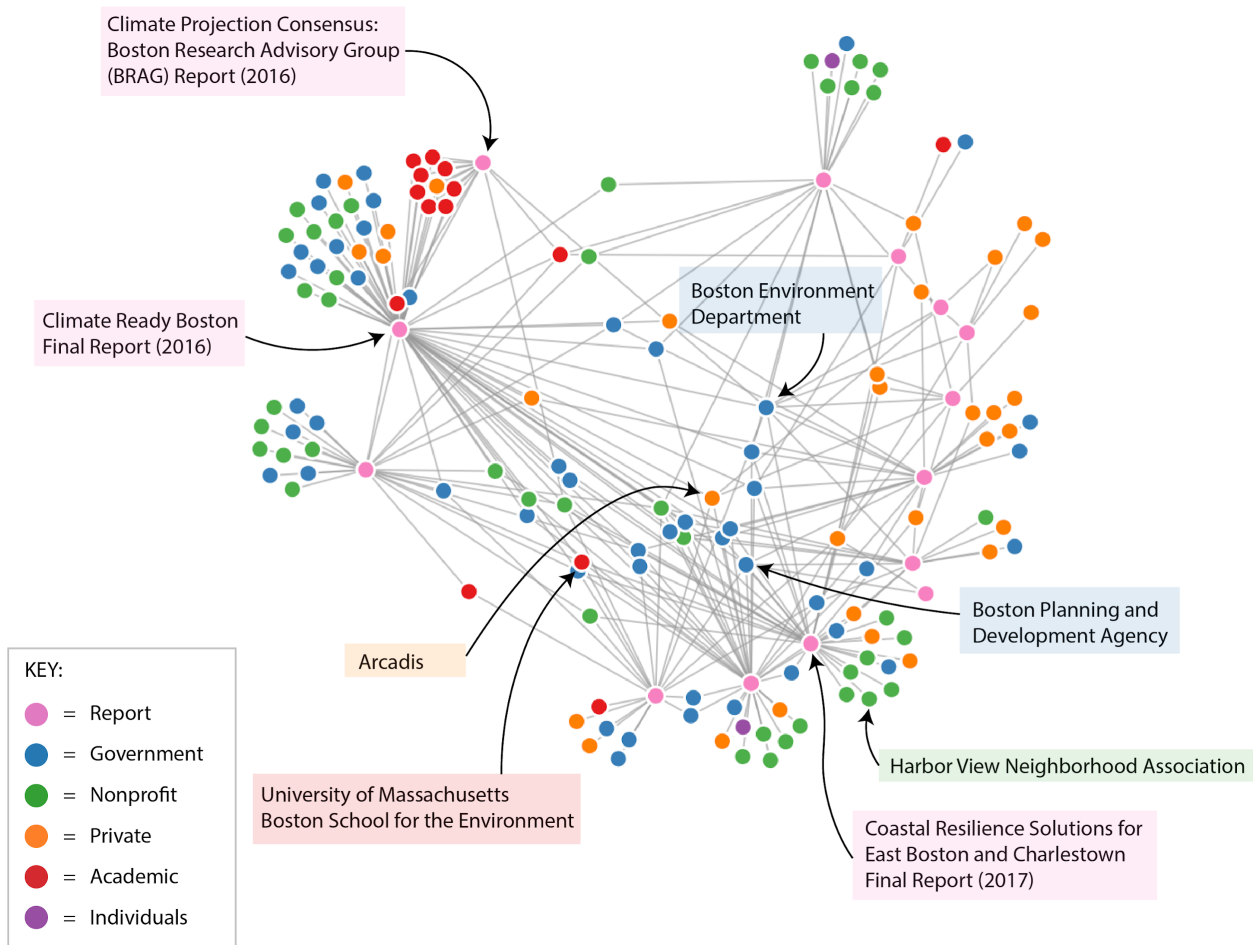


Figure 2: Stakeholder network map of Climate Ready Boston.

Open government data flows in Climate Ready Boston:

The five open government data products present in Climate Ready Boston projects are: (1) Climate projection consensus from the Boston Research Advisory Group report, (2) the Boston Harbor Flood Risk Model from the MassDOT-FHWA Pilot Project Report: Climate Change and Extreme Weather Vulnerability Assessments and Adaptation Options for the Central Artery, (3) Boston social factors for vulnerability identified by Dr. Atyia Martin in her paper, “A Framework to Understand the Relationship between Social Factors That Reduce Resilience in Cities: Application to the City of Boston”, (4) the Exposure and Consequence Analysis from Climate Ready Boston Final Report, and (5) the Greater Boston Exposure and Consequence Analysis from Feasibility of Harbor-wide Barrier Systems report. Figure 3.0 shows both the reports that produced OGD products and reports that referenced these products. Figures 3.1-3.5 correspond with the five open government data products and are accompanied by in-depth review of each OGD product below.

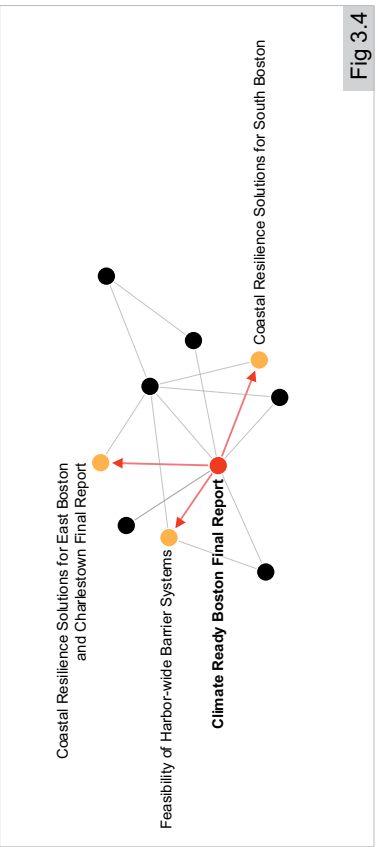
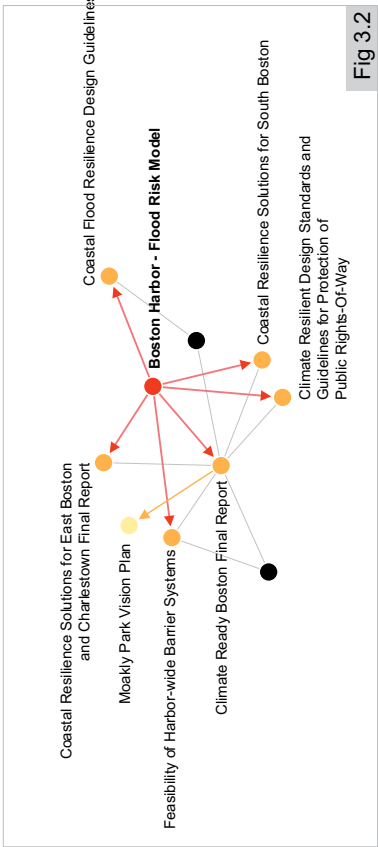
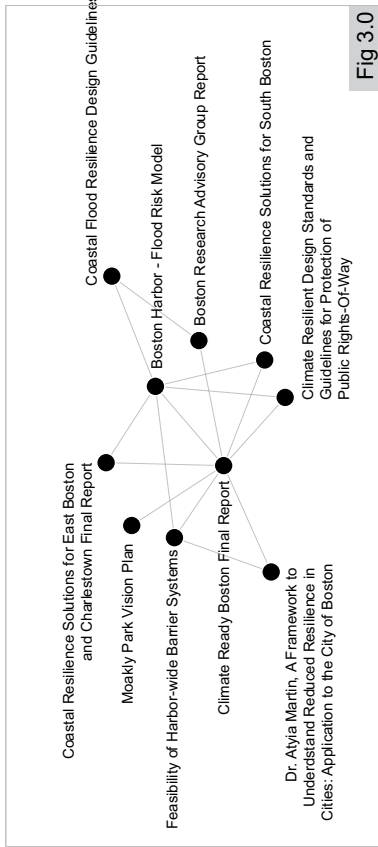
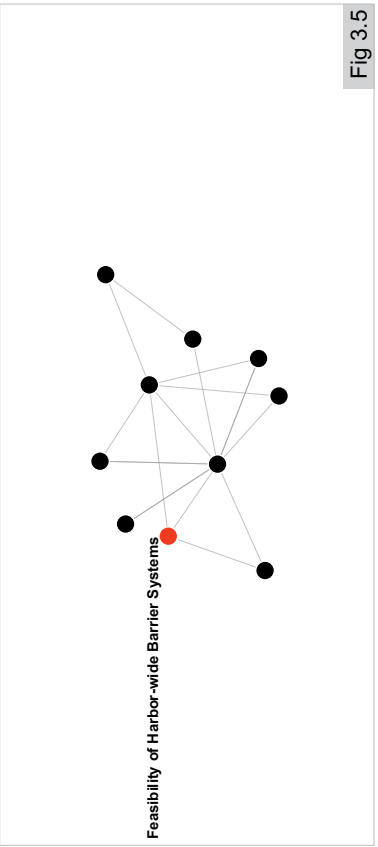
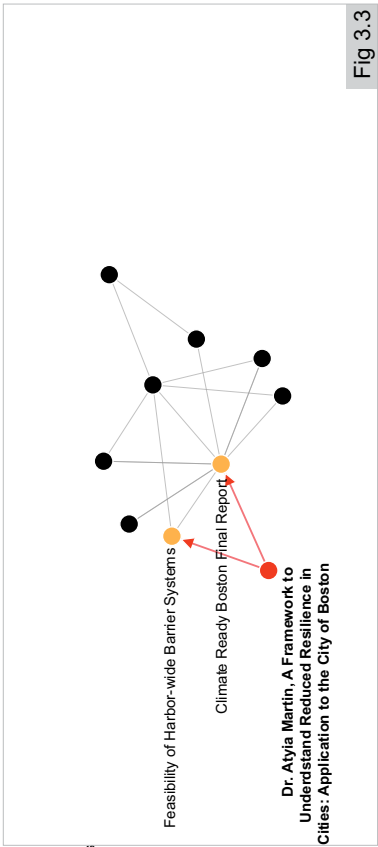
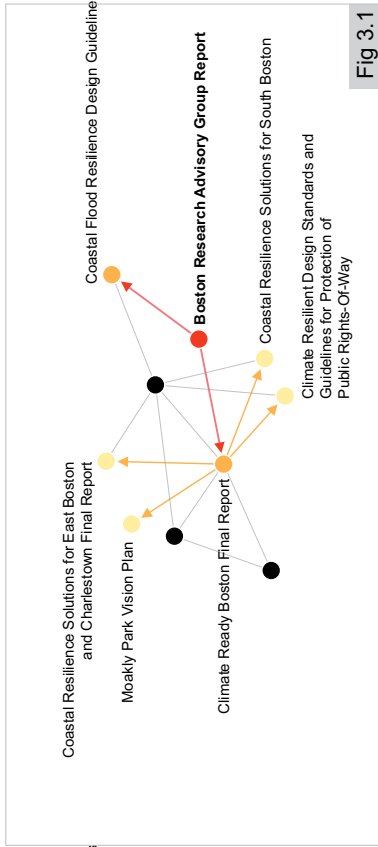


Figure 3.0-3.5 . Open government data flow network maps. The nodes represent reports associated with CRB. Red nodes are primary OGD consumers. Arrows to the target show direct influence from referencing the source node in the target node report. Orange and yellow nodes are direct or indirect consumers of OGD products. **Fig 3.0** labels the entire subset of the CRB network that consume OGD directly or through OGD products. **Fig 3.1** Boston Research Advisory Group Report as OGD consumer. **Fig 3.2** MassDOT-FHWA as OGD consumer, producing BH-FRM. **Fig 3.3** "A Framework to Understand Reduced Resilience in Cities: Application to the City of Boston" as OGD consumer. **Fig 3.4** CRB final report as OGD consumer. **Fig 3.5** Feasibility of Harbor-wide Barrier Systems report as OGD consumer.

(1) The Boston Research Advisory Group Report (2016)

Open Government Datasets: Boston, MA tide gauge station (#8443970) operated by the National Ocean and Atmospheric Administration (NOAA) water level data; LANDSAT imagery for surface temperature

Product: Sea level rise projections; other climate projections

Project Team: University of Massachusetts Boston School for the Environment, UMass Amherst, Tufts University, Boston University, Harvard University, MIT, Northeastern, UMass Lowell, Cornell University, and Rutgers University.

The June 2016 Boston Research Advisory Group (BRAG) released *Climate Change and Sea Level Rise Projections for Boston: The Boston Research Advisory Group Report* (BRAG report) that presented scientific consensus on Boston climate projections for temperature change, sea level rise, coastal storms, extreme participation, and extreme temperatures (Douglas et al., 2016). BRAG was specifically organized by the city for Climate Ready Boston to gather agreed upon climate projections. BRAG was led by environmental scientists from University of Massachusetts Boston School for the Environment, and consisted of collaboration between researchers from UMass Boston, UMass Amherst, Tufts University, Boston University, Harvard University, MIT, Northeastern, UMass Lowell, Cornell University, and Rutgers University. Scientists worked in teams to review existing climate projections from a variety of climate models, emissions scenario, and studies. For example, BRAG used the IPCC emission scenarios (called “representative concentration pathways”, RCPs) RCPs 2.6, 4.5, 6.0, and 8.6, to provide a range of climate outcomes.

Though researchers primarily used numbers and findings from other environmental science studies, they also used water level data from the Boston tide gauge station in order to predict local changes. “We note that projections of future RSL [relative sea level] are provided

specifically for the location of the Boston, MA tide gauge station (#8443970) operated by the National Ocean and Atmospheric Administration (NOAA)” (Douglas et al., 2016, p. 6). Though it is unclear how they obtained the water level data, the dataset is freely available for download and most easily obtained from NOAA’s website. Additionally in the extreme temperature section of the report, researchers used LANDSAT imagery to show evidence for the urban heat island effect. The BRAG Report is considered a primary product of OGD in the form of scientific findings. The climate projection numbers from the BRAG Report are also the reference datum for CRB activities.

BRAG had a very large impact on the CRB final report because it provided a number, 36 inches of sea level rise by 2070, for all future planning to prepare for. All projects, if not directly referencing findings from BRAG are subject to design for the sea level rise amount BRAG reported. The CRB final report’s climate projection consensus was primarily based off of the findings of the BRAG report. The *Coastal Flood Resilience Design Guidelines* created by the Boston Planning and Development Agency for new building design and retrofit for flood resilience references BRAG numbers (Boston Planning & Development Agency, 2017). The *Coastal Resilience Solutions for East Boston and Charlestown Final Report* (City of Boston, 2017) and the *Coastal Resilience Solutions for South Boston Final Report* (City of Boston, 2018c), two neighborhood flood resilience plans reference the climate projection consensus from the CRB final report. This propagation of BRAG’s influence can be seen in in Figure 3.1.

(2) Boston Harbor Flood Risk Model (2015) (BH-FRM)

Open Government Datasets: MassGIS and Boston Redevelopment Agency maps; Massachusetts Coastal Infrastructure Inventory (sea walls and barriers); FEMA coastal transects; US Army Corps of Engineers hurricane inundation maps

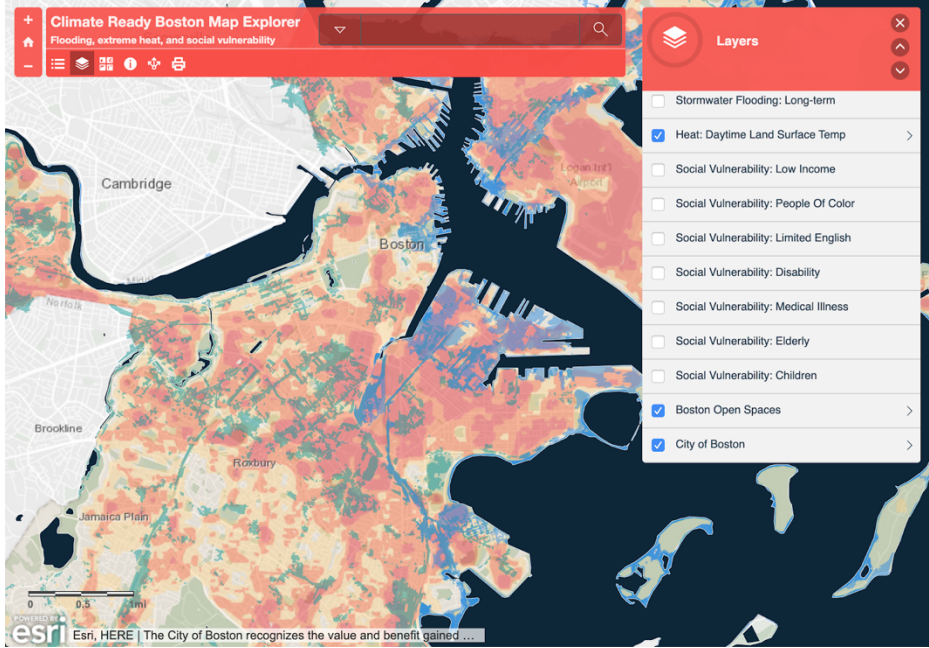
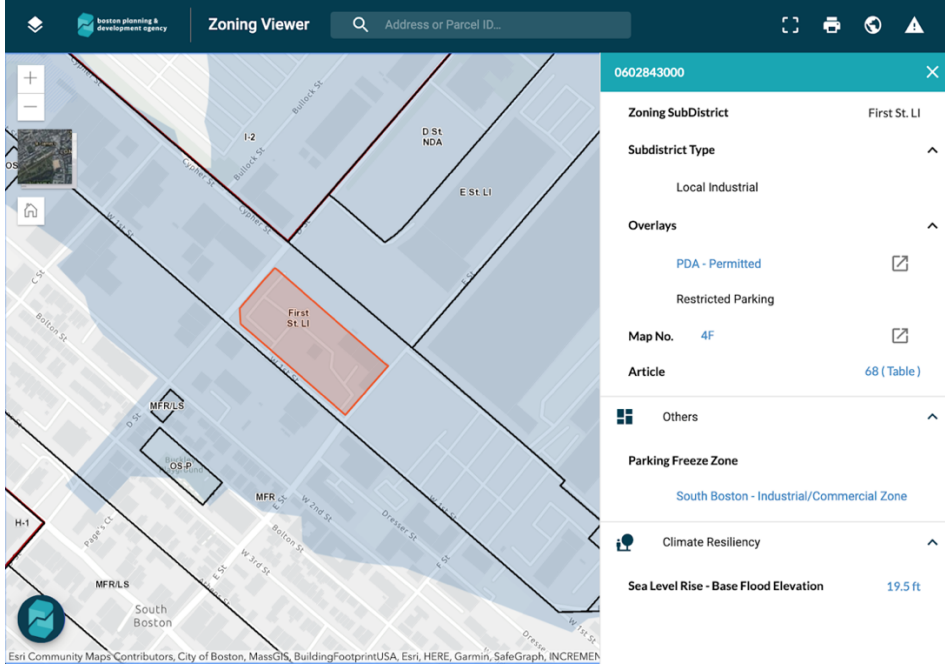
Product: Flood risk model which creates flood layers for different sea level rise and storm scenarios

Project Team: MassDOT Highway Division Environmental Services Section, UMass Boston, Woods Hole Group, and University of New Hampshire

The Boston Harbor Flood Risk Model (BH-FRM) tool was produced for a pilot project commissioned by the Massachusetts Department of Transportation and the Federal Highway Administration to assess and improve the resiliency of the Central Artery and Tunnel System (CA/T). The project was managed by the MassDOT Highway Division Environmental Services Section and was executed by UMass-Boston, Woods Hole Group, and University of New Hampshire (Bosma et al., 2015). The Boston Harbor Flood Risk Model (BH-FRM) is a mathematically simulated model of coastal and riverine flooding for different sea level rise and storm scenarios.

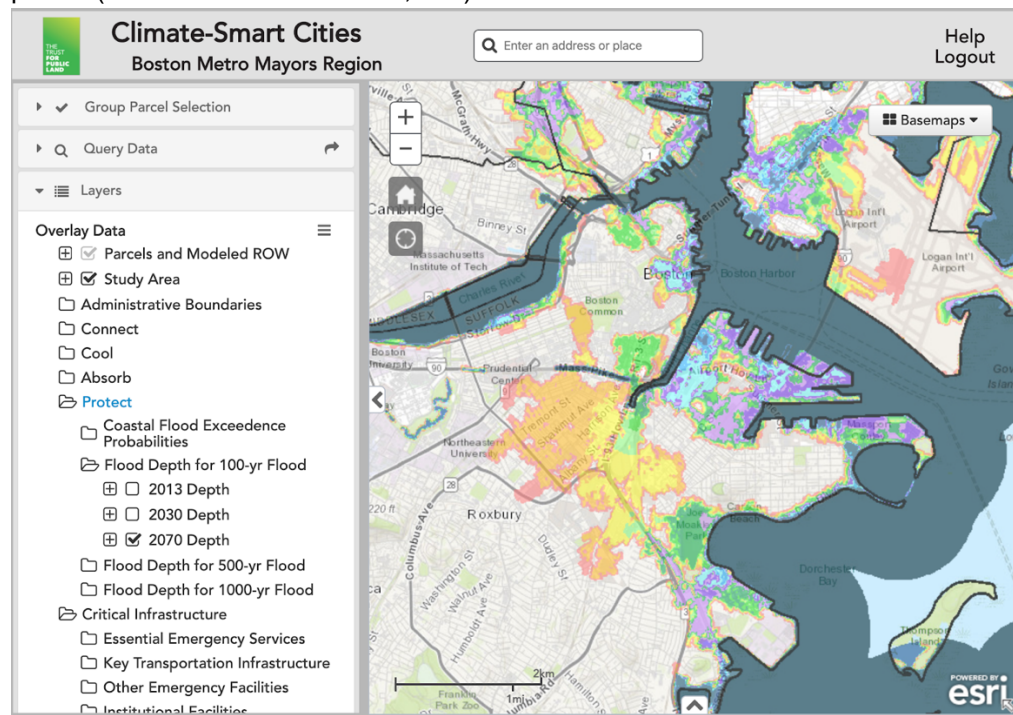
The Boston Harbor Flood Risk Model has been just as, if not more influential than the BRAG report. The coastal and riverine flooding subsection in the climate vulnerability assessment of the CRB final report relied heavily on the BH-FRM. Property damage estimates from coastal and riverine flooding were based off of the land areas that would be inundated from the BH-FRM, using the BRAG sea level rise scenarios. All subsequent reports used the BH-FRM in order to locate floodways, design interventions, etc. The flood maps geodata were published on Analyze Boston, and many online maps have been made using BH-FRM data: Table 5 is a list of mapping tools that use BH-FRM flood layers; some of the projects or reports are not directly related to CRB initiatives. Figure 3.2 shows the influence of the BH-FRM visually through a network map, where the colored nodes explicitly accredited BH-FRM.

Table 5. List of online mapping tools using Boston Harbor Flood Risk Model geodata.

Project/Report	Online Mapping tool
<p>Climate Ready Boston Final Report</p>	<p>“Climate Ready Boston Map Explorer” is the official map for Climate Ready Boston. It contains BH-FRM layers and seven indicator variables for increased vulnerability climate change (City of Boston, n.d.-g)</p> 
<p>Coastal Flood Resilience Design Guidelines and Article 37 Green Building and Climate Resiliency Guidelines</p>	<p>“Flood Hazard Area Online Mapping Tool” in the Zoning Viewer by the BPDA and Boston Zoning Commission returns base flood elevation information by property or parcel. (Boston Planning & Development Agency, n.d.)</p> 

Trust for Public Land's Climate-Smart Cities Program in partnership with the Metropolitan Area Planning Council (MAPC)

“Boston Metro Mayors Decision Support Tool” for Boston metro area cities to guide strategic siting of parks, open space and green infrastructure solutions, open to the public. (The Trust for Public Land, n.d.)



(3) Dr. Atyia Martin, A Framework to Understand the Relationship between Social Factors That Reduce Resilience in Cities: Application to the City of Boston

Open Government Datasets: American Community Survey 2008–2012 5-Year Estimate by the U.S. Census Bureau

Product: A framework with seven key variables that indicate social vulnerability, tested with City of Boston data

Project Team: Dr. Atyia Martin

The former Chief Resilience Officer for the City of Boston Dr. Atyia Martin’s research paper “A Framework to Understand the Relationship between Social Factors That Reduce Resilience in

Cities: Application to the City of Boston” created the Social Determinants of Vulnerability Framework that consists of seven interrelated demographic factors that indicate social vulnerability (Martin, 2015). This framework was validated using quantitative methods using City of Boston data. The paper retrieved variables at the census tract level from U.S. Census Bureau’s American Community Survey (ACS) 2008–2012 5-Year Estimate at the census tract level were: children, people with disabilities, older adults, chronic and acute medical illness, social isolation, low-to-no income, people of color, limited English Proficiency, renters, less than high school education, women, and lack of vehicle” (Martin, 2015, pp. 56–57). The paper identified South Roxbury, Dorchester, and Mattapan as the neighborhoods with the highest social vulnerability.

The findings from Martin’s paper contributed to the bulk of Climate Ready Boston Final Report’s vulnerability assessment on people and reinforced the need for equity-based actions and negative effects on lives. The Climate Ready Boston Map Explorer online mapping tool contains seven layers of geospatial data, each corresponding to a variable from Martin’s paper (see first row of table 5). The geospatial data is also published on Boston’s open data portal. The *Feasibility of Harbor-wide Barrier Systems* report also references and uses the methodology from Martin’s paper for a comparative vulnerability assessment between a harbor-wide barrier system or a shore-based barrier system. Figure 3.3 shows the extent Martin’s paper is referenced.

(4) Exposure and Consequence Analysis -- Climate Ready Boston Final Report (2016)

Open Government Datasets: US 2010 Census population estimates per census tract, Statistics on vulnerable populations as determined using U.S. Census and American

Community Survey (ACS) data compiled by Dr. Atyia Martin, City of Boston Property Tax Assessing Data

Product: Exposure and Consequence Analysis, expected risk (in dollars) of building resiliency for different flooding scenarios

Project Team: Climate Ready Boston team: City of Boston, University of Massachusetts Boston School for the Environment, HR&A Advisors, Arcadis, Sasaki

Announced in December of 2016, *Climate Ready Boston Final Report* (City of Boston, 2016a) set Boston's climate adaptation and resiliency action plan, under Mayor Martin Walsh's citywide master plan *Imagine Boston 2030*. Climate Ready Boston works on extreme heat, coastal and riverine flooding resiliency. The Exposure and Consequence Analysis is part of the climate vulnerability assessment section of the Climate Ready Boston Final Report. Drawing from the spatial overlay of flood maps from the BH-FRM, the CRB final report team estimated the expected risk of coastal and riverine flooding.

The Exposure and Consequence Analysis provided evidence-backed reasoning for CRB activities (City of Boston, 2016b). It also provided justification for coastal resiliency neighborhood planning in East Boston and Charlestown. The methodology to calculate risk was adopted in the *Feasibility of Harbor-wide Barrier Systems* report. Figure 3.4 shows the influence of the Exposure and Consequence Analysis.

(5) Exposure and Consequence Analysis for extended Boston -- Feasibility of Harbor-wide Barrier Systems (2018)

Open Government Datasets: US 2010 Census population estimates per census tract, Parcel inventory, Statistics on vulnerable populations as determined using U.S. Census and American

Community Survey (ACS) data compiled by Dr. Atyia Martin. MassGIS Level 4 Assessor's Parcel Data, City of Boston Property Tax Assessing Data

Product: Exposure and Consequence Analysis for towns and cities surrounding Boston, expected risk (in dollars) of building resiliency for different flooding scenarios

Project Team: Climate Ready Boston team: University of Massachusetts Boston School for the Environment, Arcadis, Woods Hole Oceanographic Institution, Woods Hole Group, Urban Harbors Institute

Feasibility of Harbor-wide Barrier Systems is a preliminary assessment by a multidisciplinary team led by the Sustainable Solutions Lab at the University of Massachusetts Boston on the feasibilities and potential benefits, costs, and environmental impacts of three harbor-wide barrier configurations: Inner Harbor Barrier (shore based), Outer Harbor Barrier (mixture of shore based and inter-island barriers) and Metro Boston Dike Barrier (Kirshen, 2018).

An exposure and consequence analysis for the towns and cities the harbor-wide systems would protect was conducted for the *Feasibility of Harbor-wide Barrier Systems* report using the same methodology and data sources as the exposure and consequence analysis for the CRB final report. The towns and cities included are Boston, Braintree, Brookline, Cambridge, Chelsea, Everett, Hingham, Hull, Malden, Medford, Milton, Newton, Quincy, Revere, Somerville, Weymouth, and Winthrop, which represent the extent of communities expected to benefit from the Outer Harbor Barrier configuration. Appendix D "Methodology for economic and vulnerable Populations Analyses" of the *Feasibility of Harbor-wide Barrier Systems* report detailed the methodology to produce the exposure and consequence analysis for extended Boston.

Appendix D and the exposure and consequence analysis for extended Boston was prepared by Arcadis design and engineering consultancy for the UMass Boston team. Arcadis was on the project team for Climate Ready Boston and at the least, familiar, and at most responsible for the exposure and consequence analysis for the CRB final report.

This report generated valuable risk assessment information and damage calculations associated with three different coastal defense configurations, and the recommendation for shore-based defense configuration determined the Boston Environment Department's flood resilience strategy; however, the OGD products of this feasibility report, a cost analysis and exposure and consequence analysis for hypothetical configurations, did not influence positive action in the Climate Ready Boston scope. Figure 3.5 shows the influence of the Exposure and Consequence Analysis for the Greater Boston Area.

Part V: Discussion

In this section, similarities between the five OGD products described above are discussed.

Then, a larger discussion on the insights during the investigative and data collection process is included.

Analysis of the five OGD Products:

There are three main observations from the OGD products:

1. The data used in the OGD products tend to be geospatial, environment, and demographic related:

US Census data and American Community Survey (ACS) data was used in the OGD products related to risk. Environment data was used in the climate science reports. NOAA's tide gauge station in Boston (ID: 8443970) has been collecting data since 1921, which is entirely available on its tides and currents webpage.

2. The OGD products that are influential are largely created via government sponsorship of the project. This means that much of the research data is also internal government data.

The BH-FRM was sponsored by MassDOT and the FWHA in response to threats to the central artery and tunnel which are state and federal infrastructures. In addition to the BH-FRM, the project team also were given proprietary data on assets such as information on pump stations, power stations, etc. owned and operated by MassDOT and FWHA. BRAG was also formed by the CRB team to create a climate consensus.

3. The same stakeholders are responsible for creating multiple influential OGD products.

Other than Dr. Atiya Martin's academic paper on social vulnerability, Climate Ready Boston activities are largely based off research tasked to University of Massachusetts Boston. The exposure and consequence analysis products for CRB report and the Feasibility of Harbor-wide Barrier Systems were made by government collaboration with UMass Boston and contracted

private consultants that reoccur in CRB activities, most prominently Woods Hole Group and Arcadis.

The stakeholders who generate actionable knowledge from OGD, who have been able influence CRB with their data product, are able to do so because their authority comes not from the authority of data, but because of their authority from their organization's identity, as a private consultant or academic research institution. Looking at the few OGD products in the CRB ecosystem, only four of the five products were actionable. The climate projections from the BRAG report were fed into the BH-FRM to identify the land area at risk for flooding and to the flood paths for strategic points of intervention. The Exposure and Consequence Analysis in the CRB final report calculated the expected loss from physical damage to buildings, physical damage to contents and inventory, and displacement costs of businesses and occupations. It determined how resilient Boston aimed to be and set a budget and timeline for CRB. The Exposure and Consequence Analysis in the *Feasibility of Harbor-wide Barrier Systems* report also proposed CRB should take an inner harbor shore-based flood defense strategy. Dr. Atyia Martin's report on social factors for vulnerability generated visibility on the disproportionate vulnerability for certain populations, but the responsibility for equitable climate resilience action has been delegated to other agencies such as the Boston Public Health Commission in CRB initiative 2.3 "Conduct an outreach campaign to facilities that serve vulnerable populations to support preparedness and adaptation" and to the Office of Emergency Management in CRB initiative 2.4 "Update the City's heat emergency action plan".

The existing reports related to CRB do not have equity or community social resiliency as their primary focus areas, and instead focus on landscape urbanism using gray and green infrastructure for coastal resilience. So in the case of Climate Ready Boston, the open aspect of open government data has not increased inclusivity, equity, or justice. OGD has not been

utilized by bottom-up stakeholders such as neighborhood organizations, nor enabled non-traditional actors such as individuals to add to CRB planning agenda.

Insights:

During the investigative and data collection process, several insights on open government data in the Boston climate adaptation context arose. Overall, evidence of open government data influence was difficult to find.

When examining the primary source of data consumption, it was difficult to ascertain how the data were obtained. For example in the BRAG report, historic water level data recorded by a NOAA operated water gauge was used to predict the sea level rise in Boston Harbor. The water gauge data is available on NOAA's web database; however, NOAA was on the project's steering committee, and could have provided water level data to BRAG directly. Furthermore, the MassDOT-FHWA Pilot Project Report, which created the Boston Harbor Flood Risk Model, concretely demonstrates that acquisition of data from data portals projects is unimportant for projects sponsored by a government agency. The methodology section of the report documents an introductory meeting with MassDOT GIS staff to acquire data relevant to the project:

"MassDOT provided to UMass Boston an ESRI-format geodatabase (BostonData.mdb) for use by the Project Team. This geodatabase primarily contained point, line and polygon feature classes (GIS datasets) representing MassDOT Assets associated with the CA/T, and several feature classes that were derived from other public sources (e.g., MassGIS and Boston Redevelopment Agency)" (Bosma et al., 2015, p. 9).

This means that even though these datasets are freely published on the web through government websites (for example the American Community Survey), the open aspect of the datasets may be irrelevant to whether or not the data is used in climate resilience action. Dr. Atyia Martin's paper was the only open government data product unaffiliated with government,

likely that the data was retrieved from the U.S Census Bureau web source. Most times, only insights generated from government sponsored projects are legitimate and perpetuated in future government sponsored projects, at least in Boston's climate resiliency action context. It is interesting to see UMass Boston's constant engagement with CRB activities and it raises the question of which stakeholder, UMass Boston or City of Boston, initiates the collaboration, and if research done in an academic institution is more trustworthy than research done by a private consultant.

I did not find any evidence of influential open government data products that were not produced from government or consultant parties.

The reason for creating a stakeholder network map was to generate a comprehensive list of involved stakeholder organizations, so that each organization was searched for open government data usage related to Climate Ready Boston. This exhaustive search attempted to fill potential omissions of OGD influence in government published documents. An examination of the involved nonprofit, place-based stakeholder organizations showed that little to no quantitative analysis had been done around climate resilience or open government data usage.

An exploration of Boston's open data portal, Analyze Boston, revealed that while some datasets, such as the Employee Earnings Report were very popular, the datasets related to climate, especially the data produced from Climate Ready Boston activities were viewed less: the 36inch Sea Level Rise 10pct Annual Flood map was viewed 39 times. An open search for "analyze boston climate" returned several academic journals, webpages showcasing student data visualization projects, and hackathon events, such as the 2017 Analyze Boston Open Data Challenge.

The winning entry for the Climate Change category in Analyze Boston's 2017 Open Data Challenge hackathon was an interactive mapping tool called Beantown Solar: "For this track, our team decided to help the City of Boston and others begin to comprehend the extent to which we can leverage the square footage available on top of our buildings to offset our energy usage via solar power. Utilizing the BERDO and BPDA asset from Boston, along with Google Sunroof, we have produced advanced visualizations of Boston and a scenario planner for future planning usage" (City of Boston, n.d.-a). However, further search for "beantown solar" did not return any results.

I found an independent project "Leveraging Open Data for Climate Resilience Planning in Boston" on a personal website (Gunkel, 2017); the author used the Trust for Public Land's Climate-Smart Cities Decision Support Tool and 311 data from Analyze Boston to demonstrate the need for green infrastructure at Moakley Park, a critical flooding pathway, to protect against coastal flooding that would affect Dorchester and South Boston neighborhoods. Analysis of mold and dampness incidents reported to 311 surround Moakley Park revealed chronic exposure to mold and dampness highly correlated with inequities in housing quality between privately owned housing and Boston Housing Authority public housing, non-white, and low-income population. This independent project leverages open government data and generates insights on existing health inequities that would be exacerbated by coastal flooding and provides recommendations for flood resilience green infrastructure.

I contacted the author about any action taken from his piece and he said "No, nobody in the City proactively reached out since it was written. Back when it was written I tried to win the ear of the City, especially if folks from the Climate Ready Boston team. But they were very busy with personnel shifts and getting the planning activities for some of the very first open houses, design charrettes around Climate Ready East Boston off the ground. It would have been actually perfect timing if my piece would have reached them a couple months later when the

city's work on Moakley Park really began." He added that he presented his work at the Boston Area Research Initiative conference, but not much resulted from that.

This means either that open government data is not used often, or actions and findings informed by OGD are not attributed online. Interviews suggest it is the former rather than the latter.

None of my interviewees were able to point to a specific example of open government data usage in the Boston climate resiliency context. Many interviewees seemed confused by my question, and most times couldn't speak to open government data in climate action. One interviewee said: "I'm not clear about open government data in climate action." Another interviewee said: "I've been working for six months and I haven't heard anyone mention open data" And another interviewee said: "No, I don't know of any organizations working with open data; maybe you should try to find a more contentious area, where you might actually find open data used for justice." The response of the CRB city official closely aligned with the stakeholder network map, where she brought up BPDA, MassDOT, MBTA as the primary stakeholders, and could not identify any groups that had been working with OGD. Additionally, she corroborated my findings on OGD products when asked about the role of data in CRB.

Three interviewees responded that smaller, community-based organizations often lack the capacity to engage in data analysis unless they are in collaboration with academic institutions. They are often understaffed, lack technical expertise, time, and capital to invest in data analysis, and those resources could be utilized more effectively in their programming. The types of organizations that do engage with open government data tend to be journalistic watchdog organizations. Open government data aims increase inclusivity by providing quantitative data openly and freely, yet in the CRB context, only academic and government-initiated research uses OGD. The existence of OGD currently does not contribute to the increased participation of

citizens nor does it generate insights or provide tools that influence Climate Ready Boston to produce equitable outcomes.

Government processes can be impervious to outside influences. One interviewee brought up the time scale at which the government works, in that governments need to adhere to a set of procedures going through a request for proposal and procurement process, for example designing coastal resilience solutions for Charlestown and East Boston, that does not necessarily allow for outside events to be incorporated. The importance of timing is further illustrated by independent project introduced above, “Leveraging Open Data for Climate Resilience Planning in Boston” in which the internal activities of the city prevented input. The stakeholder network shows that Climate Ready Boston activities behave in a standard way, because the city operates under set procedure and protocol, making it difficult to introduce innovation. No non-traditional stakeholders were found in the stakeholder map. Government agencies, private consulting firms, private design firms, community-based nonprofits, and wealthier nonprofits were the main stakeholder categories represented. Additionally, the lack of projects from a brief search for “analyze boston climate” hints at the lack of open government data usage for climate action in Boston, along with the low number of views CRB data got on the Analyze Boston website.

The findings raise a future question: how can open government data begin to be used to increase inclusivity, equity, and justice? Though Climate Ready Boston has incorporated some levels of citizen participation in their projects by holding open house meetings for their neighborhood coastal resilience design projects (Climate Resilient Solutions for East Boston and Charlestown, Climate Resilient Solutions for South Boston, Climate Ready Downtown and North End, Climate Ready Dorchester, Moakley Park redesign), CRB has yet to dedicate an initiative solely to ensure equitable outcomes in its climate initiatives. As explained above,

government processes can be impervious to outside influences. CRB action has also relied heavily on commissioned research done by University of Massachusetts Boston in the past, suggesting that the City of Boston trusts research done by an academic institution. A Climate Ready Boston commissioned academic research team that collaborates with different community nonprofits to generate insights using OGD could actionably steer CRB initiatives to ensure equitable outcomes. This would provide a direct participatory channel in climate action planning, as the research team is commissioned by CRB. Collaboration with an academic institution would lower the barrier to engage in data-backed, evidence-backed advocacy from community organizations.

Future research directions:

The methodology of this study has limitations. It primarily gathers information from documents that have been published, so it is difficult to trace indirect influence that open government data may have. In order to balance this effect, more interviews with different stakeholder groups would confirm with more certainty about the presence of OGD. The OGD impact assessments covered in the literature review section, where Yoon and Copland interviewed 45 individuals from community organizations, suggests that OGD can have impact at the community level.

Future directions of this paper would be to interview more people from different organizations to capture knowledge that may not make it to a published report. To search for latent opportunities to increase inclusivity in municipal agenda setting, a study on existing research groups in academic institutions that already work with local community organizations could be conducted.

Another direction would be to expand area of study to climate resilience beyond the city's Environment Department's Climate Ready Boston jurisdiction. The Boston Environment Department is focusing efforts on infrastructural flood resilience through a landscape urbanism approach, as seen by the private practices involved in the CRB network; however, a very

important piece in climate resilience, which may deal more heavily in social and equity issues, is a climate emergency response plan. The Office of Emergency Management is currently working on a Hazard Mitigation Plan, and the Boston Public Health Commission is involved with planning for post-disaster capacity and planning.

Part VI: Conclusion

This thesis investigated the presence and role of open government data in Climate Ready Boston climate resilience project. Through extensive searching through online published reports, documents, and searching through various organizations webpages for traces of open government data, only five OGD products that influenced other Climate Ready projects were found. Of these five OGD products, four were sponsored and led by various government agencies, and the other was an academic research paper.

Traces of open government data were difficult to find, which suggests that open government data is underutilized in Boston's climate resilience planning so far. This cannot be claimed with certainty since it is difficult to prove the absence of something, and more importantly the method of this investigation limited by what sources I review. However, it is important to demystify the purported benefits or synergies of open government data with climate action, and to understand the contextual challenges of realizing the full potential of this technology. The findings suggest a promising path to increase inclusivity for equitable outcome using open government data via a city sponsored/commissioned academic research team, but it requires conscious government, academic, and community collaboration. Future directions to identify latent possibilities for open government data are to conduct interviews with every identified stakeholder organization, and then to investigate the presence of open government data in the city of Boston's Climate Hazard mitigation plan, along with the Boston Public Health Commission's response plan and capacity in the face of climate hazard.

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Appendix A: Compiled list of perceived benefits of open government data

Table adapted from Janssen et al., and Gonzalez-Zapata

CATEGORY	BENEFITS
Political and Social	<p>----- Janssen</p> <ul style="list-style-type: none"> More transparency Democratic accountability More participation and self-empowerment of citizens (users) Creation of trust in government Public engagement Scrutinization of data Equal access to data New governmental services for citizens Improvement of citizen services Improvement of citizen satisfaction Improvement of policy-making processes More visibility for the data provider Stimulation of knowledge developments Creation of new insights in the public sector New (innovative) social services <p>----- Gonzalez-Zapata</p> <ul style="list-style-type: none"> The constitutional right to access public information Democracy Citizen's empowerment and participation To have the appearance of transparency Transparency and democracy standards -- political empowerment and participation as core goals Improvement of efficiency of public sector Improvement of effectiveness of public sector
Economic	<p>----- Janssen</p> <ul style="list-style-type: none"> Economic growth and stimulation of competitiveness Stimulation of innovation Contribution toward the improvement of processes, products, and/or services Development of new products and services Use of the wisdom of the crowds: tapping into the intelligence of the collective Creation of a new sector adding value to the economy Availability of information for investors and companies <p>----- Gonzalez-Zapata</p> <ul style="list-style-type: none"> Economic growth through market/private sector firm-based manipulation of data Create new products, services, and jobs, profits, and investments
Operational and technical	<p>----- Janssen</p> <ul style="list-style-type: none"> The ability to reuse data/not having to collect the same data again and counteracting unnecessary duplication and associated costs (also by other public institutions) Optimization of administrative processes Improvement of public policies Access to external problem-solving capacity Fair decision-making by enabling comparison Easier access to data and discovery of data Creation of new data based on combining data External quality checks of data (validation) Sustainability of data (no data loss) The ability to merge, integrate, and mesh public and private data <p>----- Gonzalez-Zapata</p> <ul style="list-style-type: none"> Improve coordination between public agencies Improved internal data standards and ease of dissemination

Appendix B: Interviews and Interview questions

Section 1: Interviews

Anonymous. Massachusetts Institute of Technology. April 3, 2020

Anonymous. Massachusetts Institute of Technology. April 7, 2020

Davis, Zoe. Climate Ready Boston Coordinator, City of Boston. April 13, 2020.

Ortiz, Maria. City Strategy Advisor for New York City, American Cities Climate Change Challenge at NRDC. April 24, 2020.

Section 2: Interview Questions

Each conducted interview was 30 minutes to one hour long on a phone or video call. Before each interview, I provided a brief summary of the thesis' goals. In the beginning of each interview, I asked the interviewee to introduce themselves and their background. Then I asked questions such as:

- What is the role of open government data in climate adaptation planning and action?
- Can you think of specific actors in Boston's climate adaptation planning that have used open government data?
- Can you think of instances where the usage of open government data has enabled a non-traditional actor to insert themselves into Boston's climate adaptation planning process, and done so in a way that has made the climate action more inclusive, equitable, or just?
- Has the "open" nature of open government data (easily accessible, machine readable, free) increased transparency, accountability, value in the processes in climate change action? Or made policies and actions more inclusive, just, or equitable?
- Are there non-traditional, bottom-up actors that have been able to challenge or strengthen climate resilience, in ways they may not have been able to without open government data?

Appendix C: Methodology to Create Network Maps

Two network maps were made. The first network map is the “Climate Ready Boston stakeholder network map”. The second network map is the “open government data flow network map”. The network maps were created using the D3.js JavaScript library and the datasets were created by compiling data from reports (see Methodology chapter, Table 4.1 & 4.2).

Climate Ready Boston stakeholder network map:

D3.js visualization: <https://observablehq.com/@jalin/force-directed-graph>

Dataset:

https://gist.githubusercontent.com/linjac/87f35951ce00b4a7195e5c60c44f6d01/raw/f93190e0963fd1fb1b1d0163eac87c7c29c09856/network_data.csv

The network map is constructed from a unique list of nodes and a unique list of links. Each node contains an id and the group. The nodes are colored according to their group. There are six distinct groups:

```
{academic: 0,    government: 1
 individual: 2,  nonprofit: 3
 private: 4,     report: 5 }
```

Each link consists of a reference to a source node and a target node.

Sample nodes:

- Object { id: "Boston Housing Authority", group: "government" }
- Object { id: "Charles River Watershed Association", group: "nonprofit" }
- Object { id: "CRB Final Report (2016)", group: "report" }

Sample links:

- Object { source: "CRB Final Report (2016)", target: "Arcadis" }
- Object { source: "Coastal Resilience Solutions for South Boston (2018)", target: "Boston Housing Authority" }

The nodes were positioned by simulated forces using d3-force (<https://github.com/d3/d3-force>). The nodes with group: “report” were subject to a radial force that bound their position to a circle 400 pixels wide. All other nodes represented stakeholder entities, which were linked to at least one node with group: “report”. The links exerted a small tension force on the nodes such that the if a stakeholder node were connected to more report nodes (> 2), that stakeholder node would be pulled in multiple directions and be positioned within the 400-pixel wide circle. If the stakeholder node was minimally connected to the report, it would gravitate towards the radial periphery of the map.

Open government data flow network map:

D3.js visualization: <https://observablehq.com/@jalin/force-directed-graph/3>

Dataset:

https://gist.githubusercontent.com/linjac/dffb713c6db706866377ec200edc4643/raw/6a9ad895a55836a2f46569ab842f6ebc662a25e1/ogd_flows.csv

The network map is constructed from a selector, a unique list of nodes, and a unique list of links. There are five options in the selector, each option representing an OGD product. Each node contains an id and the group assignment. The nodes are colored according to their group. The nodes represent reports in which open government data was used or when an OGD product was referenced. There are four distinct groups: { 0, 1, 2, -1 }. The selector designates its associated node with group: "0", which is colored red. Nodes which directly reference the OGD product are designated group: "1", and they are colored orange. Nodes that are designated group: "2" benefit from the selected OGD product but reference nodes in group: "1". They are colored yellow. Nodes that are not influenced by selected OGD product are designated group: "-1" and colored black.

Each link consists of a reference to a source node and a target node and an indication to draw the link with an arrowhead. The direction of the arrow shows the flow of OGD from source to target.

Selector options:

```
[ 1: "MassDOT-FWHA Boston Harbor Flood Risk Model"
  2: "BRAG Climate Projections"
  3: "Martin, Social factors for vulnerability"
  4: "CRB Exposure and Consequence Analysis"
  5: "Greater Boston - Exposure and Consequence Analysis" ]
```

Sample nodes when option 3 is selected:

- Object { id: "Dr. Atyia Martin, A Framework to Understand the Re...ence in Cities: Application to the City of Boston", group: "0" }
- Object { id: "CRB Final Report (2016)", group: "1" }
- Object { id: "Moakley Park Vision Plan", group: "-1" }

Sample links when option 3 is selected:

- Object {
target: "Feasibility of Harbor-wide Barrier Systems"
source: "Dr. Atyia Martin, A Framework to Understand the Re...ence in
Cities: Application to the City of Boston"
derived: 1 }
- Object {
target: "Feasibility of Harbor-wide Barrier Systems"
source: "CRB Final Report (2016)"
derived: -1 }

The nodes were positioned by simulated forces using d3-force (<https://github.com/d3/d3-force>)