DATA + DISASTERS:

Rethinking the role of Metro Boston's data intermediaries in disaster management

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ABSTRACT

Recent U.S. hurricanes such as Hurricane Harvey in 2017 have raised urgent questions about the role of data providers in disaster response and recovery. Digital tools such as maps that display emergency shelter locations or levels of E.Coli contamination in floodwaters are typically created and managed by a local data intermediary. A data intermediary is defined by the National Neighborhood Indicators Partnership as a mediator between data and local stakeholders such as community groups and residents who use data from advocacy to program planning and policymaking. Currently, the Data Services department at the Metropolitan Area Planning Council (MAPC), the regional planning agency for Metro Boston, serves as a data intermediary for the region.

This research will argue that in addition to their daily functions, MAPC should assume new roles as the 'disaster data intermediary' during times of crisis given their technical capacity and ability to be more localized than their federal and state counterparts. Natural disasters impact regionally as they tend to cross jurisdictional boundaries and require coordination amongst many municipalities and players who could benefit from shared resources. Drawing conclusions from interviews of data entities who experienced Hurricanes Katrina, Sandy, and Harvey, this thesis will propose new tasks for MAPC. From enacting an internal protocol during emergencies to long-term advocacy for open data policies and portals, these recommendations are organized in the context of disaster mitigation, preparedness, response, and recovery.

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COMMONLY USED ACRONYMS

API	Application Programming Interface
COG	Council of Governments
DCP	Department of City Planning (New York)
DHS	Department of Homeland Security
DOIT	Department of Innovation and Technology (Boston)
DoITT	Department of Information Technology and Telecommunications (New York)
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GIS	Geographic Information Systems
MassDOT	Massachusetts Department of Transportation
MassPort	Massachusetts Port Authority
MAPC	Metropolitan Area Planning Council
MARPA	Massachusetts Association of Regional Planning Agencies
MEMA	Massachusetts Emergency Management Agency
MWRA	Massachusetts Water Resources Authority
MBTA	Massachusetts Bay Transportation Authority
MODA	Mayor's Office of Data Analytics (New York)
MORRE	Mayor's Office of Resilience and Racial Equity (Boston)
MONUM	Mayor's Office of New Urban Mechanics (Boston)
NERAC	Northeast Homeland Security Regional Advisory Council
NGO	Non-governmental organization
NOAA	National Oceanic and Atmospheric Administration
NNIP	National Neighborhood Indicators Partnership
OEM	Office of Emergency Management
ORR	Mayor's Office of Recovery and Resiliency (New York)
RHI	Red Hook Initiative
RPA	Regional Planning Agency

1. INTRODUCTION

The three costliest storms to strike the United States mainland - Hurricane Katrina, Hurricane Sandy, and Hurricane Harvey - have raised urgent questions about the role of data providers in disaster response and recovery (NOAA 2018). Many existing climate change adaptation plans propose physical interventions like sea walls or processes to enhance social resilience in communities. Fewer studies have analyzed how cities and emergency responders can leverage open data infrastructures during times of crisis. For instance, public safety and awareness can be improved with maps displaying the level of E.Coli or other contamination in floodwaters. Emergency shelters can host live updates on the number of beds available and lacking supplies to coordinate rescue operations and donations. Credit card transactions could be released to determine which stores in affected areas are open for business as a method of tracking recovery. These are but a few of the many possible uses at the intersection of data, technology, and disaster management.

To acquire and maintain such data, a local data intermediary - a liaison between data and local stakeholders - must assume new roles and responsibilities in the context of disaster management (Hendey et al. 2016). The Data Services Department at the Metropolitan Area Planning Council (MAPC) is already serving as a data intermediary for the Metro Boston region. This thesis will propose that they should also serve as what I call a 'disaster data intermediary' by adopting further responsibilities during and in preparation for times of crisis. Metro Boston has thus far been spared a disaster as damaging as Sandy or Harvey. However, coastal areas in Massachusetts are highly vulnerable to sea level rise and storm surges to be exacerbated by climate change (Massachusetts 2017). Natural disasters are a regional matter as they tend to cross jurisdictional boundaries and require coordination amongst many municipalities and players who could benefit from shared data and resources (Hurricane Sandy Rebuilding Task Force 2013). Yet, the Federal Emergency Management Agency (FEMA) and other agencies restrict access to their data even during emergencies and the bureaucratic process to update data is notoriously slow (Informant 2018).

MAPC is a suitable disaster data intermediary for various reasons. As a regional planning agency, MAPC's work is inherently more localized than the federal or state government but operates at a scale larger than a single city. Their staff are also equipped with the technical capacity to serve as the disaster data intermediary, a characteristic that other agencies may lack. Although the agency has traditionally concerned itself with the long-term, projecting planning goals

into the future, the immediacy and urgency of extreme weather events provides an opportunity to address more immediate needs by reimagining their role in the disaster management process.

This research will assess growing academic literatures around the role of technology and data in disaster management, the open data movement and the democratization of data, and regional resilience planning. Representatives from data entities who experienced Hurricanes Katrina in 2005, Sandy in 2012, and Harvey in 2017 were interviewed with an eye to distilling best practices and lessons learned. Conclusions drawn from the interviews will inform recommendations for MAPC's role as a disaster data intermediary. These recommendations cover a spectrum from enacting an internal protocol during emergencies to long-term advocacy for open data policies and portals and are organized in the context of disaster mitigation, preparedness, response, and recovery.

1.1 CURRENT CONTEXT IN METRO BOSTON

Although Boston is less vulnerable to severe storm surges than cities further south, it is still ranked as one of the top 25 cities most susceptible to coastal flooding by 2050 in the United States (Climate Central 2017). Metro Boston's long history of landfilling tidal marshes to increase its waterfront has resulted in a coast threatened by sea level rise. Cities along the Boston Harbor have expanded to the point that the harbor has lost 81% of its preindustrial tidal marshland (Shi 2017). While Hurricane Sandy in 2012 ultimately did not make landfall in Massachusetts, it still left 380,000 people without power and residents in low-lying areas were evacuated. Coastal towns like Barnstable, Braintree, and Fairhaven experienced the heaviest flooding, while towns on Cape Cod had the highest wind speeds and moderate flooding (Schworm et al. 2012).

Storm surge in Scituate, MA
Source: Boston Globe, March 2018

The City of Boston has recently made strides to become a more climate-resilient city. In their report *Climate Ready Boston*, the city predicts that seas will rise three feet by 2070. This means the current 1% annual chance flood (or 100-year flood) will occur every month at the highest tides. Additionally, even the nine-inch

sea level rise projection for 2030 indicates that the 1% chance flood is four to five times more likely than it is today. To respond to these threats, the city has developed short and long-term physical design interventions within city limits as well as initiated plans to build social resilience amongst vulnerable communities (Climate Ready Boston 2017).

Flooding in downtown Boston
Source: WBUR, 2018

Extreme winter storms are also a major concern for Metro Boston that are likely to be heightened by climate change. Since the beginning of 2018, Boston has experienced a 'bomb cyclone' in January and four Nor'easter storms in March. The third Nor'easter, called Winter Storm Skylar, caused a three-foot storm surge and dropped 15 inches of snow, nearly breaking Boston's record (The Weather Channel 2018). The severity of these storms damaged many homes in coastal towns like Scituate and Cape Cod and even flooded areas of downtown Boston in the Seaport district (Capucci 2018). The year-round threat of coastal flooding and increased frequency of extreme weather events justifies this thesis research in Boston and that cities and regional agencies should continue to proactively plan for disaster management with climate change considerations.

Over the past two decades, there have been countless climate change initiatives in Boston and the metro area. Numerous organizations like the Boston Harbor Association or the Green Ribbon Commission have worked independently or in partnership to devise plans such as the City of Boston's Climate Action Plan (Boston Green Ribbon Commission 2018). Boston was also named one of the Rockefeller Foundation's 100 Resilient Cities. The Mayor's Office of Resilience and Racial Equity (MORRE) has been working with the Rockefeller Foundation and vulnerable community groups to plan for catastrophes and slow-moving disasters that will disproportionately affect marginalized groups (Interview 5).

In 2015, MAPC facilitated the creation of the Metro Mayors Climate Preparedness Taskforce, a group of 15 mayors in the Metro Boston area committed to preparing the region for climate change and reducing greenhouse gas emissions in their respective cities. Along with the 15 mayors, federal and state agencies such as the EPA, MBTA, MassDot, MWRA, and MassPort are also involved in the Taskforce. One of the first projects with the Metro Mayors Coalition and MAPC

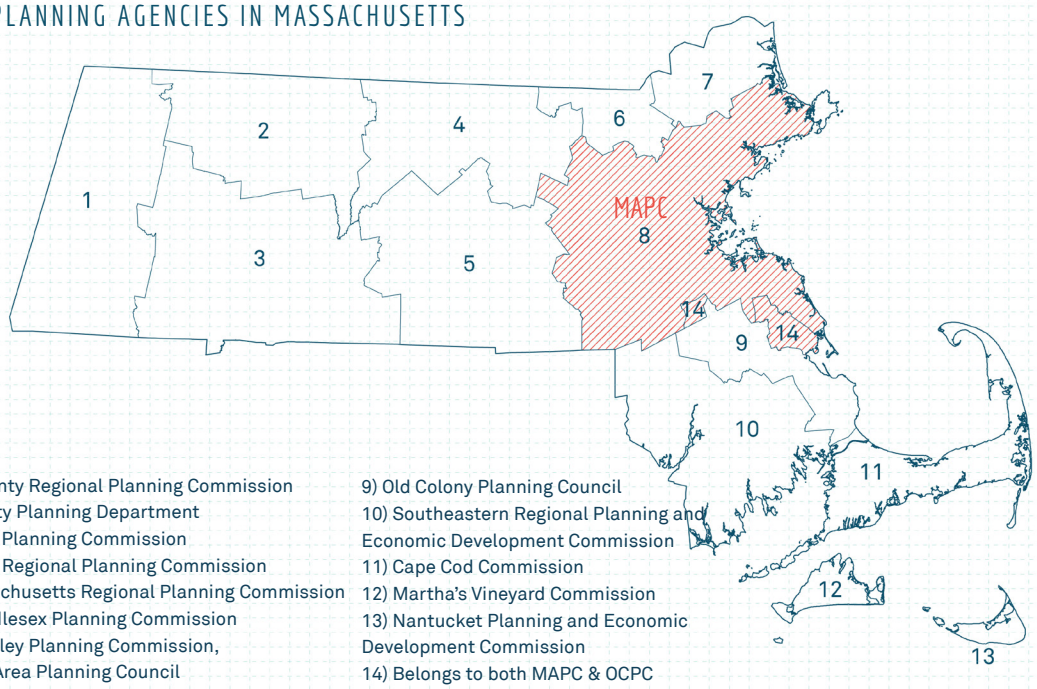
was to release a website called "Keep Cool" (keepcool.mapc.org) to inform the public about extreme heat effects, another major climate concern for Metro Boston (MAPC-Metro Mayors Climate Preparedness Taskforce n.d.).

Despite the sheer number of climate initiatives in Boston, there is a lack of work that addresses how data infrastructure can inform disaster management in climate related events. Given that climate disasters typically exceed the scale of a single city, this research will investigate the increased role of regional planning agencies as data intermediaries during these times which will be explored in the following section.

1.2 REGIONAL PLANNING AGENCIES IN MASSACHUSETTS

Regional Councils or Council of Governments (COG) originated in the 1960s to carry out federal, state, and local programs in transportation planning, environmental planning, and economic development. Depending on the context, councils serve to build partnerships between agencies, provide technical services, and support fiscal management in addition to various other tasks (NARC 2013). Often called regional planning commissions or planning districts, in Massachusetts these groups are referred to as regional planning agencies. The 13 regional planning agencies form the Massachusetts Association of Regional Planning Agencies (MARPA).

REGIONAL PLANNING AGENCIES IN MASSACHUSETTS



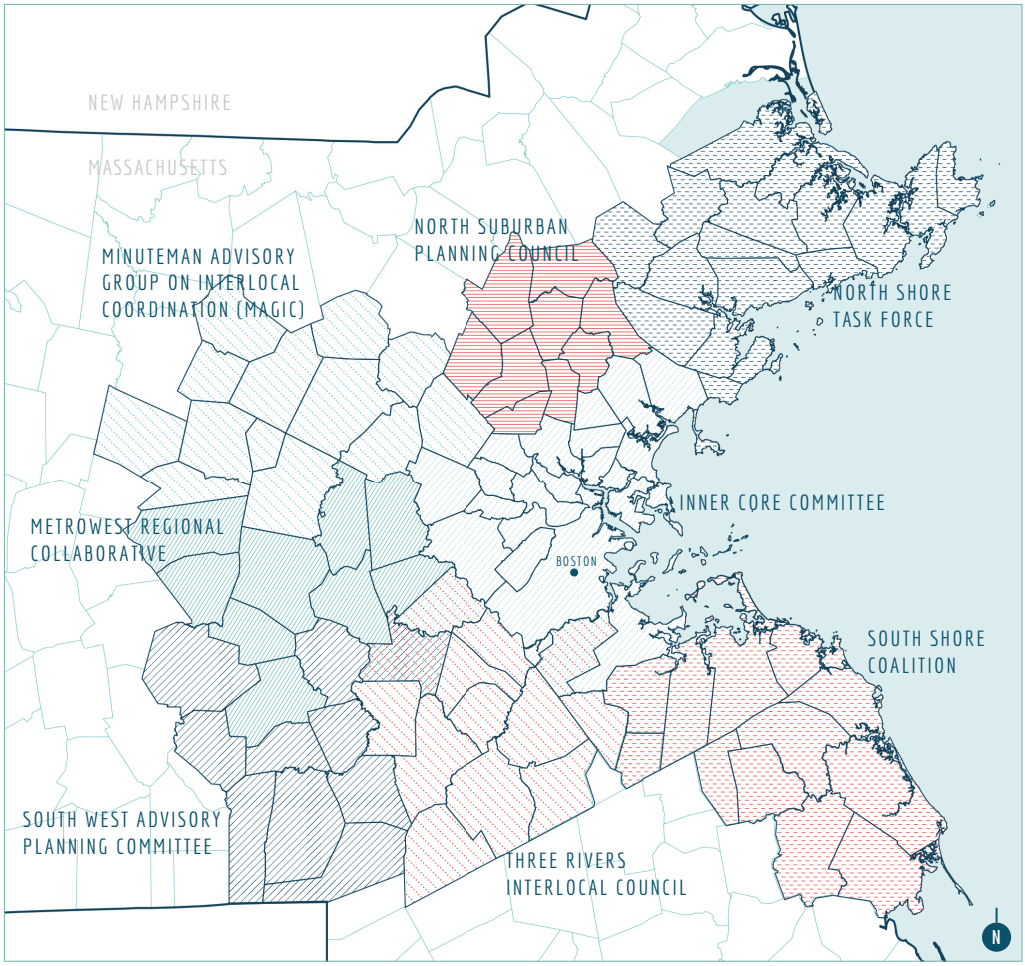
1) Berkshire County Regional Planning Commission
2) Franklin County Planning Department
3) Pioneer Valley Planning Commission
4) Montachusett Regional Planning Commission
5) Central Massachusetts Regional Planning Commission
6) Northern Middlesex Planning Commission
7) Merrimack Valley Planning Commission,
8) Metropolitan Area Planning Council
9) Old Colony Planning Council
10) Southeastern Regional Planning and Economic Development Commission
11) Cape Cod Commission
12) Martha's Vineyard Commission
13) Nantucket Planning and Economic Development Commission
14) Belongs to both MAPC & OCPC

Source: MARPA 2018

These organizations specialize in "planning, policymaking, communication coordination, advocacy, education, analysis, and technical assistance" (MARPA 2016). In the U.S., 35,000 local governments including cities, towns, and counties are currently served by regional councils or COGs (NARC 2013).

Metropolitan Area Planning Council (MAPC) was established in 1963 as a regional planning agency for the Boston metropolitan area. It currently serves 101 cities and towns and was created under Massachusetts General Law Chapter 40B Section 24. It is governed by an actual council, comprised of representatives from each city and town within the MAPC region. The agency promotes smart regional growth with planners who specialize in transportation, land-use, public health, and many other areas of expertise. The agency does not enact policy change or regulate land use; rather, it provides technical assistance and services for

MAPC AND ITS SUBREGIONS



Source: MAPC 2018

municipalities (MAPC-About n.d.). Their regional plan called *MetroFuture* was published in 2008 and outlines goals for Metro Boston by 2030 focusing on sustainable growth, housing, healthy communities, regional prosperity, transportation, and healthy environment (MAPC-MetroFuture n.d.). The recommendations from this thesis would coincide with MAPC's plans to update *MetroFuture* over the next few years and propose action items for disaster management.

This study will primarily focus on the prospective role of MAPC's Data Services Department. The Data Services Department was established in 2008 and acts as the data intermediary for the entire region. Since the agency has historically focused on projecting long-term goals in *MetroFuture*, the data that MAPC produces typically has a longer time frame than other intermediaries (Interview 12). This research will suggest that in addition to their everyday duties, they should fulfill the role as a 'disaster data intermediary' within emergency management for Greater Boston.

1.3 WHAT IS A DATA INTERMEDIARY?

MAPC is a member of the National Neighborhood Indicators Partnership (NNIP) which started in 1996. NNIP is a coalition of data intermediaries organized by The Urban Institute, a nonprofit research institution based in Washington D.C. A data intermediary is defined by NNIP as a "mediator between data and local stakeholders—nonprofit organizations, governments, foundations, and residents. They use data to describe their communities, and they empower communities to use data in their activities, from community building, to advocacy and program planning, to policymaking" (Hendey et al. 2016, 6). Data intermediaries can come in many forms and are not restricted to regional planning agencies. They can be nonprofits, think tanks, research centers linked to academic institutions, social enterprises, or any other coalition of organizations (NNIP-About Our Partners 2018).

The NNIP model outlines these core functions:

+ Build and operate an information system with recurrently updated data on neighborhood conditions across topics

+ Facilitate and promote the practical use of data by community and government leaders in community building and local policymaking
+ Emphasize the use of information to build the capacities of institutions and residents in low-income neighborhoods (NNIP Concept 2018).

As a member, MAPC is part of a peer-based network of data intermediaries from 32 cities across the United States. Through this network, MAPC shares information and projects, is invited to participate in grant proposals, and sends representatives to annuals meetings devoted to how data can serve local neighborhoods and policymaking within those communities.

1.4 MAPC TODAY

MAPC has traditionally focused on research that is forward-looking and, as a planning agency, their time frame can be much longer than other intermediaries. However, as the climate continues to change and extreme weather events become more frequent, the ability to respond to emergency conditions becomes crucial. Currently, MAPC's Data Services team does not have an emergency plan. This thesis proposes that the agency develop plans at many scales, from internal employee protocol during a crisis to addressing broadly how the region can be prepared for a disaster using technology.

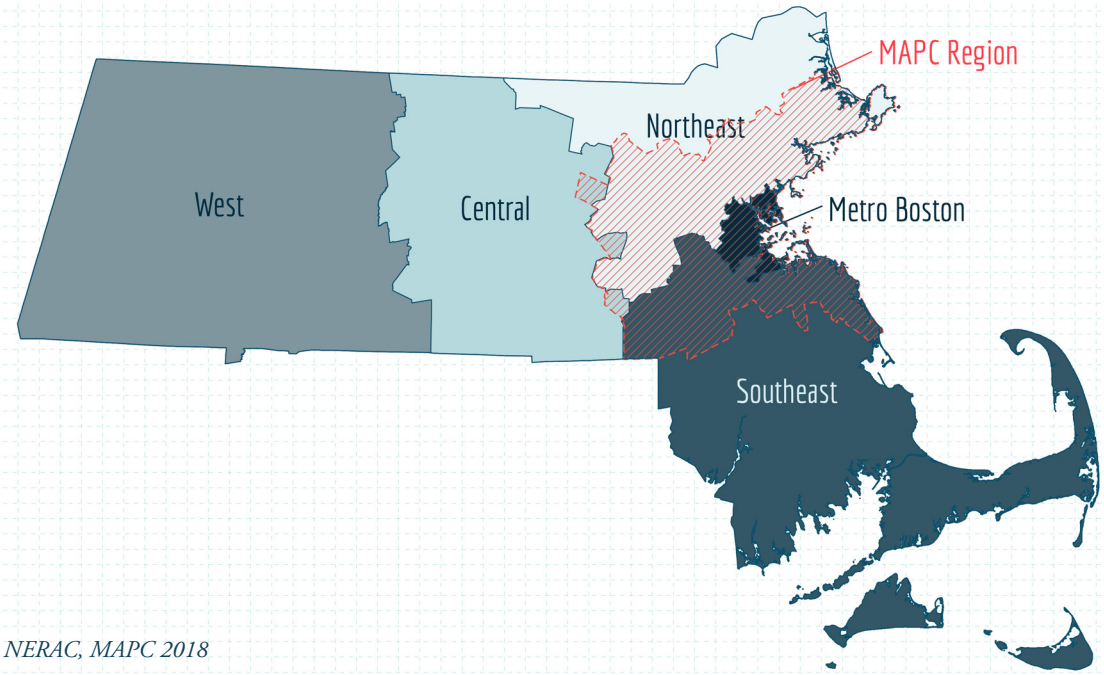
Within Data Services there are four branches- Analytical Services, Digital Services, Research Group, and Information Technology. Together, this team has produced and collected data for MAPC's own research, commissioned the creation of new data, and compiled datasets from cities to form region-wide "mosaics of local conditions" (MAPC-Open Data n.d.). Some examples include: statewide vehicle census data, a database of pedestrian and bike trail maps, and a land parcel database for the entire state. The department is currently comprised of GIS analysts, engineers, web developers, regional planners, and researchers (MAPC-Data Services n.d.).

While the City of Boston is well-equipped with staff and technological resources, Scituate, Quincy, and other small towns - who were disproportionately affected by the 2018 winter storms - may not have this capacity. During storm events, GIS departments and other data users within these municipalities could rely on MAPC for technical assistance (Interview 13). The effects of natural disasters

are generally regional, ignoring jurisdictional lines and requiring coordination between many municipalities and federal, state, and local agencies. (Hurricane Sandy Rebuilding Task Force 2013). Reaching vulnerable neighborhoods in the Metro Boston area such as immigrant communities or coastal towns prone to flooding should be a top priority for the region. Since MAPC is a regional actor with substantial technical capacity, it is well-positioned to serve as Greater Boston's disaster data intermediary.

MAPC's current involvement in emergency management is primarily from a fiduciary position leaving on-the-ground matters to be handled by federal and state agencies like the Massachusetts Emergency Management Agency (MEMA). MAPC's Department of Municipal Collaboration serves as the state's homeland security fiduciary by distributing Federal Department of Homeland Security (DHS) funds throughout Massachusetts (MAPC-Public Safety n.d.). There are five Homeland Security Councils in the state: Central, Southeast, West, Northeast, and Metro Boston. These councils use funds to plan, organize, train, prepare and respond to terrorist attacks and disasters. MAPC distributes funds to the four councils with the exception of the Metro Boston Homeland Security Planning Region which is managed by Boston's Office of Emergency Management. In addition to distributing funds across the state, MAPC also manages projects on behalf of the Northeast Homeland Security Regional Advisory Council (NERAC)

MASSACHUSETTS HOMELAND SECURITY REGIONS + MAPC REGION



Source: NERAC, MAPC 2018

from investing in regional communications systems among first responders and purchasing emergency response equipment (MAPC-Homeland Security n.d.). These funds traditionally have been used to prepare for social disasters and terrorism-related threats (e.g., the Boston Marathon bombing) although more weather related initiatives may be prioritized in the future (Interview 14). The jurisdictional boundaries used by these emergency management agencies can get complicated as they differ from the rest of the MAPC region, shown in the map above. This further highlights the importance of coordination amongst emergency management organizations during times of crisis especially when jurisdictions can overlap and vary.

MAPC has also led many initiatives for regional climate change mitigation and adaptation. Some examples are vulnerability assessments and action plans, hazard mitigation plans with MEMA, and emergency response planning (MAPC-Climate n.d., Interview 10). These projects are managed by the agency's Clean Energy and Environment departments. In addition to the Metro Mayors Climate Preparedness Taskforce, MAPC has coordinated with smaller subregions like the North Suburban Planning Council on local climate change plans. The Data Services team should collaborate further with the Clean Energy, Environment, and Municipal Collaboration teams and devise a united MAPC climate resilience and emergency preparedness plan. The recommendations made in this thesis apply particularly to the Data Services department. As such, the use of the name 'MAPC' throughout the thesis will specifically refer to this team, unless otherwise noted.

1.5 MAPC AS THE "DISASTER DATA INTERMEDIARY" FOR METRO BOSTON

Given that MAPC is already operating as a data intermediary on a daily basis suggests that it is well-equipped to function as the 'disaster data intermediary' for Metro Boston. The agency is already comprised of many of the "ingredients of success" that Plyer and Ortiz declare in their essay "Building Data Capacity to Foster Resilient Communities" (2011, 196-197):

+ Sufficient staff with technical capacity
+ The ability and flexibility to create data
+ Existing partnerships with multiple organizations
+ Use of mainstream media in addition to the internet

+ *Sufficient staff with technical capacity*

In interviews, other NNIP members from small nonprofits and academic institutions mentioned capacity issues and having insufficient staff to carry out the tasks necessary for a disaster data intermediary. The Data Services department at MAPC is fortunate to currently have 13 staff members from their four branches. The department is comprised of technically skilled experts including GIS specialists, web developers, and engineers. Additionally, urban planning experts constitute the rest of the agency, specializing in a variety of topics such as transportation or environment.

+ *The ability and flexibility to create data*

Without ties to a private institution, MAPC is generally able to set an independent research agenda. Some planning commissions around the country are perceived as excessively politicized whereas MAPC acts as a neutral, non-governing body. The Data Services department should be able to adapt, modernize, and collect data that is useful for the entire region.

+ *Existing partnerships with multiple organizations*

MAPC has a long history of partnering and coordinating with many organizations in the Boston area. They have a strong relationship with Boston Indicators, the other NNIP partner in Boston dedicated to providing data for a more equitable and just city. They have partnered with the Mayor's Office of New Urban Mechanics (MONUM) and the Department of Innovation and Technology (DOIT), two departments from the City of Boston dedicated to improving lives through technology (Interview 3, 4). These teams have collaborated on projects like the 311 data app, managing Boston's open data portal, and providing "Wicked Free Wi-fi" throughout the city (City of Boston-New Urban Mechanics, n.d.).

+ *Use of mainstream media in addition to the internet*

MAPC also has established relationships with media sources in Boston including local television stations, newspapers, and radio stations. The Communications team has built connections with major media stations such as the Boston Globe who will frequently publish stories about MAPC's work (Interview 11). Smaller intermediaries claimed that this ability was difficult without proper staff or

required significant time (Interview 6, 8). In addition to publishing their material on the internet, MAPC's Communications team has worked with local stations to broadcast the agency's work on channels of smaller towns and provided data to local newspapers to boost credibility across the region (Interview 11).

1.6 THE BASICS OF DISASTER MANAGEMENT

Disaster management refers to planning and managing extreme events that "can injure or kill great numbers of people, do extensive property damage, and disrupt community life"(Sylves 2008, 5). These disasters can be man-made or from natural causes. Various disciplines including meteorology, seismology, engineering, architecture, and urban planning are involved in disaster research, illustrating the multidisciplinary nature of disaster planning (Sylves 2008). The four phases of disaster planning are widely identified as mitigation, preparedness, response, and recovery. These phases will be referred to throughout this thesis and are adapted from Richard Sylves' *Disaster Policy and Politics* (2008, 21-24):

Mitigation: Any activities that prevent an emergency and reduce the chance of an emergency from happening, including identifying, measuring, and addressing hazard vulnerability. Actions taken during the recovery phase of a disaster can also contribute to the mitigation phase. Hence, disaster management is often referred to as a cycle.

Preparedness: Includes any plan, preparations, or agreements among responding agencies made to save lives, reduce damage, and identifying critical resources.

Response: Typically refers to the duration of the disaster itself when the preparedness plans are enacted. It entails providing emergency aid and assistance, reducing any further damage, and minimizing problems for the recovery phase.

Recovery: Refers to both the immediate aftermath of the disaster and the actions required for restoration, rebuilding, and providing support until the community returns to normal. In some cases, researchers make a distinction between short-term and long-term recovery efforts.

2. LIMITATIONS OF RESEARCH

This thesis relies on qualitative research gathered from 11 formal interviews conducted by phone, and 8 informational interviews conducted in person and by phone. Interviewees were either recommended by MAPC staff or are members of the NNIP network. I did not directly interview first responders or other members of the emergency management industry but picked interviewees based on their relevance to MAPC's work and abilities. In some cases, potential interviewees were contacted through email but many requests were unanswered or were unable to be conducted within the given time frame of the thesis.

Interviews with representatives from data intermediaries were organized based on their experiences with Hurricane Harvey in Houston, Hurricane Sandy in New York, and Hurricane Katrina in New Orleans. The explorations are not meant to be comprehensive of these hurricanes but are limited to the results of the interviews and other publicly available information. They do not capture a holistic view of what occurred but show a small snapshot into the operative data infrastructures and lessons learned from those experiences.

The variety of contexts from cities across the country were an added benefit to draw scalable conclusions to MAPC that are not restricted to a single city or geographic area. However, it is acknowledged that there is a limited degree to which the experiences can be directly applicable to Boston. Any recommendations must be considered with local players and in a manner mindful of conditions in Metro Boston. Additionally, hurricanes were chosen as an example disaster but man-made disasters and other natural disasters may warrant different approaches, data needs, and collaboration with other agencies that are outside the scope of this research.

3. THEORETICAL GROUNDINGS

This research is grounded in three bodies of literature: 1) literature that explores the increasing role of technology and data in recent disasters; 2) research on the democratizing potential of the open data movement; and 3) research on the relevant of the regional scale for resilience planning.

3.1 THE INCREASING ROLE OF DATA AND TECHNOLOGY IN DISASTERS

Over the past decade, data-driven disaster management has emerged as a research area in the context of both natural and man-made disasters. In *Data Against Natural Disasters*, Amin and Goldstein provide six international case studies that permit them to draw larger conclusions about disaster management. They argue for major investments in response capacity and for the value of information management of tasks such as tracking displaced and vulnerable populations, logging damage to housing and infrastructure, and distributing aid. The text describes various natural disasters from 2004 to 2007 including the 2005 earthquake in Pakistan, and the 2004 tsunami in Sri Lanka. Though the type of disaster and local context differ in each case, their larger theme is the necessity of accurate, timely information and a disaster data management plan (2008).

"BETTER PREPARATION ...IMPROVED MITIGATION.. MORE EFFICIENT AND EFFECTIVE RESPONSE, AND MORE RAPID RECOVERY ARE ALL POSSIBLE"
-Rao et al.

A crucial recommendation from the Amin and Goldstein case studies is to invest in disaster information management systems and data collection before a disaster hits. To employ an unfamiliar system in the midst of a disaster is too daunting, and to introduce a new tool during an emergency is stressful. Therefore an "ex ante preparation" is imperative (2008, 18). Both Amin and Goldstein and Osuteye et al. (2017) advocate for the production of substantial baseline data. Baseline data like roads and locations of communities must be gathered prior to a disaster and must also be compatible with a variety of platforms. This suggestion may be more applicable to developing countries that may not have established Geographic Information Systems (GIS) departments; however, it is advice that every city, county, and region should reinforce. Another recommendation from Amin and Goldstein is to identify a "clear institutional owner" of information (2008, 19). An institutional owner, such as MAPC, should have the ability to enhance disaster preparedness and coordinate

with other organizations. They should be able to collect baseline data, address data compatibility issues, and establish clear roles in order to minimize confusion during the crisis. These tasks should be carried out regardless of staff turnover and frequent training sessions should be held so that members are well-equipped at any given moment (Amin and Goldstein 2008).

Li et al. contend that data-driven disaster management is "applying advanced data collection and analysis technologies to achieve more effective and responsive disaster management" (2017, 1). There are two types of data sources used for disaster management: dynamic data and static data. Dynamic data sources provide temporal situation reports from OEMs, news reports, press releases, 311 calls, and crowd-sourced data from social media websites. Common static data sources include historical data from federal and state levels, road networks, and geospatial datasets. Recent advancements in satellite imagery and mapping through platforms like Google Earth and Google Maps have also made geospatial technology more ubiquitous, allowing for more public participation in disaster relief and response. Kawasaki et al. have emphasized that improvements in web-based geospatial technology obviate advanced GIS knowledge and have changed the role of spatial data in disaster response. They believe that greater quantities of geospatial data can be produced in shorter amounts of time and reach the communities that need it the most (2013). As technology progresses and dynamic data sources multiply, disaster data intermediaries should consider how disaster management tools will also evolve.

When incorporating new technologies into products, MAPC should consider design principles determined by Rao et al. that are sometimes overlooked when designing disaster IT systems. Systems should have smooth transitions and scaling between the daily operational mode and "disaster mode" (2007, 88). To avoid confusion and chaos during a disaster, an "always on" approach should be followed rather than different disaster versions of commonly used applications (2007, 91). Rao et al. recommend redundancy and diversity to achieve resilience with IT equipment resulting in multiple backups and protective measures for IT infrastructure (2007). These are all valid arguments for MAPC to consider when confirming that their data infrastructure systems and designed products are resilient.

3.1.1. DISASTER INFORMATION MANAGEMENT AND LOSS DATABASE MANAGEMENT

Much of the disaster literature evaluates formal information management software for managing and analyzing information and facilitating decision making. An example is Sahana, created by tech volunteers after the 2004 Sri Lankan tsunami that affected over 1 million people (Amin and Goldstein 2008). A free and open source application, Sahana provides support for relief and rehabilitation by using a combination of libraries and application programming interfaces (APIs). The United States Division of Homeland Security and Emergency Management also created a system called WebEOC to manage large-scale disasters. WebEOC is used by first responders, community leaders, and command level personnel to share any public safety operations, sensitive information, and infrastructure updates (Li et al 2017).

Disaster management systems can support a variety of functions such as tracking missing persons, coordination amongst aid groups, and distributing aid and inventory. Free and open source systems like Sahana are desirable for developing nations that may not be able to afford WebEOC or other high cost commercial systems. However, in particularly vulnerable nations, early adoption of these systems is critical and staff should be properly trained to use them. Additionally, roles for NGOs and government officials using Sahana and similar systems should be clearly defined beforehand (Amin and Goldstein 2008).

Loss database management systems are also a focus of disaster planning literature. Programs used by governments vary but some of the more widely used ones include NatCatSERVICE, EM-Dat, or DesInventar (Wirtz et al. 2014, Osuteye et al 2017). These are used by scientists, governments, and non-profit organizations to track data related to health, economic, and human losses after a disaster. While this thesis will not elaborate on the technicalities of loss database software systems, there are some overarching themes that resonate with the current study. As mentioned previously, more accurate baseline data on social factors including age, gender, income, environmental, political factors is fundamental to better assess urban loss and risk. Osuteye stresses the importance of complete and disaggregated datasets to inform policy decisions for planners. Additionally, these datasets should be prioritized in the mitigation and preparedness phases and address everyday risks as well as large-scale disasters (2017). Similarly, Wirtz et al.

explain that better data will allow for better risk assessment and decision-making when it comes to natural disasters (2014). Although these software systems are outside of the scope of MAPC's work and it is not recommended to adopt them, it is valuable to be aware of the systems that have emerged in disaster planning work and recognize that multiple governments and organizations rely heavily on these digital assets.

3.1.2. SOCIAL MEDIA, SPATIAL MEDIA, AND DIGITAL HUMANITARIANISM

Numerous recent studies and reports have examined the use of social media during times of crisis. The internet has allowed social media to be far-reaching and instantaneous, and studies prove that people will rely on tools that are familiar to them in times of panic (Castillo 2016). Data collected from social media accounts can be collected in real-time and urgent requests can be addressed. Additionally, social media data often includes geotagged information that allows for quick location identification (Li et al. 2017). At the time of writing this thesis, Facebook, Snapchat, Instagram, and Twitter were the most widely used social media platforms (Smith and Anderson 2018). Many cities and the departments within them, including police and emergency departments, use platforms like Facebook and Twitter to communicate important information with their citizens (Ng 2011). With the rise of social media in the past decade, many researchers have analyzed social media usage around disasters like the 2010 Chile earthquake and the 2011 Great East Japan Earthquake (Li et al. 2017).

Crowdsourcing real-time data from social media during disasters has become more common. These data are most useful in the response and recovery phases, when immediate information is required and access to conventional data sources may be blocked or compromised (Li et al 2017). Castillo introduces the idea of "digital volunteerism" which is the act of offering digital volunteer work (Castillo 2016, n.p.). Crowdsourced data from both local and remote volunteers has become more common, supported by crisis mapping programs like Ushahidi. Ushahidi was created in 2008 during the post-election violence in Kenya. Now a full scale NGO, Ushahidi is currently used by a variety of groups for reports around elections, patterns of conflict, and to coordinate relief efforts after natural disasters. The platform enables users to submit information through geo-tagged text messages, Twitter, email, or via an online interface; these submissions are then

visualized on a web map. The platform has been instrumental in the response to a number of disasters such as the 2010 Haitian earthquake. Ushahidi differentiated itself from other programs by collecting geo-located SMS text data, whereas other platforms relied solely on the internet. Only a tenth of Haitians had internet access versus a third of the population had mobile phones with SMS abilities (Zook et al. 2010).

Though crowdsourced data is useful in many circumstances, verification is a major concern during disasters when quality data is needed to make significant and timely decisions (Li et al. 2017). Shelton et al. demonstrate that social media usage during Hurricane Sandy strongly correlated with "long-standing patterns of socio spatial inequality" which results in "data shadows" that do not reflect the reality on the ground (2014, 167, 169). They note that geo-tagged data from Hurricane Katrina was associated with "wealthier, whiter, more tourist-oriented locations within New Orleans" while the areas hit hardest were low-income, black neighborhoods. Although to some degree participatory and promising, these solutions are only ever "partial, both in terms of participation and assistance, and are no replacement for more coordinated 'on the ground' relief efforts" (Shelton et al. 2014, 169). Elwood and Leszczynski argue that crowdsourced spatial media platforms are blurring the lines between experts and amateurs and promoting "geovisual transparency"(2013, 556). However, Elwood and Leszczynski challenge whether these tools have informed policy decisions that are beneficial to the groups without access to them. They also question whether engagement with such platforms is actually less demanding for users, a concern frequently raised by critics of the open data movement detailed in the following section (2013). While acknowledging the shortcomings of data collected through digital humanitarian work, Burns argues that such data can "still convey important knowledge about a disaster" and has potential in affecting community groups and social justice efforts in the disaster context (2018, 576).

If MAPC decides to use social media as a crowdsourcing mechanism, they should consider options that automate the data quality verification process and compile various social media channels into a single platform. Currently, social media platforms do not communicate with each other or use an agreed upon standard during emergencies. Urban Risk Lab, a research group at MIT, is currently developing a web map called RiskMap.us that collects various social media data sources onto a single map and has enabled an automatic verification system using

a bot (Interview 16). MAPC should build off such ideas and incorporate existing social media applications people already use instead of creating new ones that require a learning curve.

3.1.3. CHALLENGES TO ADOPTING NEW TECHNOLOGY IN DISASTERS

The sheer number of information systems, databases, mapping platforms, and other applications that have emerged from disaster contexts has led to a great deal of further research. In the American context, Ng explains that cities are interested in adopting new technologies and programs that would enable them to have better disaster and emergency management. However, due to lack of funding or staff capacity, it is difficult to rapidly implement new technologies (2011). Rao et al. agree saying that responsibilities during disasters are distributed at all levels of government from local, state, to federal that have varying degrees of technological capacity. Another challenge is that organizations involved in disaster management typically work independently on a day to day basis, but when forced to collaborate with others during disasters may run into data interoperability issues. Additionally, funding for disaster management is typically only available and distributed once the disaster has already occurred and the purchases made usually address immediate needs in place of longer term applications (2007).

Regardless of their affordances, technology and data cannot be viewed as a "panacea" to disasters. Rather, successful disaster management depends on a balance of technological, organizational, and social factors (Rao et al. 2007, 34). Technology and data must be integrated into emergency response processes in such a way that operations run more efficiently instead of creating barriers or difficulties. Disaster response will continue to involve more data-driven techniques, inform advancements in existing technologies, and increase dependence on social media data. As Amin and Goldstein suggest, an institution should be in place to ensure disaster planning occurs well in advance of the disaster, facilitate transitions between the phases of the disaster management cycle, and alleviate some of the challenges of implementing new technologies (2008). I describe such an institution as a 'disaster data intermediary,' and argue that MAPC is the appropriate organization to serve in this role for Metro Boston.

3.2. THE CASE FOR OPEN AND DEMOCRATIZING DATA

In "Democratization of Data: Bridging the Gap for Community Groups," David Sawicki and William Craig propose using data intermediaries to democratize data back in 1996. They assert that while community groups from low-income and vulnerable neighborhoods have the most to benefit from data, they are the least equipped to access and use it. Community groups could utilize these sources to fulfill their own missions as well as to participate and influence policies affecting their members. MAPC as a data intermediary can strengthen these groups in a variety of ways but at the core, they can provide access to data and any support for analysis and policy change. In the 22 years since Sawicki and Craig published their article, the digital landscape has changed drastically with the dot-com boom, the rise of social media, and the era of Big Data and open data. The prevalent use of the internet over the past few decades has shaped how intermediaries have been able to distribute and share their data (Treuhaft 2006).

Open data advocates argue that releasing government data has great social, civic, and economic benefits (Dumpawar 2015). In *The Data Revolution*, Rob Kitchin describes open data as previously inaccessible data that is free to reuse and redistribute in a machine-readable format. Some sources, namely OpenDefinition.org and OpenGovData.com, have more specific principles outlining the definition of "open". The list on the opposing page describes OpenGovData's definition of open data, adapted by Rob Kitchin (2014, 51).

"PROFESSIONAL PLANNERS AND POLICY MAKERS KNOW HOW TO TURN DATA INTO INFORMATION, INFORMATION INTO KNOWLEDGE, AND KNOWLEDGE INTO POLICY."

-Sawicki + Craig

The open data movement gained momentum in the late 2000s when the US government published data.gov to host non-sensitive federal and state data, and the UK government followed suit with data.gov.uk (Dumpawar 2015). Certain datasets such as census and weather data have been publicly available in the US for some time. Since 2015, over 40 countries in the world have established open data initiatives (Qadir and Ali 2016). Kitchin claims that open data enables transparency of government activity and increased accountability. Access to data allows people to be more informed and leads to what he calls "participatory democracy"(2014, 55). Opening data can allow for external critics to study the efficacy and performance of government bodies, enabling better governance and

OPENGOVDATA'S DEFINITION OF 'OPEN DATA'

Data must be complete	All data are made available, subject to statutes of privacy, security or privilege limitations.
Data must be primary	Data are published as collected at the source, with the finest possible level of granularity, not in aggregate or modified forms.
Data must be timely	Data are made available as quickly as necessary to preserve the value of the data.
Data must be accessible	Data are available to the widest range of users for the widest range of purposes.
Data must be machine-processable	Data are reasonably structured to allow automated processing.
Access must be non-discriminatory	Data are available to anyone, with no requirement of registration.
Data formats must be non-proprietary	Data are available in a format over which no entity has exclusive control.
Data must be licence-free	Data are not subject to any copyright, patent, trademark or trade secret regulation. Reasonable privacy, security and privilege restrictions may be allowed.
Compliance must be reviewable	A contact person must be designated to respond to people trying to use the data or complaints about violations of the principles and another body must have the jurisdiction to determine if the principles have been applied appropriately.

Source: Kitchin, original spelling, 2014, p.51

transparency. Organizations practicing open data policies will be more accessible, can build trust with the public, and improve their brand (Kitchin 2014). Finally, publically generated data has great commercial value, and publicizing government data can allow for "new data-centric services and applications, fostering innovation in the market" (Dumpawar 2015, 30).

The open source movement developed in parallel with the open data movement. The concepts of digital humanitarianism (similar to Castillo's "digital volunteerism"), user generated information, and participatory software such as OpenStreetMap have emerged. After the 2010 earthquake in Haiti, many volunteers from all over the world contributed to OpenStreetMap which was later used as the de facto map for United Nation agencies (Qadir and Ali 2014). Such open source software for disaster management can be useful for governments by enabling other innovators to test their ideas using non-commercial technology and to improve software before adoption (Rao et al. 2007).

Despite the numerous benefits, there is some apprehension about the open data movement. The movements are never neutral but are "underpinned by political and economic ideology" (Kitchen 2014). Under the pretense of transparency, governments and businesses can use open data for their own private agendas. Businesses can access data at no cost and will result in a "marketisation of public services" (Kitchen 2014, 56). Additionally, as Boyd and Crawford demonstrate in their essay "Critical Questions for Big Data," all interpretation and analysis of data has inherent bias. Even though the prospect of open data is well-intentioned, most of the general public will only be able to "engage minimally" and the skill required to "download, process, and analyze open data are still in the domain of the privileged few" (Dumpawar 2015, 42). The current ecosystem will perpetuate and magnify the existing digital divide causing some to be "Big Data rich" while others are "Big Data poor" (Boyd and Crawford 2012, 674). These criticisms suggest the necessity to be "mindful of how data are made available, how they are being used, and how they are being funded" (Kitchin 2014, 61).

Similarly, there are many criticisms of the promises made by open data proponents. Haklay's definition of the democratization of data is the "ability to assemble, organise, and share geographical information accessible to anyone, anywhere, and anytime" (2013, 56). Yet there are still concerns around basic access to the internet and the lack of skills to engage in activities beyond browsing. He notes that with OpenStreetMap, participation was exclusionary in that most

content was generated by a few power users. These systems also tend to be very male-dominated and, like Dumpawar, he believes participation is usually limited to the "highly educated and usually affluent." They typically reward the contributors with the most time and ability to engage while "ignoring and marginalising other contributors" (Haklay 2013, 62). Furthermore, Shaw and Graham address this unbalanced distribution of power in the age of the "urbanization of information," where cities are digitally connected through many layers of the urban environment (2017, 909). This is taken to suggest the right to information just as significant as spatial justice and the right to the city. They critique Google for their "informational monopoly" over urban information through tools like Google Maps, Google Earth, and Google Search (2017, 921). If companies like Google continue to develop platforms and profit from the urbanization of information, the consequences will be "uneven information-based geographies and economies" (2017, 922). The authors call to action for a more equitable right to information, that problems should be deliberately addressed, and, as Elwood and Leszczynski insist, the transparency of such tools should be further scrutinized (Shaw and Graham 2017).

"LOCAL INSTITUTIONS CAN'T FULLY MOVE INTO THE DIGITAL AGE WHEN THE POPULATIONS THEY SERVE ARE OFFLINE OR ONLY TENUOUSLY CONNECTED TO THE INTERNET."

-Technology and the Resilience of Metropolitan Regions

While the criticisms and concerns are valid, the benefits of opening and democratizing data are still vast. Though census and weather data may be public, there are still many datasets crucial for disaster response yet to be made available. Adherence to open data principles is also not equally practiced across all sectors. The private sector in particular has been slow to adopt and adhere to such principles. Data advocates should continue to lobby for open data for the greater public benefit - an undertaking that will repeatedly appear in the subsequent case studies. Although technology has advanced immensely since Sawicki and Craig's article from 1996, their argument remains valid today: a data intermediary is essential to vouch for populations who need data on a daily basis and would be disproportionately affected by a disaster.

3.3 THE RISE OF REGIONAL RESILIENCE

The practice of regional planning is often attributed to Patrick Geddes, a Scottish biologist and town planner. Geddes developed the "Valley Section," a cross section of land from mountain to sea that diagrammed how human occupancy interacts with the environment. Geddes and his contemporaries including Ebenezer Howard and Frederick Law Olmsted focused much of their attention on the physical design of regions, emphasizing nature and rural environments separate from cities (Neuman 2000). The Regional Planning Association of America (RPAA) was founded in 1923, taking up some of the ideas of these earlier thinkers and developing regionalist thinking in the American context such as the "regional city" (Hall 2014, 165). In 1929, the RPAA published *The Regional Plan of New York and its Environs* to unify 31 counties in Connecticut, New York, and New Jersey under one regional plan (Regional Plan of New York n.d.). During the mid-twentieth century, federal and state governments advocated for regional initiatives and created the previously mentioned regional councils and agencies to coordinate infrastructure, transportation, and environmental issues (Shi 2017).

Today, the term "city" is frequently used to describe the "broader economic, environmental, and infrastructure networks of the entire metropolitan region of which a city is a part" (Katz and Bradley 2013, vii). Duany and Speak express in *The Smart Growth Manual* that regional planning is crucial since it operates at a scale more reflective of people's lives. Successful regional planning considers natural corridors, transportation systems, and urban centers that encompass an entire metro area (2010). In *The Metropolitan Revolution*, Katz and Bradley insist that cities and metro areas are becoming leaders in the nation with the ability to take risk and make hard choices more than their state or federal counterparts. Metro areas are able to operate more swiftly than federal and state governments, which they believe indicates a power shift to strong city leaders across the nation. Agencies like MAPC can modernize, adapt, and be more innovative than their governmental partners. Cities and metro areas can function like a laboratory to test new ideas and "spot innovation elsewhere and apply it at home" (Katz and Bradley 2013, 10). Neuman also contends that metro regions today are much different than those of 20 years ago and have immensely changed since earlier regionalists first introduced the concept a century ago. Technology, economic drivers, and the globalization of

> "THINK GLOBALLY, ACT LOCALLY BUT PLAN REGIONALLY."
>
> -*The Smart Growth Manual*

cities have changed the landscape in ways that some have argued will make regional design more pertinent for planning and design professionals (Neuman 2000).

In 2013, the Hurricane Sandy Rebuilding Task Force was appointed by President Obama to coordinate federal, state, and city efforts in rebuilding the communities of Sandy-affected states. In their report, *Hurricane Sandy Rebuilding Strategy: Stronger Communities, A Resilient Region* they concluded,

> "Natural disasters do not respect State or local boundaries, thus rebuilding plans cannot be bound by jurisdictional lines…. As communities began to recover, it was clear that, historically, too little consideration was given to inherent interdependencies – whether between multiple states, neighboring counties, or seaside towns. A series of uncoordinated hazard mitigation measures may yield unintended consequences and could ultimately decrease resilience in the long-term (2013, 36)."

The concept of 'regional resilience' is presently an emerging topic explored and described by multiple researchers. In her essay, Foster defines regional resilience as a combination of two components - capacity and performance. Resilience capacity refers to the 'pre-stress' ability of a region to endure a future unknown stress. Resilience performance, on the other hand, is a post stress measurement of how well a region responds and recovers from a crisis. Together, regional resilience can be defined as "the ability of a region to anticipate, prepare for, respond to and recover from a disturbance" (Foster 2011, 19). Resilience experts make a distinction between acute stresses versus chronic stresses, but it is difficult to concretely say if resilience differs between the two types of situations (Foster 2011).

Peng et al. distinguish regional resilience based on three characteristics: stability, self-organization, and innovation. The authors define 'stability' by adopting Foster's full definition of regional resilience but adding that response capacity measures the stability of regional development. 'Self-organization' or 'self-recovery ability' measures the "ability to deliver timely, effective fair, and reasonable response to emergencies, so as to ensure a faster, better, safer and fairer recovery." Innovation refers to the region being restored to its original condition without any changes to its original trajectory and uses opportunities to "further enhance its own abilities." The authors themselves acknowledge that the definition of regional resilience has not been consistently defined amongst researchers and that the concept should be clarified (2017, 87-89).

In her dissertation titled *A New Climate for Regionalism: Metropolitan Experiment in Climate Change Adaptation*, Shi states that for many, Hurricane Sandy highlighted the fact that "cities are not dots on a map as they are so often visualized at the global scale, but highly geographically grounded political jurisdictions situated in a landscape of cities that are ecologically, economical, demographically, and institutionally interdependent on one another" (2017, 10). Shi claims to be one of the first researchers to compare case studies of U.S. climate adaptation plans conducted by "regional collaboratives" across the country (2017, 15). She argues that local measures alone are not sufficient for climate adaptation plans because they do not consider economies of scale, shared infrastructure, ecological systems, or fiscal systems. Hyperlocalized resilience measures and visions may only exacerbate uneven development that contributes to existing vulnerabilities. It is not enough to perform climate adaptation studies at the regional scale, but regions should identify priority projects, build relationships between municipalities, and recognize disparities between existing political power structures. Regional entities that do not have governing power will not be as successful in their climate adaptation plans as those in metro areas where they have control over land use and the ability to enforce plans. She challenges the status quo in regional governance, asserting that agencies like MAPC should be empowered to transform regions currently facing the pressures of climate change (Shi 2017).

"...METROS HAVE EMERGED AS THE UBER-NETWORK: INTERLINKED FIRMS, INSTITUTIONS, AND INDIVIDUALS WORKING TOGETHER ACROSS SECTORS, DISCIPLINES, JURISDICTIONS, ARTIFICIAL POLITICAL BORDERS, AND YES, EVEN POLITICAL PARTIES."

-The Metropolitan Revolution

Much like Katz and Bradley, Mossberger et al. also believe that metropolitan areas spur social and economic innovation with "specialized labor markets, knowledge spillover across firms, larger and more specialized governments, and wealth of cultural and research institutions"(2015, 5). However, they suggest that the strengths of metropolitan regions–density, scale, and complexity–can also cause vulnerability to hazards, shocks, and other disruptions. Information and technology is crucial for regional systems to "sense incremental and major changes in the environment" and to learn from "past experience, to experiment with possible alternative actions, and to anticipate the future" (2015, 7). One major issue is that regions with a lower rate of internet use are more vulnerable than others, especially in a world becoming more dependent on technology. Echoing Haklay, the researchers emphasize that not only is access

to the internet important, but individuals must also have the skills to use it (2015).

Mossberger et al. use Hurricane Katrina as an example to portray how low-income neighborhoods had fewer resources to cope with disasters and a lack of connectivity put them more at risk. The authors push for regional organizations to partner with private and public sector entities to bridge this digital divide expressing that "local institutions can't fully move into the digital age when the populations they serve are offline or only tenuously connected to the internet" (2015, 8). They assert that the region is the ideal scale to share ideas "across sectors, to take advantage of experimentation across many businesses, governments, and nonprofits that populate a metropolitan area" (2015, 15). In addition to the more traditional interpretation of a 'resilient region' like Foster and Peng, they also add that it is "one that has rapid information flows and connectivity to promote efforts reaching across residents, sectors, and communities" (2015, 15).

These bodies of literature justify the need for a disaster data intermediary that is a reliable institution to oversee *ex ante* disaster planning that can advocate for and implement open data policies, and that operates at a regional scale across sectors. In the following section, the case studies will exhibit these theories in actual situations leading to recommendations for MAPC, and convey how the agency can truly "promote a vision of a connected region that is innovative, resilient, and inclusive" (Mossberger et al. 2015, 15).

4. CASE STUDIES

The experiences of data intermediaries from past hurricanes convey the increasing role of data in disaster management, the significance of regional resilience planning, and the functions of data intermediaries. The cases were written with the specific goal of making relevant recommendations to MAPC and highlight experiences involving data or regional scale issues.

4.1 THE DATA CENTER, HURRICANE KATRINA NEW ORLEANS, 2005

Hurricane Katrina made landfall in Louisiana on August 29, 2005 as a Category 3 storm. It is one of the most devastating disasters in U.S. history, resulting in $125 billion in damage (NOAA 2018). When the levees protecting the city failed, approximately 80% of the city was flooded (The Data Center 2018). The storm claimed over 1800 lives and more than 1 million people along the Gulf Coast were displaced (Encyclopaedia Britannica n.d.). This case study recounts the experiences of The Data Center, a NNIP member and an independent research organization that analyzes and monitors data for the Southeast Louisiana region. Their story demonstrates best practices for producing data during response and recovery, communicating via traditional media channels in addition to the internet, and the considerations of open and transparent data policies.

The Data Center, which was called the Greater New Orleans Community Data Center at the time, played a major role in the response and recovery phases of Katrina. Founded in 1997, the organization's mission is to help civic leaders use data to make informed decisions. In 2001, they published a website, www.gnocdc.org, with information on the 73 neighborhoods in New Orleans. This site supported local nonprofits who could download data in easily accessible table and spreadsheet formats. By implementing a robust website prior to the storm, The Data Center leveraged local credibility

TOP 5 COSTLIEST HURRICANES IN U.S. HISTORY

2005

$160 BILLION

1. Hurricane Katrina
Category 3
Louisiana, Mississippi, Florida

2012

$71 BILLION

4. Hurricane Sandy
Category 1
New York, New Jersey, Connecticut

2017

$125 BILLION

2. Hurricane Harvey
Category 4
Texas, Louisiana

$50 BILLION

5. Hurricane Irma
Category 4
Florida

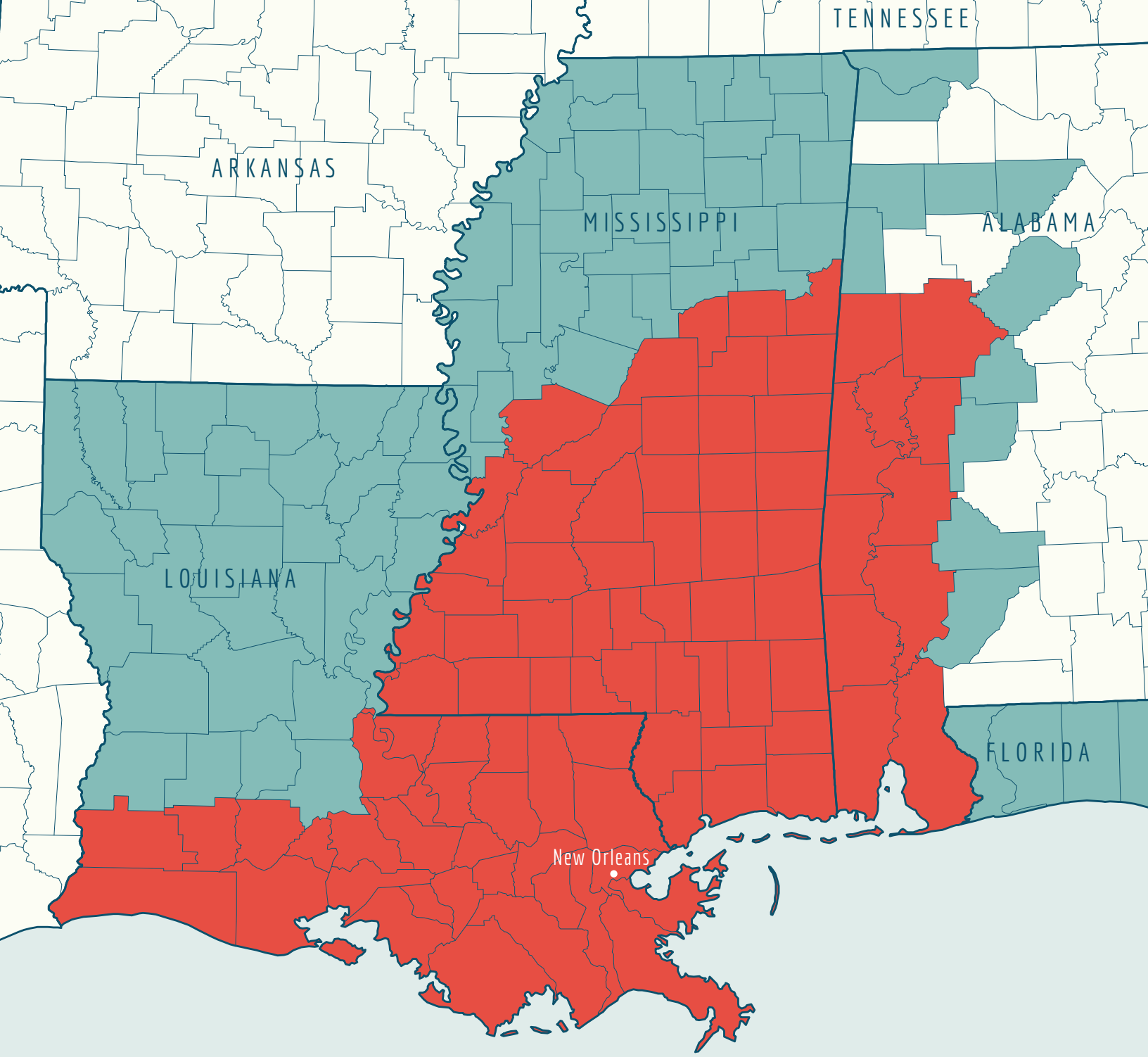
$90 BILLION

3. Hurricane Maria
Category 5
Puerto Rico
Dominican Republic

Source: The Weather Channel, NOAA, 2018

HURRICANE KATRINA

Source: News-Press



HURRICANE KATRINA DISASTER DECLARATIONS BY COUNTY

SOURCE: FEMA, 2005

Individual Assistance and Public Assistance

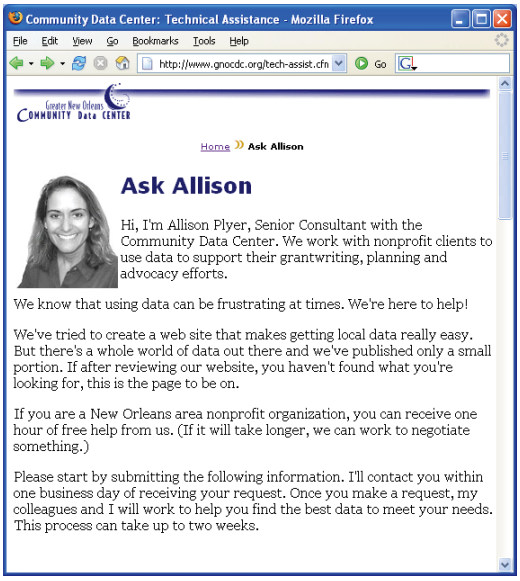
Public Assistance

No Designation

N

within the community which allowed them to be highly cited in the immediate aftermath of Katrina (Ross 2017).

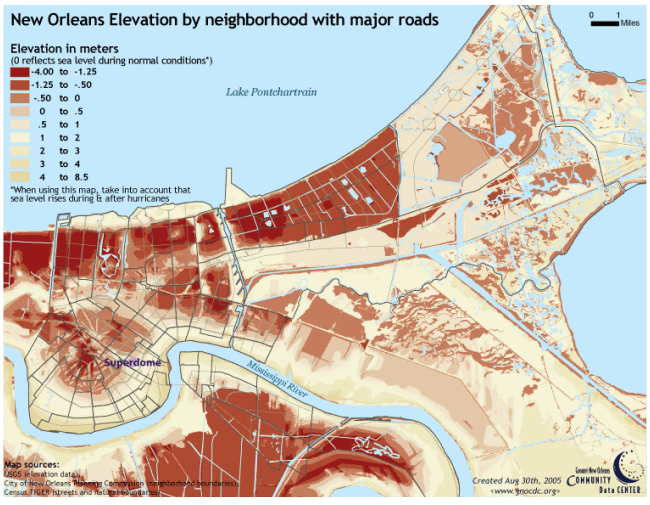
Denice Ross, who is presently a Public Interest Technology Fellow at New America, was working at The Data Center during Hurricane Katrina and could speak from personal experience. In an interview, she recalled that their website remained functional because it was served on hardware that was located in Kentucky and was not at risk of flooding. Other institutions like the City of New Orleans' and Tulane University's sites crashed, so much of the traffic was driven to The Data Center's website. In addition to the remote location of the server, a remote staff member in San Diego was also able to maintain the website, while the rest of the staff had to evacuate the city.



Ask Allison tool by The Data Center
Source: Ross, 2017

Allison Plyer, the current Chief Demographer at The Data Center, insists that a mechanism to track incoming data requests is necessary. For The Data Center, this tool was called "Ask Allison," enabling users to interact directly with team members and ask questions or request specific data. Ask Allison was already familiar to citizens prior to Katrina and allowed The Data Center to identify relevant data that was in high demand. This information would then be foregrounded on the website's landing page so that it was easily accessible (Plyer 2010).

Early in the response phase, The Data Center noticed that requests for elevation data were frequent, so they quickly produced and published an elevation map. They received many questions from non-local agencies and media looking for neighborhood-level information. The EPA asked for shapefiles and members of media outlets inquired about neighborhood specifics like the difference between "Lower 9th Ward" or "Old 9th Ward." Additionally, individuals were contacting The Data Center, worried about family members who were stranded or seeking information about their homes (Plyer



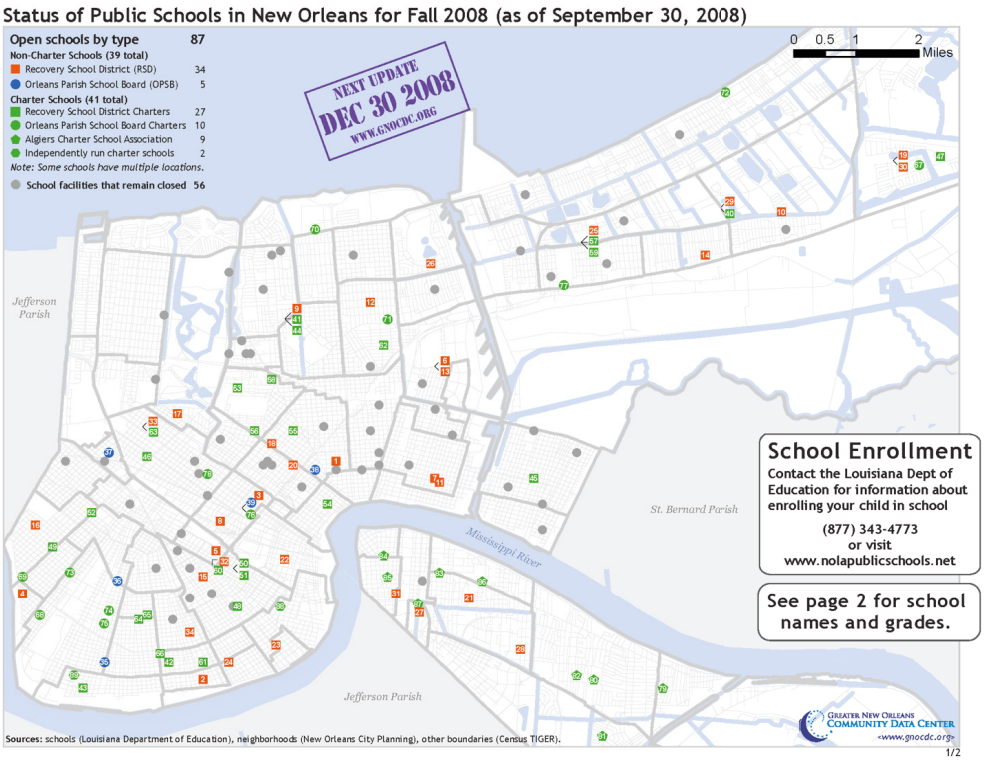
Elevation Map by The Data Center
Source: Ross, 2017

2010). A significant increase in requests for information is a pattern that repeatedly occurs in these case studies. Plyer recommends that intermediaries should establish a procedure to prioritize the requests in the event that they can't all be addressed.

THE DATA CENTER
Independent Analysis for Informed Decisions in Southeast Louisiana

While they were able to publish their information online through PDFs, blog posts, and social media, The Data Center realized the importance of local TV, radio, and news outlets to more fully democratize data and begin to address the 'digital divide' (Plyer 2010). Plyer contended in an interview that, to this day, many New Orleans citizens do not have internet access so reaching those populations through traditional media channels was key. The staff had the ability to respond quickly to media requests which gave them a good reputation amongst news outlets who would invite them to make appearances on their shows. As a result, multiple federal agencies and organizations from across the nation accessed their site and used their data (Plyer 2010).

In her presentation at a NNIP conference in October 2017, Ross claims



Map of open public schools by The Data Center
Source: Ross, 2017

that The Data Center recognized the need to use non-traditional data collection methods as recovery progressed, including crowdsourcing. Since many citizens were forced to relocate, the most common request was for small-scale data on the repopulation of neighborhoods. Seeing that the Census Bureau could not act quickly to produce this data, The Data Center produced their own. They were able to evaluate postal mail, car registration, and voter registration data as valid indicators of neighborhoods that were recovering versus those that were lagging behind. Residents who had evacuated also needed to know if schools, daycares, and hospitals had reopened to decide whether they should return. Data on such facilities initially had to be updated on a weekly basis, so The Data Center began to use a "Best Used By" stamp on their data and learned to decommission products that were no longer necessary or up-to-date (Ross 2017).

During an interview, Plyer emphasized that after a disaster rumors can spread, especially when recovery is lagging. One task for The Data Center was to identify rumors, find data to address them, and distribute accurate information broadly. The Data Center participated in community meetings, took note of media claims, and monitored their data requests to identify common misunderstandings amongst communities. She stresses the importance of different methods of disseminating data to a variety of audiences, after realizing that policy and decision makers in New Orleans would not read long reports but preferred powerpoint presentations. MAPC should produce data outputs through different modes when considering their users, such as the citizens who may lack the time and capacity to download and analyze raw data files.

In her article "The Most Empowering Tool for Hurricane Recovery," Ross reflects on the past twelve years since Katrina. She contends that some agencies can be uncomfortable with open data and transparency for fear of the criticisms that they might receive (2017). Although Kitchin argues this scrutiny will force public entities to be more accountable, the backlash may deter some sectors from ever embracing open data policies. Amy Liu and Allison Plyer describe a case of how transparent data affected all sectors and stimulated faster response and recovery,

> "This kind of transparent data informed action. The White House and federal and state agencies used it to shape the design of housing-assistance programs and to better understand which aspects of the recovery needed more attention. Monthly and quarterly updates put pressure on government

> agencies to get dollars on the streets faster, with greater flexibility to match local needs. State leaders used the data to make the case for additional supplemental federal funding for home and infrastructure repairs. The information empowered nonprofits and neighborhood advocates as they emphasized the need for more rental housing. And this public data resource helped spur private investment by measuring signs of economic vitality in key sectors and neighborhoods"(Liu and Plyer 2017, n.p.).

Ross recalls an instance with building permit data that was in high demand because it is the "first signal of a property owner's intent to rebuild" (Ross 2017, n.p.). However, building permit data was only released for certain neighborhoods. When asked by many parties to release city-wide permit data, city officials claimed it would be too costly to pay the software company to make the data downloadable. This vendor lock-in tactic exploited by software companies is a reason why many governments cannot afford to switch services or open their data to the public (Ross 2017).

Today, the Data Center continues to develop indicators to track post-Katrina progress in New Orleans and close the gap in income equality. They collaborate with the Brookings Institution to publish *The New Orleans Index* to track the recovery process. The reports were initially published on a monthly basis and then gradually switched to a yearly publication. The case of The Data Center during Hurricane Katrina demonstrates the variety of roles that data played in the response and recovery phases before open data policies and social media tools used today were widely adopted.

KEY LESSONS FROM THE DATA CENTER

+ Decommission products as needed, add a "Best Used By" date so outdated information is not used
+ Use traditional media outlets like television and radio in addition to the internet
+ Have a tool in place like "Ask Allison" that allowed users to directly correspond with The Data Center staff members to submit data requests and prioritize incoming data requests
+ Advocate for open data policies and coordination amongst local, federal, and state agencies prior to a disaster
+ Use non-traditional data collection methods

HURRICANE SANDY

Source: New York Magazine

4.2 HURRICANE SANDY, NEW YORK + NEW JERSEY, 2012

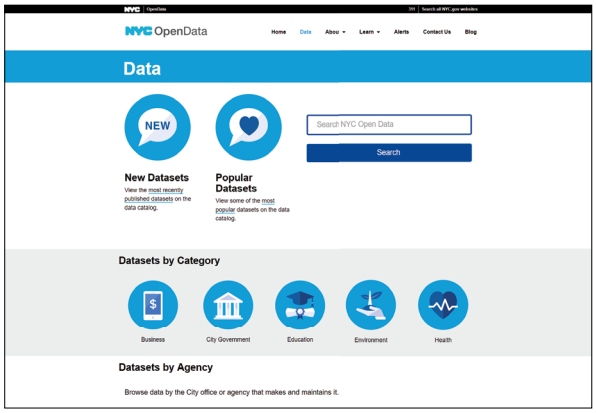
Hurricane Sandy (also called Superstorm Sandy) was a late-season storm that started in the Caribbean and traveled up the Eastern Seaboard. Although Sandy caused sea levels to rise from Florida to Maine, the greatest inundation levels occurred in New Jersey, New York, and Connecticut. The storm surge hit the tri-state area on October 29, 2012 damaging homes along the Jersey Shore and flooding subway stations and streets in Lower Manhattan (Sharp 2012). According to NOAA, Sandy caused approximately $71 billion in damage overall (2018). The lessons from Sandy demonstrate the significance of regional collaboration in a dense and interconnected area, offer an example of progressive open data policies and portals, and explore the implications of increased social media usage during disasters since Katrina.

In an interview, members from the Department of City Planning (DCP) said that some response and recovery efforts were coordinated across agencies while others were not. City planners recall collaborating with FEMA, Army Corps of Engineers, and NOAA. Similarly, the Deputy Director of Planning from The Mayor's Office of Resilience and Recovery (ORR) corresponded with the New York Governor's Office of Storm Recovery as well as the Port Authority, a bi-state transportation agency for New York and New Jersey. It is not clear if a formal communication system was established; instead, partnerships seemed to have formed on a case-by-case basis.

The Hurricane Sandy Rebuilding Task Force was created by President Obama in 2013 to oversee various federal, state, and local agencies in the rebuilding process after the storm. Their report stresses the importance of regional collaboration, noting that if infrastructure in the New York and New Jersey region were to fail, "there would be a cascading effect on both the region and the nation as whole, as more wealth is created in this area than in any other metropolitan area in the United States" (2013, 54). One example was Sandy's impact on fuel terminals and pipelines in New Jersey leading to severe fuel shortages in New York City. In post-disaster resilience measures, the effects of moving sand from one area to rebuild beaches in another would weaken coastal protection and affect marine industries and tourism. Agencies from all levels would benefit from recognizing their interdependencies, participating in transparent decision-making to avoid "unplanned redundancies," and identifying gaps in resilience efforts (Hurricane Sandy Rebuilding Task Force 2013, 54).

OPEN DATA POLICIES + PORTALS

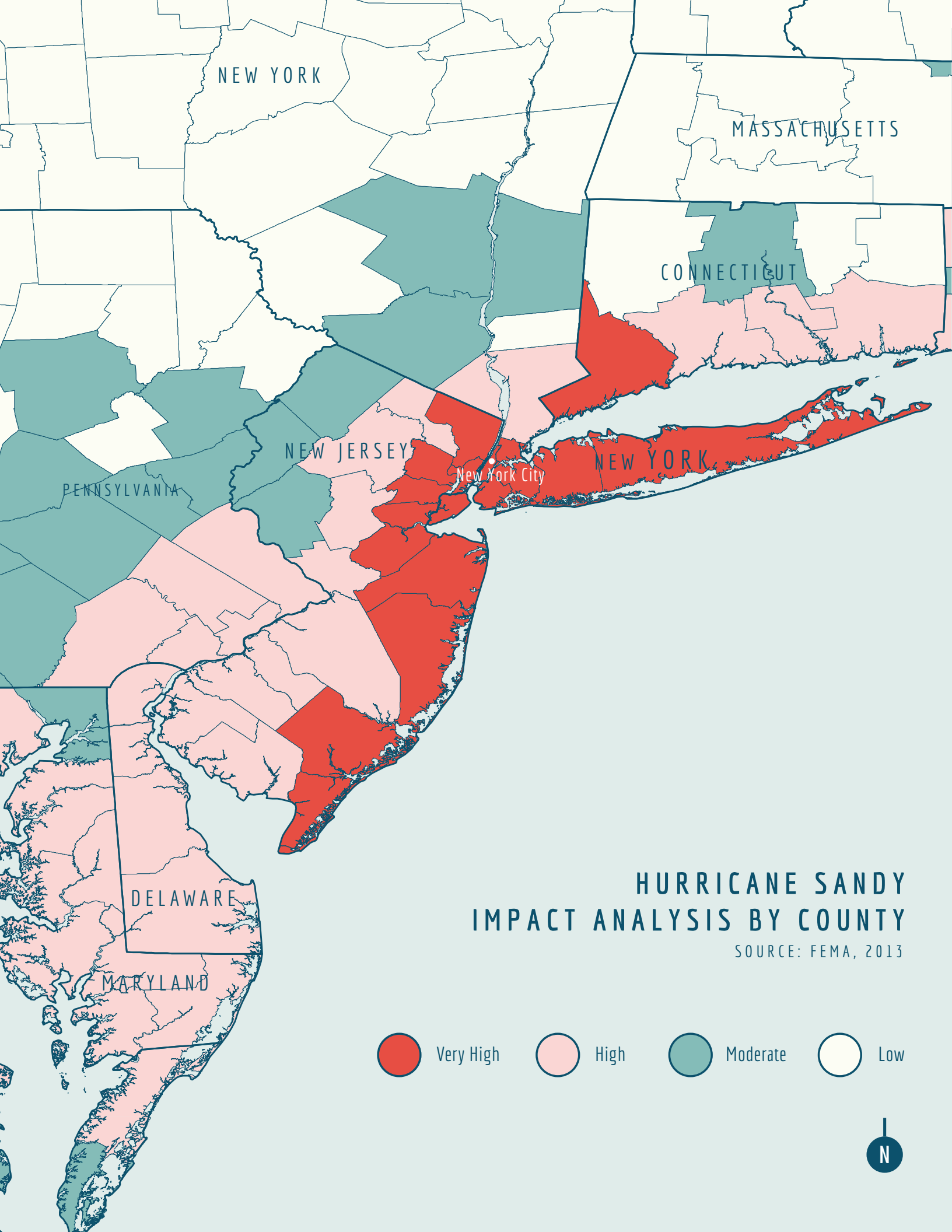
Given the size and institutional complexity of New York, it is difficult to pinpoint a single data intermediary that serves the entire region. For comparison, the population of the entire Metro Boston in 2018 is 4.7 million while New York City alone is 8.5 million (DATAUSA 2018). The City of New York is a major data intermediary with significant technical capacity. In 2012, Mayor Bloomberg signed the "Open Data Law" which mandated all public data to be assembled into a single data portal by 2018. The Mayor's Office of Data Analytics (MODA) and the Department of Information Technology and Telecommunications (DoITT) formed NYC Open Data, (opendata.cityofnewyork.us), an open data portal that houses all the city's data (City of New York 2017). The Open Data portal is organized by category and each of the 92 city agencies who contribute to the portal have an appointed "Open Data Coordinator." They have published an extensive Technical Standards Manual for agencies to follow to publish data that meets the required standards and formats. They have also produced an interactive, online progress tracker, so that the general public can track yearly updates and if certain data sets have been added or removed. Although operating at a larger scale than Boston, New York's open data policy and portal serves as an ideal model for other cities and metro regions.



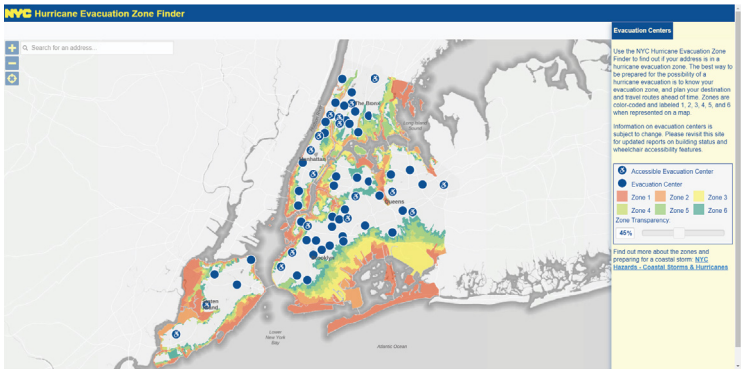
NYC Open Data Portal *Source: NYC Open Data, 2018*

AN ABUNDANCE OF MAPS

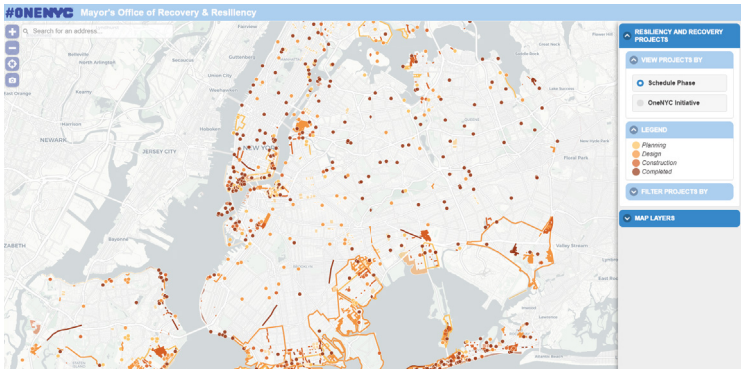
In the aftermath of Sandy, a number of flood mapping products were released covering flood insurance, sea level rise, and hurricane evacuation zones. Department of City Planning staff members said one of their earliest tasks was to direct users to the most accurate versions of these maps. In a quick Google search, it is clear that


NEW YORK
MASSACHUSETTS
CONNECTICUT
NEW JERSEY
NEW YORK
New York City
PENNSYLVANIA
DELAWARE
MARYLAND
HURRICANE SANDY
IMPACT ANALYSIS BY COUNTY
SOURCE: FEMA, 2013
Very High
High
Moderate
Low
N

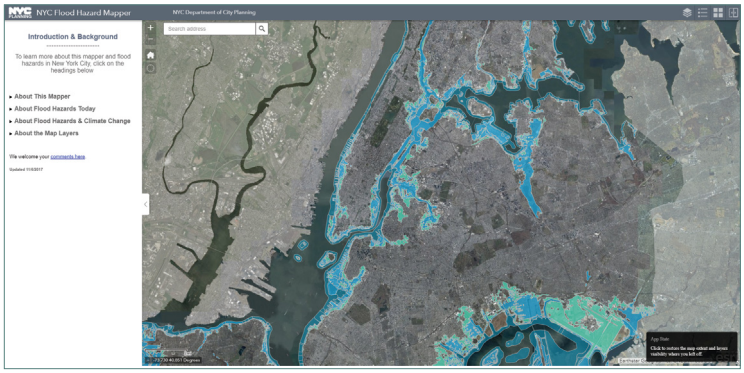
there is an overwhelming number of these products including NYC Flood Hazard Mapper[1], ONE NYC Resiliency Map[2], and FloodHelpNY[3]. Additionally, New York has appealed to update the FEMA flood zone maps to incorporate sea level rise, stronger storms, and other climate change factors. The interviewee from the Mayor's Office of Resiliency and Recovery believes this effort that will affect the entire region, because changes to New York maps will be made for neighboring New Jersey and Connecticut as well. I would argue that the volume of maps produced by various agencies can be a source of confusion, especially when very slight differences between flood maps in a dense city like New York have financial implications worth millions of dollars (Chen 2018). A data intermediary should ensure a consistent message is being delivered, that modeling methods are transparent, and that any scientific jargon is explained and easily understood by the average user.



NYC Hurricane Evacuation Zone Finder Map *Source: NYC, 2018*



NYC Resiliency Map *Source: NYC, 2018*



NYC Flood Hazard Mapper *Source: NYC, 2018*

1 http://www1.nyc.gov/site/planning/data-maps/flood-hazard-mapper.page
2 https://maps.nyc.gov/resiliency/
3 https://www.floodhelpny.org/

SOCIAL MEDIA USAGE

Occurring seven years after Katrina, Hurricane Sandy marked one of the first disasters where government agencies and citizens alike turned to social media to share information, respond to emergencies, and stay informed New York's Office of Emergency Management, New Jersey Governor Chris Christie's Office, and FEMA were some of the many agencies that used Twitter and Facebook for response, aid, and assistance (Cohen 2013). After Hurricane Irene in 2011, the City of New York created a "Social Media Emergency Protocol" that streamlined content sent over various social media platforms across all city agencies and departments during emergencies. The City also partnered with Google's Crisis Team to develop a crisis map and Twitter who donated promoted tweets to ensure that certain tweets would appear at the top of the search page (Homeland Security 2013). Given increasing social media usage since 2012, it is safe to assume that social data platforms will continue to play an ever-larger role in disaster planning. The implications of this continued growth is further explored in the following Hurricane Harvey case study.

COMMUNITY RESILIENCE

Interviewees also emphasized the experience of the Red Hook Initiative (RHI), a community group that led an efficient community-led emergency response and helped thousands during Sandy. A nonprofit based in Brooklyn, RHI has served the Red Hook neighborhood for 15 years. Red Hook is a uniquely vulnerable community where 70% of the residents live in affordable housing and is surrounded by water on three sides. Since the storm, RHI has orchestrated training sessions to teach residents about emergency preparedness and community resilience. One of their most notable ongoing projects is the Red Hook Wifi project that provides free internet access to the community, bridging the digital divide and empowering youth to make change in their neighborhood (Red Hook Initiative 2018). An informant mentioned that the city is currently reevaluating how to effectively coordinate with community groups to address local urgencies. This continues a recurring theme throughout the case studies mandating that a disaster data intermediary must seek out such partnerships with community groups in need.

KEY LESSONS FROM NEW YORK DATA INTERMEDIARIES

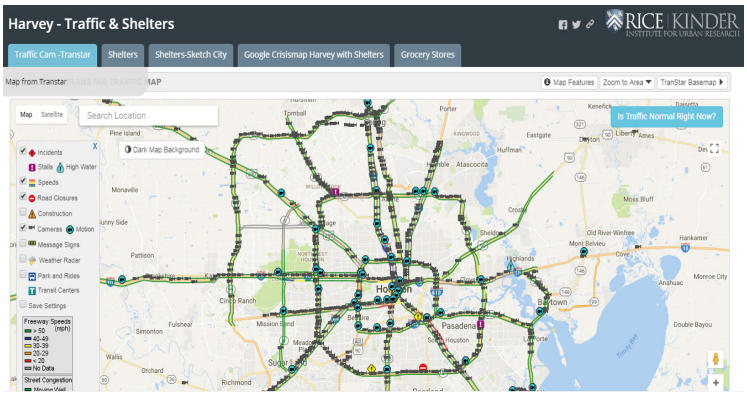
+ Cross-agency collaboration can avoid redundancies and confusion (e.g., multiple flood maps displaying contradicting or information that is difficult to understand to the average user)
+ Regional collaboration is fundamental, particularly in dense areas like the New York/New Jersey area where much infrastructure is shared across jurisdictional boundaries
+ As social media usage increases, new methods of leveraging that data during disasters should be planned beforehand
+ Partnerships with local community groups like The Red Hook Initiative already doing emergency planning and working to bridge the digital divide should be established

HURRICANE HARVEY

Source: CNET

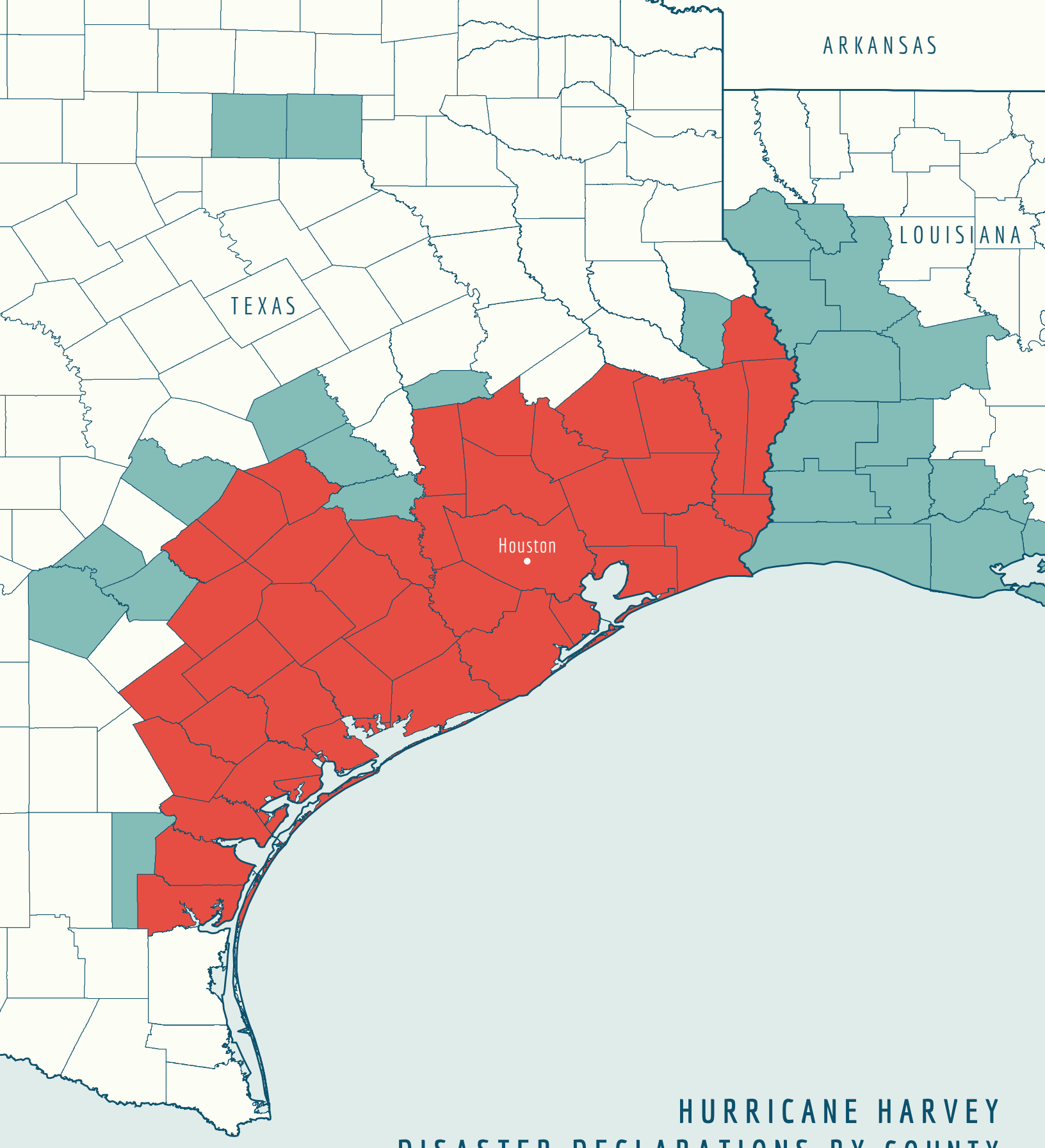
4.3 HURRICANE HARVEY, HOUSTON, 2017

Hurricane Harvey was a Category 4 storm that hit the Texas and Louisiana coast on August 25, 2017. It the second costliest hurricane in US history at $125 billion dollars of damage (NOAA 2018). Harvey is estimated to have destroyed over 200,000 homes and dropped two feet of rainfall in the first 24 hours (Amadeo 2018). Harvey is the third 500-year flood to strike Houston in the past three years which is a cause for alarm. A 500-year flood is a 1 in 500 chance of flooding in any given year or a 0.2 percent chance of occurring (Kimmelman 2017). Houston came under national scrutiny in Harvey's aftermath for decades of developing over wetlands that would have drained rainwater naturally and for a lack of formal zoning codes. In one case, residents living in and near floodable reservoirs were unaware of the risk (Kimmelman 2017), demonstrating the failure of data dissemination from the city to its citizens. This case study focuses on the The Kinder Institute for Urban Research, a think tank housed at Rice University and a NNIP member. Additionally, it discusses a successful example of a local government partnership with a civic technology group, Sketch City, who created crowdsourced tools which were duplicated for Hurricane Irma responders in Miami directly after Harvey.



Harvey Live Web Map by The Kinder Institute *Source: Wu, 2017*

The Kinder Institute for Urban Research is a "think and do tank" that focuses on urban issues in Houston and the American Sun Belt (The Kinder Institute 2018, n.p.). At a NNIP conference in October 2017, Jie Wu, the Director of Research Management at Kinder, spoke about her professional experience during Harvey. As the rain fell, staff members from Kinder were stranded or had evacuated their homes but were able to continue working with access to power and internet. They began to collect data to respond



HURRICANE HARVEY
DISASTER DECLARATIONS BY COUNTY

SOURCE: FEMA, 2017

Individual Assistance and Public Assistance

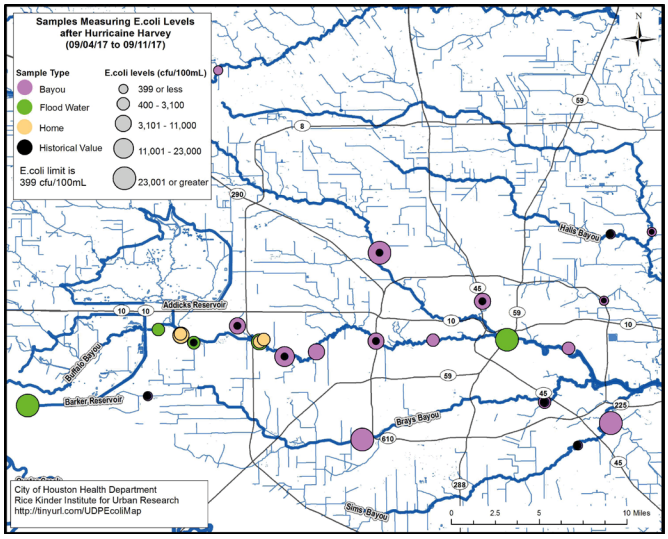
Public Assistance

No Designation

N

to frequent inquiries (e.g., the status of flooding, open grocery stores, and traffic information) which they compiled into a real-time web map. Like The Data Center in New Orleans, Kinder received multiple requests for neighborhood level data from media outlets seeking local context for their reports.

As an academic institution with no formal relationships with the City of Houston or Harris County, Kinder remained a neutral source of information in the eyes of the public, boosting their credibility. After the storm, Kinder was able to form new relationships and data sharing agreements with local organizations. They also created an open data portal called Urban Data Platform (kinderudp.org). To communicate their data to a general audience, Kinder also released "data stories" which are long-form visual articles. In addition to the Urban Data Platform, they created a dashboard Houston Community Data Connections (HCDC), datahouston.org, to visualize neighborhood needs and provide information at the local level (Wu 2017).

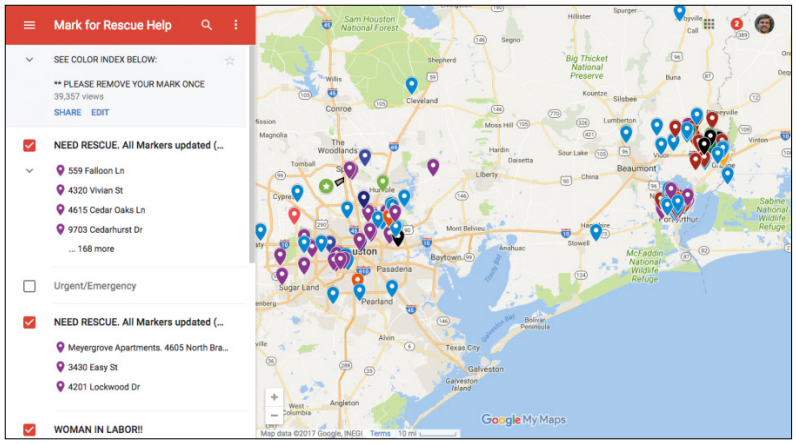


E.Coli levels map by The Kinder Institute
Source: Kinder Institute, 2017

Wu notes that Harvey disrupted the research agenda for the Kinder Institute, and they reevaluated their priorities as a data intermediary and research institution. They ventured into new research areas such as mapping E. Coli levels in partnership with the Baylor College of Medicine and discovered that levels of E.Coli were 57 times the acceptable limit after flooding. While still in the long-term recovery phase, they plan to analyze post-Harvey data and will expand their data portal to include more datasets. They intend to push for more open data policies, gain access to federal data, and share information between Houston institutions and national NNIP partners (Wu 2017).

The City of Houston and Harris County also sought to communicate important information to their residents. They were helped by a group of civic technologists called Sketch City, the Code for America brigade in Houston. Sketch City created a rescue map which collected information via Google Sheets onto a Google Map and was used by first responders and volunteers to identify and rescue

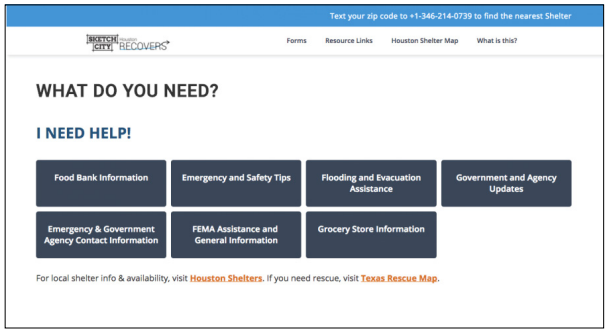
people in need. They also created a relief website called Harvey Needs (harveyneeds.org) to coordinate supplies, donations, volunteers, and emergency shelter locations using a single platform. Residents could interact with this resource by sending a text containing their zip code; they would then receive a text with the location of the closest emergency shelter. Sketch City then copied the code for the City of Miami who was struck by Hurricane Irma right on the tails of Harvey. The success of these projects has pushed city officials from both Houston and Miami to consider more civic tech collaboration and developing tools in advance so they can be activated in times of emergency (Bousquet 2017).

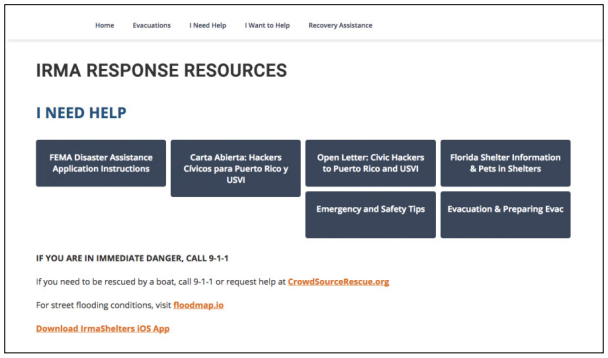


Rescue Map by Sketch City *Source: Data-Smart City Solutions, 2017*

The Kinder Institute's and civic technologists' activities after Harvey illustrate the importance of implementing open data policies in disaster planning. When city hall is closed and city websites are down, such policies allow for data and platforms to be "mirrored for use and reuse, removing roadblocks and choke points to members of the public seeking crucial information" (Abazajain and Dodds 2017, n.p.). An open data culture will enable sharing across agencies, especially when ensuring that first responders have appropriate data beforehand.

The case studies of Harvey and Irma demonstrate the variety of players who are active in the response and recovery phase including city governments, private institutions, and civic groups. These agencies should coordinate their efforts and share information to avoid redundancies. A data intermediary like The





Above: Harvey Needs Website by Sketch City
Below: Irma Response Website by Sketch City + Irma Responders
Source: Data-Smart City Solutions, 2017

Kinder Institute could facilitate these relationships and set roles prior to a disaster. While Houston and Miami are currently in the recovery phase, it is urgent that these agencies should begin the long process of setting guidelines for coordinating and collaborating.

KEY LESSONS FROM THE KINDER INSTITUTE AND SKETCH CITY

+ Identify civic tech groups such as Sketch City, the Code for America brigade for Houston, to collaborate with in the response phase
+ Develop tools that are open source, scalable, and portable (e.g., maps and code shared by Harvey and Irma responders)
+ Build relationships with local media and community groups prior to the disaster to boost local credibility
+ Mobilize quickly when necessary - Kinder's live web map exhibits that data intermediaries can also be reactive to gaps in the response

The three case studies spanning over a decade exhibit the significance of data infrastructures and circumstances that will likely reappear in future disasters. The many dissemination techniques used by The Data Center during Hurricane Katrina should be emulated and transparent data informing recovery efforts should encourage intermediaries to push for open data policies. Hurricane Sandy illustrates precedents of progressive open data policies, social media usage, and social resilience in communities. Hurricane Harvey displays the ability of both private and volunteer data providers to mobilize quickly during response and its scalable effects to other disasters like Hurricane Irma. In the following section these key lessons from each case will translate to recommendations for MAPC across the phases of the disaster management cycle.

5. RECOMMENDATIONS FOR MAPC

The recommendations are organized in the disaster planning phases as a loose structure for MAPC and do not imply that they should strictly adhere to them. In particular, recommendations made in the mitigation and recovery phases could be implemented into everyday actions and throughout the entirety of the disaster. These recommendations were pooled from interviews with other NNIP partners, lessons from the case studies, and the literature review.

5.1 MITIGATION

What can MAPC be doing during 'blue skies' to reduce vulnerability during a disaster?

+ Build an open data culture and advocate for more transparent policies
+ Develop a set of guidelines for open data standards that cities, state, nonprofits, and private sector companies to follow
+ Devise a community engagement plan to reach vulnerable communities and nonprofits
+ Identify data partners in Metro Boston
+ Develop a unified communication strategy for the agency as a whole
+ Design all products with user-centered principles
+ Publish data throughout the year to boost credibility and strengthen the MAPC brand
+ Promote regional resilience initiatives with regional datasets

In this thesis, mitigation will refer to what MAPC can do on a day-to-day basis during 'blue skies.' Mitigation is arguably the most important phase of the disaster management cycle because actions performed in this phase will alleviate damages that may occur during and after the disaster.

+ Build an open data culture and advocate for more transparent policies

Establishing an open data culture before the storm is crucial and will require long-term commitments. In 2015, Mayor Martin Walsh signed the Open and Protected Policy Law which prompted the City of Boston to create an open data portal (Wood 2015). The state also has created MassGIS and MassData open data portals where certain statewide information can be downloaded. There are many datasets, however, that would be helpful during disasters that remain unavailable. A

'data wishlist' for recovery assembled by Denice Ross and other data intermediaries can be found in Appendix B (Ross 2017). For example, building permit data or mortgage delinquency rates can be effective for tracking recovery. The most ideal scenario would be for MAPC to work with government agencies to promote an open data culture at all times. However, if agencies are hesitant to commit to open data principles, perhaps MAPC can form agreements and exceptions for data access during times of emergency.

In addition to opening public sector data, some interviewees advocated for what is called 'data philanthropy' in which private companies share their data for the public benefit. In Houston, intermediaries advocated for credit card companies to release transaction data to observe which stores were open for business. The data was not released in time but had certain agreements been in place beforehand, this information could have been useful for residents (Interview 8). MAPC and other Boston institutions should begin to form partnerships with private sector companies like utility companies whose data would be crucial in times of emergency.

+ Develop a set of guidelines for open data standards that cities, state, nonprofits, and private sector companies to follow

Similar to the Technical Standards Manual developed by DoITT in New York, MAPC should provide a set of guidelines and best practices for data sharing. As mentioned in the OpenGovData list of characteristics, open data should be well documented, provide proper data sources, and ensure no interoperability issues. Without these factors, it is difficult for intermediaries to assess data quality and credibility. Additionally, within the data sharing agreement, MAPC should make sure to protect the privacy of individuals and publish appropriately aggregated data.

+ Devise a community engagement plan to reach vulnerable communities and nonprofits

"Gaining local credibility must be demonstrated through consistent involvement in community meetings and groups," Plyer argues (Interview 2). Community groups and nonprofits frequently use data for grant proposals and to advocate for their interests (Interview 6). As such, data should be easy to download and provided in a variety of formats to place in proposals in tables or sheets. Furthermore, many communities may not be equipped to actualize the power of data because the

barrier to entry is high. The Data Services team should partner with the Clean Energy, Environment, and Community Engagement teams within MAPC to devise a proactive plan for outreach to communities at risk. If a formal disaster planning initiative is set in place, community members should be involved in every step of the process. MAPC should pursue external partnerships with the Mayor's Office of Resilience and Racial Equity (MORRE) or Boston Indicators. MAPC should consider diverse methods of outreach such as GIS training sessions, webinars hosted for smaller towns, and other means to educate and assemble communities around creative uses of data. The Red Hook Initiative in Brooklyn is an admirable example of a community group that is aiming to bridge the digital divide and involve vulnerable communities.

+ Identify data partners in Metro Boston

MAPC should identify peer institutions and explore collaborations well in advance of an emergency. Loose roles should be agreed upon in accordance with agencies' domains of expertise but during a disaster, flexibility and rapid response will be vital. Some possible partners are MONUM, DOIT, Boston Indicators, and civic tech groups like Code for Boston.

+ Develop a unified communication strategy for the agency as a whole

The Data Services and Communications teams at MAPC should devise a media plan ahead of time and identify partners in local news and radio stations to disseminate accurate information during a disaster. Similar to the Data Common portal, the MAPC website should also broadcast timely messaging during a disaster that can direct users and bring relevant information to the front of the page. The MBTA service alert messaging system could serve as a suitable precedent.

+ Design all products with user-centered principles

From her experience with Katrina, Ross claims that all products should be designed with user-centered principles in mind. User testing can be performed with focus groups or presenting the tools at community meetings to fully understand how people will interact with the product on their own devices (Interview 6). One of MAPC's current projects is to create an open data portal called the Data Common. The data portal should borrow successful elements from NYC Open Data and City of Boston's Analyze Boston for easily organized and searchable databases. MAPC

should also design features of the data portal that can be turned on during a disaster without drastically changing the functionality. For instance, certain features could spotlight relevant and highly requested data on the front page.

+ Publish data throughout the year to boost credibility and strengthen the MAPC brand

MAPC should continue to regularly publish data and press releases throughout the year to boost local credibility. One tactic is to provide local media channels in small towns with data and analysis to use in their reports (Interview 11). This way MAPC can become the authoritative data source and promote agency awareness so that in times of crisis people know to rely on them for information.

+ Promote regional resilience initiatives with regional datasets

As the Hurricane Sandy Rebuilding Task Force learned, recovery efforts for Hurricane Sandy were not necessarily managed at the regional scale though much infrastructure in the New York and New Jersey region is shared. MAPC should push for more robust regional resilience initiatives in addition to their climate adaptation plans through the Metro Mayors Climate Preparedness Taskforce and subregional projects. In particular, datasets that may be significant to recovery should be prioritized and collected. Examples of regionally relevant data can be found on the Data Wishlist in Appendix B.

5.2 PREPAREDNESS

How can MAPC prepare for disaster response and recovery?

+ Determine a method of internal communication during a disaster
+ Determine roles prior to the disaster
+ Prepare to support the response phase
+ Ensure that all data and servers are backed up
+ Conduct a simulation training session

Currently the Data Services team does not have an internal emergency protocol for their employees. Staff members from The Data Center and The Kinder Institute also did not consider being personally affected by the hurricane. Prior to a disaster, it is vital to have an established protocol for when the lack of power and internet may lead to the out of state displacement of staff or even data storage.

+ Determine a method of internal communication during a disaster

MAPC should consider how to communicate during a disaster that may affect power, cellular towers, and internet outages. The team currently uses Slack as the internal messaging service within the agency. They can devise a strategy like phone trees or consider using platforms like Twilio to send SMS or phone calls. Phone numbers should be consistently added and updated to a list, a task that can be allocated beforehand.

+ Determine roles prior to the disaster

With a team of around 15 members, it is important to determine ahead of time who will perform certain functions. Team members in leadership positions should ensure members of their team are safe and accounted for. Other specific tasks might include deciding who will respond to media or data requests from other municipalities, and who will implement disaster messaging on websites.

+ Prepare to support the response phase

If first responders or emergency management workers have data needs, meeting these should be prioritized. In the case of Hurricane Irma, distributing the locations of nursery homes for first responders to prioritize could have saved many lives

(Bousquet 2017).

+ Ensure that all data and servers are backed up

Any physical data infrastructure should be protected and all data should backed up on cloud-based servers. Standards for backing up data should be applied throughout the entire agency, not just for the Data Services department. Multiple lines of defense should be considered and data should be stored in dispersed locations around the country. Additionally cyber attacks and other types of disasters should be deliberated when making these plans.

+ Conduct a simulation training session

MAPC should conduct role-playing scenarios to practice assigned roles during an emergency event.

5.3 RESPONSE

What is MAPC's role during the disaster itself?

+ Implement urgent messaging features of the MAPC website and the Data Common portal
+ Build a tool to manage and prioritize data requests
+ Perform a scan of the needs assessment to identify gaps and evaluate the extent of MAPC's role in response
+ Work with civic tech groups such as Code for Boston to crowd-source real-time information
+ Design lightweight apps that can be decommissioned when no longer needed
+ Prepare for the recovery phase

The response phase is typically the shortest phase of the disaster and the extent of MAPC's involvement in this phase should be considered on a case-by-case basis.

+ Implement urgent messaging features of the MAPC website and the Data Common portal

Rao et al. warn that having 'disaster versions' of products that drastically diverge from everyday usage will cause confusion during times of chaos. An "always on" approach suggests that platform designers design interventions that use different visuals and messaging but that leave the functionality intact (2007, 91). For example, the Data Common portal can have a disaster category that can be displayed prominently during disasters but is hidden during the course of normal operation. The user experience can remain the same but urgent messaging can be featured prominently.

+ Build a tool to manage and prioritize data requests

During the response phase, MAPC may be contacted by both local and non-local media sources, other agencies, municipalities, nonprofits, and individuals looking for information. MAPC should build an interactive tool resembling the "Ask Allison" feature by The Data Center that allows users to input data requests and other questions. MAPC will then identify data that is frequently requested and develop a method to prominently display that data. There may be many requests

that MAPC cannot accommodate, and the agency should not be afraid of saying "no" when capacity is strained.

+ Perform a scan of the needs assessment to identify gaps and evaluate the extent of MAPC's role in response

Kathryn Pettit, the Director of NNIP, recommends that a simple scan to see what needs are unfulfilled can help determine MAPC's role during the response phase (Interview 9). If there is a major gap, MAPC can evaluate how quickly they can mobilize and address the demand. Data intermediaries are known to be slow-moving institutions so they may not always be the best agency to fulfill a reactive role. In these instances, MAPC should determine their capabilities and support any other actors like civic tech groups who may be a better fit.

+ Work with civic tech groups such as Code for Boston to crowd-source real-time information

MAPC should partner with Code for Boston and other civic groups that can galvanize digital volunteers. Fortunately, members of the Data Services team are already involved with the Code for Boston brigade but should continue to build relationships through hackathons and meetups. During the response phase, crowd-sourced, real-time information is crucial in cases where traditional data may be unavailable or compromised (Li et al. 2017). The emergency shelter map built by Sketch City during Harvey or crisis mapping platforms like Ushahidi can provide valuable and timely information. By partnering with a civic tech group, MAPC as an institution is not liable for any of the data that may be produced should there be any concern about data verification. MAPC can either provide the data to support these groups or if the volunteer groups do not have strong leadership, MAPC can build the products themselves.

+ Design lightweight apps that can be decommissioned when no longer needed

Designing apps that integrate social media platforms that people use everyday is an effective user-centered approach in developing tools (Interview 6). During a crisis, users will not take the time to learn a new product or download a new application. Existing apps such as Google Maps and Google Sheets should be leveraged, which Sketch City incorporated in their maps for Harvey and Irma. Another prime example is Riskmap.us created by the Urban Risk Lab at MIT that features an

automated bot for data verification. The bot compiles that real-time data from Facebook, Twitter, and Telegram into a single map. Any tools developed during this phase should be lean: they should be published quickly and decommissioned after they have served their purpose.

+ Prepare for the recovery phase

The interviewed experts agree that a data intermediary is most impactful in the recovery phase. MAPC should begin prepare for the recovery and limit its response activities in cases where other actors can carry these out.

5.4 RECOVERY

How can MAPC help return the region to normalcy?

+ Track recovery and progress in the short and long-term
+ Utilize best practices when collecting new data and retire outdated data
+ Ensure cross-agency collaboration to avoid redundancies and confusion
+ Build tools that are open source, portable, and scalable
+ Seek non-conventional data collection methods
+ Pursue the 'Data Wishlist' for recovery

During the recovery phase, Liu and Plyer argue that,

> "Credible public information organized in one place can help to neutralize misconceptions, put every need in context and depoliticize decision-making. Most importantly, data on recovery needs also can enable citizen involvement and allow residents to hold public leaders accountable for progress" (2017, n.p.).

As the response phase ends and moves into short- and long-term recovery, it is crucial that the transition between those two phases is smooth. MAPC as the disaster data intermediary could ensure that there is overlap and a 'hand off' by major players. The recommendations for the recovery phase should be seen as complementary to mitigation efforts.

+ Track recovery and progress in the short and long-term

Tracking recovery is a continuous proposition. Data must be collected and issued regularly in order to support rebuilding efforts. Questions about how to best deploy resources and how to prioritize funding can be answered and tracked using data. *The New Orleans Index* published by The Brookings Institution and The Data Center serves as an example of keeping a constant pulse on recovery efforts. Recovery data should be released in various formats taking into account the needs and preferences of different audiences. For example, a general audience might prefer an interactive website while for political leaders, a Powerpoint presentation might be preferable.

"DATA INTERMEDIARIES ARE THE MOST IMPORTANT PIECE OF CIVIC INFRASTRUCTURE FOR RESILIENCE AND RECOVERY."

-Denice Ross

+ Utilize best practices when collecting new data and retire outdated data

During a time of constant change, MAPC should develop best practices when publishing data that can expire or be updated. This was demonstrated by the "Best Used By" stamp developed by The Data Center. Much like the open data standards developed in the mitigation phase, the methods of data collection and its sources should be clearly defined.

+ Ensure cross-agency collaboration to avoid redundancies and confusion

MAPC should collaborate with other agencies in the region to ensure that a single message is being delivered and that there are no unplanned redundancies in recovery efforts. "Government can't do it alone," Ross says, "Public and private recovery efforts will need to align, but the required level of coordination will only be possible if everyone is working from a shared base of common information and trust" (Interview). This list may include federal agencies like FEMA, state agencies such as MBTA or MassPort, city governments, and even other regional planning agencies. Whoever the actors are, transparency across all sectors and jurisdictions will be imperative.

The following list identifies a few of the many agencies that MAPC should partner with:

Federal	State	Regional
Army Corps of Engineers	MassDOT	Massachusetts Homeland Security Councils
Coast Guard	MassGIS	Metro Mayors Coalition
FEMA	MassPort	Mystic River Watershed Alliance
NOAA	MBTA	Other regional planning agencies
	MEMA	

Local	
Boston Green Ribbon Commission	Maptime Boston
Boston Indicators	Neighborhood of Affordable Housing
City of Boston	Universities and research centers
Code for Boston	

+ Build tools that are open source, portable, and scalable

If MAPC decides to build new tools for the recovery phase, they should be open source so that they can be deployed in other cities in the context of other disasters. This was proven to work with the Sketch City example, when Hurricane Irma in Miami directly followed Hurricane Harvey. Using Github, the group was able to fork their code from the Harvey emergency website and map and share their methods with responders in Miami. MAPC should continue their use of Github when developing any tools.

+ Seek non-conventional data collection methods

MAPC may want to seek non-conventional data in place of datasets that are difficult to acquire or inaccessible. For example, The Data Center was able to leverage data from a direct-mail marketing coupon company to track repopulation in neighborhoods based on homes that were receiving mail. Another example is to partner with companies like Airbnb who donated free temporary housing for displaced residents during Harvey. MAPC should adapt and modernize to engage with the public, brainstorm new ways for data to be collected, and push the traditional boundaries of sharing data.

+ Pursue the 'Data Wishlist' for recovery

The 'Data Wishlist' for recovery was developed by Denice Ross and other veterans of past storms who identified certain datasets that could be useful in the recovery phase (Ross 2017). The list featured in this thesis adapts Ross' original list with examples from the case studies and discoveries from my own research. The datasets are ranked high, medium, and low priority based on my assumptions. High priority datasets are ones that must be obtained urgently because they may overlap with response efforts or affect public safety. Medium and low priority datasets are still significant to recovery, but can be acquired after immediate needs are addressed and will be useful as good indicators for long-term recovery.

For each dataset, the data owners and the example use cases are listed. MAPC does not necessarily have to seek these datasets themselves, but can partner with other agencies who may be able to obtain this data more quickly. Accessibility for each dataset will vary as well. Typically if the data owner is a federal agency or a private company, obtaining that data may be more difficult. Datasets owned by state and

local entities and nonprofits may be more accessible if MAPC has established prior relationships. The scale at which these datasets are collected should be determined on a case-by-case basis. While MAPC's work is mostly at the regional scale, some datasets may be more useful at the state-wide scale. The MAPC region may be an not be the most appropriate areal unit when collecting data for hurricane recovery because it does not include neighboring coastal towns located just outside the MAPC zone. In such instances, MAPC should be flexible and use their judgment in order to collect datasets that are at the appropriate geographic scale.

The list on the following page serves as an example for datasets specifically relevant to recovery efforts for hurricanes or other damaging, extreme weather events. Social disasters and other natural disasters may warrant different datasets that will be crucial to recovery but are not included in this research. The full list is reproduced in Appendix B.

(H) High Priority (M) Medium Priority (L) Low Priority

	Name	Category	Data Owner	Example or use case
(H)	Shared regional infrastructure status	Infrastructure	**State/Regional/Local** State, regional, local government	Infrastructure in one area may have regional impacts - such as the downed fuel terminals in New Jersey affecting supply in New York. Damaged roads, bridges, and highways will require regional collaboration to fix.
(H)	Emergency Shelters	Population, Housing	**Federal/Nonprofit** Red Cross and other shelter providers	The Red Cross, FEMA, and other shelters could release locations and number of beds available
(M)	People in temporary housing	Population, Housing, Philanthropy	**Private** Companies who have donated housing	Airbnb provided free housing for those displaced by Harvey. They could release information on location and length of donated housing.
(M)	FEMA Individual Disaster Assistance	Population, Housing	**Federal** FEMA	Zipcode level of those applying for disaster assistance would be valuable to deliver needed services and information about areas with large amounts of displaced residents.
(L)	Contractor fraud	Financial, Business & Services	**Nonprofit/State** Better Business Bureau, state licensing agencies	To protect citizens from scam artists, the Better Business Bureau or the State agency responsible for contractor licensing can make complaints about contractor fraud so that residents don't get scammed.

CONCLUSIONS: CHALLENGES + OPPORTUNITIES

During 'blue skies,' MAPC should be intentionally promoting open data policies, developing standards of data sharing, and building relationships with communities, media, and peer institutions through the lens of disaster management. They should prepare and practice an internal employee protocol and factor in multiple resilience measures to ensure their data is protected. During the disaster itself, they must partner with emergency responders and civic technology groups to recognize regional interdependencies, streamline efforts, and avoid any redundancy in work. Finally, in the recovery phase, they should act as the reliable, authoritative data source providing support to track short- and long-term recovery.

Ross states that, "Data intermediaries are the most important piece of civic infrastructure for resilience and recovery" (Interview 6). MAPC is the most appropriate disaster data intermediary for Metro Boston due to its current status as a data intermediary, regional purview, and technical capacity. As Katz and Bradley suggest, metropolitan organizations can mobilize and adapt more than their federal or state counterparts. The experiences from the case studies demonstrate that federal agencies and local governments have thus far not been successful with even very basic examples of civic data dissemination, such as informing Houston residents of flooding risk outside of the FEMA-designated flood zone. MAPC should continue pursuing an open data ecosystem with their peers in Metro Boston and target the private sector and federal agencies in granting access to their restricted data during disasters for the public benefit; for example, they can propose that utility companies release data on outages or collect unconventional data to track open facilities like schools or daycares for returning citizens.

The framework for disaster data intermediaries proposed in this thesis can serve as a model, but determining who fulfills that role will largely depend on local institutional conditions. The role may not always be performed by a regional planning agency but could be an academic institution or a nonprofit. As a public agency, however, MAPC has a responsibility to serve its constituents that is absent among private institutions. A challenge MAPC may face is that although it intends to be a neutral source, as a government entity, some may be critical of their intentions. The agency should invest in building relationships with communities and nonprofits to establish trust, boost credibility, and effectively address local needs.

Even if great strides are made in MAPC's disaster preparedness, it is impossible to anticipate every situation. This thesis aims to recommend a guiding

framework, but MAPC should remain flexible and react quickly in times of crisis. The challenges posed by the extreme weather events exacerbated by climate change should catalyze and offer an opportunity for MAPC in responding to immediate local needs. Technology alone, however, will not protect the region; MAPC's work must simultaneously support first responders and emergency managers on the ground as well as in long-term recovery efforts. In 2017, the U.S. experienced the three out of the top five costliest hurricanes in the country's history prompting questions about the consequences and frequency of future disasters. With proper infrastructures in place and directly addressing the disparities of dissemination, data-driven response and recovery will be more effective. MAPC should be motivated to act urgently, as forthcoming natural forces will not heed meticulous climate change plans or projected artificial boundaries.

POST-THESIS RESEARCH

I will continue developing this research over the summer of 2018 with support from the Priscilla King Gray Public Service Summer Fellowship. I will collaborate with the Data Services team to prototype the Data Common open data portal and continue discussions with the rest of the MAPC agency and key players in the Metro Boston area. My hope is that with continued collaboration, MAPC as a 'disaster data intermediary' can serve as a model to be scaled to other cities and contexts, particularly those vulnerable to climate change.

APPENDIX A - INTERVIEWS

Interview 1. Allan Zaretsky, City Planner, NYC Department of City Planning. March 9, 2018.
Interview 2. Allison Plyer, Chief Demographer, The Data Center. March 8, 2018.
Interview 3. Boston Indicators. April 6, 2018.
Interview 4. City of Boston, Mayor's Office of New Urban Mechanics. March 13, 2018.
Interview 5. City of Boston, Mayor's Office of Resilience and Racial Equity. March 27, 2018.
Interview 6. Denice Ross, Public Interest Technology Fellow, New America. March 1, 2018.
Interview 7. Deputy Director of Planning, NYC Mayor's Office of Recovery and Resiliency. 2018.
Interview 8. Informant from Houston. February 23, 2018.
Interview 9. Kathryn L.S. Pettit, Director of National Neighborhoods Indicators Partnership, Senior Research Associate at The Urban Institute. March 22, 2018.
Interview 10. MAPC, Analytical Services. April 20, 2018.
Interview 11. MAPC, Communications. April 12, 2018.
Interview 12. MAPC, Data Services. February 2018.
Interview 13. MAPC, Digital Services. February 2018.
Interview 14. MAPC, Municipal Collaboration. January 2018.
Interview 15. Mary Kimball, City Planner, NYC Department of City Planning. March 9, 2018.
Interview 16. Urban Risk Lab. February 2018.

APPENDIX B - THE DATA WISHLIST FOR RECOVERY

This list is adapted from Denice Ross and other veterans of past storms who identified certain datasets that could be useful in the recovery phase for hurricanes and similar disasters (Ross 2017). The list is organized by category and priority was determined according to the various timeframes of recovery. Data accessbility refers to how easily a data intermediary could acquire the dataset from the owner and will largely depend on local contexts.

PRIORITY

(H) High Priority - Datasets that may also be used in response efforts, affect public safety or need, and should be obtained immediately.

(M) Medium Priority - Datasets that are useful to track short-term recovery.

(L) Low Priority - Datasets that serve as good indicators long-term recovery.

DATA ACCESSIBILITY

Federal or Private Data - Typically more difficult to obtain due to beauracratic restrictions or private interests and costs

State, Local, Regional, or Nonprofit Data - May be easier to access based on strength of relationships between agencies and availability of data

	Name	Category	Data Owner	Example or use case
(M)	People in temporary housing	Population, Housing, Philanthropy	**Private** Companies who have donated housing	Airbnb provided free housing for those displaced by Harvey. They could release information on location and length of donated housing.
(M)	FEMA Individual Disaster Assistance	Population, Housing	**Federal** FEMA	Zipcode level of those applying for disaster assistance would be valuable to deliver needed services and information about areas with large amounts of displaced residents.
(H)	Emergency Shelters	Population, Housing	**Federal/Nonprofit** Red Cross and other shelter providers	The Red Cross, FEMA, and other shelters could release locations and number of beds available
(H)	Assited Living Facilities or concentrations of other at-risk individuals	Population, Housing	**Private** Private institutions	Locations of facilities with at-risk populations such as elderly can be compiled into a map or list for first responders to rescue first. Ex: During Hurricane Irma, nine patients at an assisted living facility in Florida died after their air conditioning broke while they were waiting to be rescued

Name	Category	Data Owner	Example or use case
(L) Postal data to track repopulation	Population	**Private/Federal** Direct mail marketing companies, USPS	Postal data can be valuable to track neighborhood population recovery and to record houses receiving mail. In New Orleans, a coupon company called Valassis helped The Data Center track recovery. USPS may also have this data but it must be purchased.
(H) 211 or 311 data	Relief and Needs	**Local** Community information + referral hotlines	211/311 data can track service requests and see what people are requesting most
(H) Shared regional infrastructure status	Infrastructure	**State/Regional/Local** State, regional, local governments	Infrastructure in one area may have regional impacts - such as the downed fuel terminals in New Jersey affecting supply in New York. Damaged roads, bridges, and highways will require regional collaboration to fix.
(M) Public transportation	Infrastructure	**Regional/Local** Regional, local government	Bus lines, commuter rail, subway status
(H) Utility outages	Infrastructure	**Private** Electric service providers, natural gas providers, water utilities and internet providers	Outages are likely to occur in smaller subregional areas, private companies could share data that spans across municipalities.
(M) Municipal assets status	Infrastructure	**Local** Local government	Statuses of municipal assets such as police stations, community centers, and parks are great indicators of recovery
(M) Building and demolition permits	Housing	**Local** Local government	Building permits are the first signal of a property owner's intent to rebuild. Demolition permits can be an indicator of progress in the removal of nuisance property.
(M) Damage assessments	Housing	**Federal** FEMA	Damage assessments from FEMA can set a baseline to track recovery.

Name	Category	Data Owner	Example or use case
(L) Blighted properties	Housing	**Local** Local government	Residents can see the status of properties and code enforcement inspections such as BlightStatus in New Orleans.
(L) Rental prices	Housing	**Private** Rental real estate companies	Rental prices often skyrocket after disaster, making it harder for lower income residents who lost their homes to return. Real estate rental companies like Zillow or Craigslist could publish more timely information about rental pricing so policymakers can address any problems quickly.
(L) Mortgage delinquency	Housing	**Private** Credit reporting companies	Mortgage delinquency rates usually increase due to people losing personal income. This data aggregated over time can show if people are at risk of losing their homes.
(M) Public housing status	Housing	**Federal/Local** HUD, local housing authorities	HUD publishes data on the location of public and subsidized housing. Managing an affordable housing crisis will mean keeping a close eye on availability of this housing if it was damaged in the disaster.
(H) Point of Distribution Sites	Health + Safety	**Local/Nonprofit** Local government, nonprofits, and volunteer organizations	Temporary point of distribution sites (PODs), organized by local officials and hosted in large parking lots, are the go-to resource for water, cleaning supplies, recovery paperwork assistance and more. Location, hours, and offerings of PODs would be useful to get accurate information out through multiple channels.
(H) Environmental test results	Health + Safety	**All** Federal, state, local agencies and private testers such as nonprofit environmental groups	Tesults of environmental testing (soil, air and water) from EPA, State and local government, and nonprofits open and available will help the public can improve public safety and awareness Ex. Kinder Institute's E.Coli Map

Name	Category	Data Owner	Example or use case
(H) Police data	Health + Safety	**Local** Local law enforcement, 911 dispatch center	Transparency in terms of crime reports, arrests and citations, police use of force, traffic stops, 911 calls for service and how long it takes fire, police and EMS to respond will help keep the order and build trust
(M) Donations and outcomes	Financial, Philanthropy	**Nonprofit** Nonprofits and volunteer organizations	Tracking donations to nonprofits and volunteer organizations (such as the Red Cross and United Way) and displaying what they are being spent on would be important to locals andto build confidence for would-be donors and volunteers. This transparency is an opportunity to explain the reality of overhead and the real costs of managing volunteers and donations.
(L) Contractor fraud	Financial, Business & Services	**Nonprofit/State** Better Business Bureau, state licensing agencies	To protect citizens from scam artists, the Better Business Bureau or the State agency responsible for contractor licensing can make complaints about contractor fraud so that residents don't get scammed.
(M) Federal rebuilding money	Financial	**Federal** Various federal agencies (HUD, Army Corps, EPA, HHS, etc)	Federal rebuilding money is difficult to track because it typically goes through the state, and then is administered through various programs. Each program should publish up-to-date data on how much money has been allocated, received and spent and what the outcomes are. Ex: After Katrina, rumors about federal spending were rampant
(L) Insurance claims	Financial	**Federal/Private** FEMA, private insurance companies, NFIP	Insurance claims and how much was paid out from programs such as the National Flood Insurance Program and Small Business Administration loans and private insurance companies give a sense for how much unmet need there is and what neighborhoods might be bearing larger burdens in the recovery.

Name	Category	Data Owner	Example or use case
(M) School locations & status for private and public	Businesses + Services	**State/Regional/Local/ Private** State Dept of Education or local school districts, organizations of private schools	The status of open schools can get very complex as grade levels split across campuses or schools combinining at one location for day and evening shifts. Private school data is also diifcult to track since they are decentralized.
(M) Business location and type	Businesses + Services	**State/Regional/Local** State business licensing, or local sales tax revenue database	State business license data can serve as a base for residents to report which hardware stores, pharmacies, grocery stores, gas stations and other vital businesses are open for business.
(L) Special licensing for facilities	Businesses + Services	**State/Regional/Local** State and local licensing agencies	Location and attributes of licensed facilities such as childcare centers, health facilities, restaurants etc. would be useful to show new facilities the have opened since the disaster.
(H) Credit card swipe data	Businesses + Services	**Private** Credit card companies (MasterCard, Visa, AmEx, Square, etc)	Credit card companies could release nightly data on businesses swiping credit cards in the previous day to track which stores are open

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