Evaluation of Local Government Performance after Disasters

Milad Baghersad
Florida Atlantic University
mbaghersad@fau.edu

Christopher W. Zobel
Virginia Tech
czobel@vt.edu

Ravi Behara
Florida Atlantic University
rbehara@fau.edu

ABSTRACT

Monitoring and evaluation can help organizations involved in disasters learn from their responses to prior events and improve their performance over time. Using a data set of non-emergency service requests in New York City (NYC), this paper provides a method to evaluate and compare the performance of local governments in terms of service request response times after different disaster events. In particular, the proposed method can be used to compare such performance across divisions or boroughs in a city. To illustrate this, we evaluate the performance in five of NYC's boroughs: the Bronx, Brooklyn, Manhattan, Queens, and Staten Island, across seven major natural disaster events from 2010 to 2012. Our analyses show that Queens and Brooklyn demonstrate better performance than the other boroughs in almost all of the seven events under consideration.

Keywords

311 Services, Disaster, Municipal Departments, Resilience.

INTRODUCTION

Local governments provide services that are essential for the normal functioning of societies. Maintaining traffic signal systems, road conditions, and water systems are a few examples of such services. Natural disasters, such as hurricanes and storms, can significantly impact the volume and delivery of public services provided by municipalities. For example, in the aftermath of Hurricane Sandy, the New York City (NYC) Fire Department removed more than 2000 damaged trees from the city (Mcshane 2017). The hurricane also significantly impacted streets in the city, destroying about 3500 traffic lights and leaving behind 700 thousand tons of debris (Mcshane 2017) that the NYC Department of Sanitation then had to scramble to clean up. With the help of the United States Army Corps of Engineers, the cleanup process in NYC extended to all hours of the day and involved hundreds of trucks, river barges and tugboats (Lipton & Semple 2012). It can take months for some municipalities to resume their normal level of services. For example, debris removal after hurricane Irma took more than three months for cities in South Florida (Swisher 2017).

As natural disasters are expected to grow in size and number, local governments should be prepared to face and learn from such events. Monitoring and evaluation of performance, in such situations, is an essential step to learn from past experiences and improve future responses to disasters. In this study, we propose a new metric to evaluate performance of municipalities in providing public services after disasters, based on 311 service center requests.

Many communities across the United States and Canada, including NYC, Boston, Houston, Los Angeles, Miami, and Toronto, have so-called 311 information systems in place that allow their citizens to make official requests for non-emergency municipal services, such as fixing a broken street light or repairing a leaking fire hydrant. Similar to 911 systems that are used to report emergencies, these 311 systems provide a single point of contact through which all different types of relevant services may be requested from the city. Access to this functionality is typically provided through a variety of different methods, such as an easy-to-remember phone number (311), a smartphone app, text messaging, and a website, 24 hours a day, 7 days a week, and 365 days a year. In this study, we focus on 311 service requests received by NYC since NYC has experienced several disaster events during the past decades. The proposed metric can be used to evaluate and compare the performance of different boroughs across NYC and with respect to different events.

In the following sections, we first briefly summarize the related literature. Next, we introduce our dataset: service requests received by the NYC 311 service center from June 2009 to July 2013. We then calculate the response time for the different service requests and provide our new metric: degrees of response time elevation. We use the proposed metric to compare the performance of NYC municipalities across seven major events. Finally, we provide a summary of findings and discuss future research directions.

LITERATURE REVIEW

Monitoring and evaluation is a quality improvement process which can be used by organizations involved in a disaster response to track, measure, and improve performance (Gossip, Gouda, Lee, *et al.* 2017). The process helps organizations learn from prior responses to disasters through identifying their weaknesses and strengths. However, extant research shows that organizations do not always learn their lessons from past disasters (Gossip, Gouda, Lee, *et al.* 2017; Savoia, Agboola & Biddinger 2012). For example, Savoia et. al (2012) observed that the same types of problems, such as confusion in roles and responsibilities, consistently occur during public health responses to different types of incidents. One potential obstacle in the process of learning from prior disasters is the challenge of designing a metric that can be used to evaluate and compare the performance of an organization across different events. Our study takes on this challenge by proposing a new metric to evaluate the performance of municipalities using service request response times, as calculated from the 311 data.

Due to the availability and large volume of 311 data, many researchers have used this valuable resource to study the engagement and experience of citizens, and the performance of local governments over the past few years. For example, Chatfield and Reddick (2018) used 311 data from Houston to study the relationship between customer agility and public value creation. They observed that simply adapting information technology platforms is not enough to create customer agility capabilities. O'Brien et al. (2016) used a sample of 311 users from Boston to study motivations of constituents to participate in coproduction of public services. Hartmann et. al (2017) studied 311 data of three big metropolitan areas and concluded that delivery of government services has improved in recent years after the development of such systems.

Although most of the available research on 311 data considers local governments' day-to-day operations, a few researchers have also studied the performance of local governments during disasters. Zobel et. al (2017 and 2018), for example, considered the number of service requests made during several major events in NYC and developed a metric to compare the relative performance of different departments in NYC. Zobel and Baghersad (2020) used a similar dataset to evaluate the relative resilience of the New York metropolitan area to different natural disasters across multiple dimensions. In this paper, we use the response time associated with each service request to evaluate the performance of local governments after different disasters. We believe that the response time of service requests provides a better overview of performance of local government in fulfilling their residents' requests. To the best of our knowledge, it is the first time that the response time of service requests is used to evaluate and compare the performance of local governments after disasters.

DATASET

New York City, which was one of the first metropolitan areas to establish a 311 system (NYC311), makes all of its 311 data available through the NYC Open Data initiative (https://opendata.cityofnewyork.us/). This system received over 120 million service requests between 2003 and 2012, and each unique service request in the dataset consists of attributes such as created date and closed date of the service request, the name of the agency and the borough that the service request is related to, and the type of service/complaint (see Table 1 for a description and example of some of the most important attributes).

Table 1. Most important attributes of NYC 311 service requests

Attribute name	Description	Example
Unique Key	Unique identifier of the service request	15661795
Created Date	Date and time the service was requested	2010-01-05 13:12:53
Closed Date	Date and time the service was closed	2010-01-06 11:40:00
Agency Name	Specific agency name	Department of Transportation
Complaint Type	Category of complaint type	Street Condition
Borough	Borough of incident location	BRONX
Latitude	Latitude of incident location	40.827739999999999
Longitude	Longitude of incident location	-73.850049999999996

As the basis for the analysis below, we downloaded all 311 service requests made in NYC between June 2009 and June 2013. Table 2 shows the top 20 complaint types, and their respective agencies, for these requests. Since not all of these complaint types are necessarily correlated with disaster events, we chose to further consider only service requests related to the *Damaged Tree* complaint type. Damaged Tree complaint type is between top 20 complaint types and our initial analyses showed that it is one of the service requests most effected by disaster events. We then removed service requests without a closed date, without a geo location id, or with a created date greater than the closed date. This reduced the total number of service requests in our data set to 107638. Finally, in order to focus on the performance during and after disaster events, we selected seven different major natural hazards that impacted NYC between 2010 to 2012 (Table 3).

Table 2. Top 20 complaint types and their respective agencies

Complaint type	Agency
Heating	Department of Housing Preservation and Development
General Construction	Department of Housing Preservation and Development
Plumbing	Department of Housing Preservation and Development
Noise - Residential	New York City Police Department
Paint - Plaster	Department of Housing Preservation and Development
Street Condition	Department of Transportation
Nonconst	Department of Housing Preservation and Development
Street Light Condition	Department of Transportation
Water System	Department of Environmental Protection
Blocked Driveway	New York City Police Department
Sewer	Department of Environmental Protection
Electric	Department of Housing Preservation and Development
Damaged Tree	Department of Parks and Recreation
General Construction/Plumbing	Department of Buildings
Dirty Conditions	Department of Sanitation
Noise	Department of Environmental Protection
Building/Use	Department of Buildings
Traffic Signal Condition	Department of Transportation
Illegal Parking	New York City Police Department
Sanitation Condition	Department of Sanitation

Table 3. The seven disaster events

Event	Date of Event
2010 Nor'Easter	13-14 Mar. 2010
Brooklyn / Queens tornadoes	16 Sep. 2011
N. American Blizzard	25-27 Dec. 2010
Hurricane Irene	28 Aug. 2011
Major Snowstorm	31 Oct. 2011
Hurricane Sandy	29 Oct. 2012
2012 Nor'Easter	7 Nov. 2012

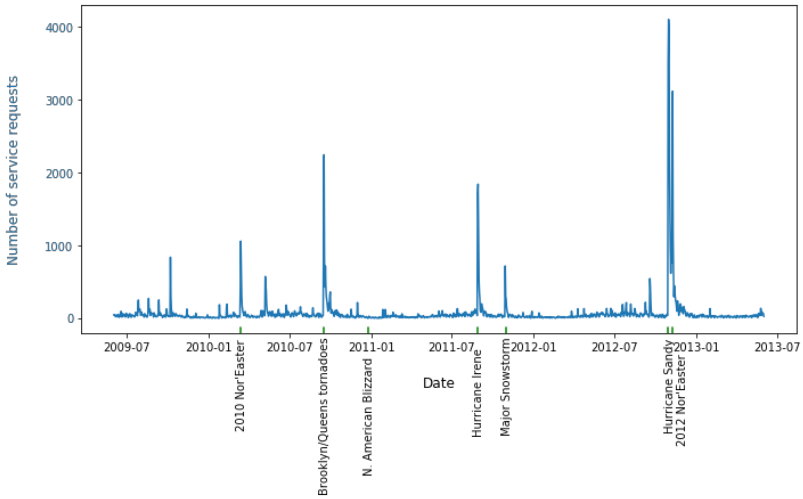

Figure 1. Number of Damaged Tree service requests over time

Figure 1 illustrates the number of *Damaged Tree* service requests received each day, for the time period over which we collected our data, along with the dates of the seven distinct disaster events. It is easy to see that the number of *Damaged Tree* service requests was higher than normal during each of these events, with the sole exception of the North American Blizzard of late 2010.

ANALYSIS

In order to analyze the service response performance of municipalities during and after each of the disaster events, we first calculate response time as follows:

$$\text{Response time} = \text{service request closed date} - \text{service request created date} \quad (1)$$

This variable, which is measured in days, shows how responsive municipalities are in fulfilling the requested service. The average *Damaged Tree* response time across the entire data set is 50 days (see Table 4). Although the third quartile is 15 days, the maximum response time is 1978 days, which shows that the response time distribution is highly skewed to the right. We therefore removed any response time greater than 365 days in order to account for outliers. Figure 2 shows the resulting distribution of *Damaged Tree* response times.

Table 4. Summary of Damaged Tree response times

Count	Mean	Std	Min	Quartile 1	Quartile 2	Quartile 3	Max
107580	50	160.83	0	1	5	15	1978

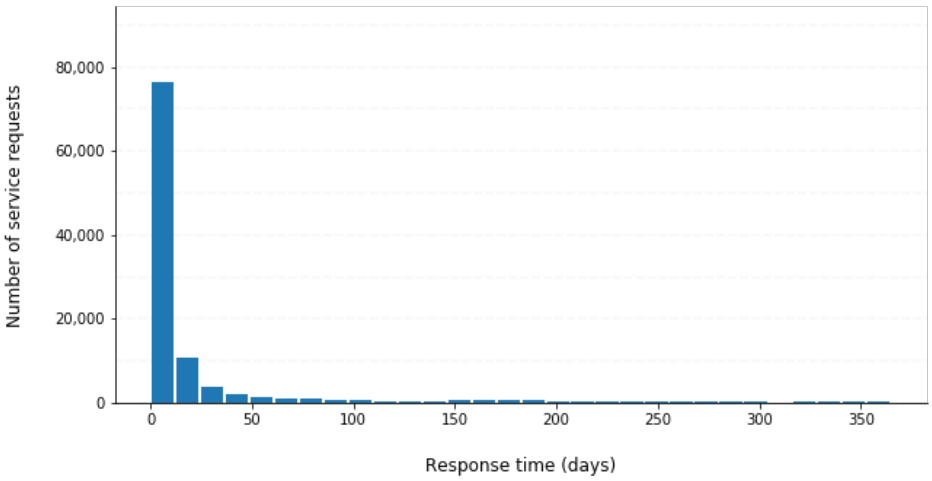

Figure 2. Distribution of Damaged Tree response time after removing response times greater than 365

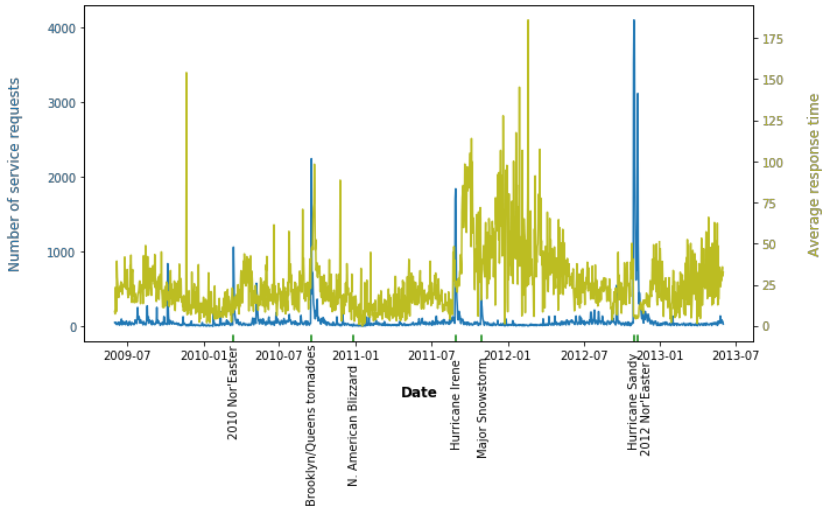

Figure 3. Number of Damaged Tree service requests and average response time per day over time

In addition to the response time per request, we also calculated the average response time per day. Figure 3 provides both the number of service requests per day and average response time per day, over time. This clearly shows that, relative to the other events, the average *Damaged Tree* response time decreased significantly after Hurricane Sandy, perhaps due to the extensive help received from the federal government after Sandy. Figure 3 also shows that the response time after Brooklyn/Queens tornadoes was significantly higher than normal. It is also interesting to note that average response time surges lag the event. This is expected since services are usually suspended during the event. The Brooklyn/Queens tornadoes is an exception, as it is a short duration event, so the surge occurs immediately after the event.

To compare the overall performance across the seven events, we calculated the average number of service requests per day and the average response time per request for a period of 29 days, from one week before to three weeks after each event, using formulas 2 and 3, accordingly:

Average number of service requests per day = total number of service requests during the 29 days / 29 (2)

Average response time per request = sum of response times during the 29 days / total number of service requests (3)

Figure 4 subsequently provides the average number of service requests per day together with the average response time for each of the seven events. This shows that although NYC received a higher number of *Damaged Tree* service requests during Hurricane Sandy and the 2012 Nor'easter, the average response times during these events were significantly lower than the response times during the Major Snowstorm of 2011, Hurricane Irene, and the Brooklyn/Queens tornadoes.

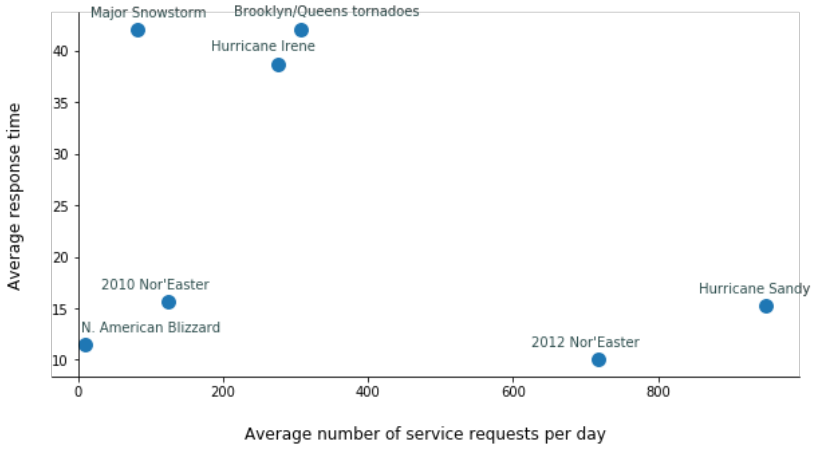

Figure 4. Average number of service requests and average service time for the seven events

It is important to note that although Figure 4 provides a summary of the performance associated with different events, it does not provide a direct comparison between them, which can be problematic. For example, the average response time associated with Hurricane Sandy is slightly higher than the average response time during and after the North American Blizzard. However, considering the higher number of service requests during Hurricane Sandy, we can conclude that the performance during Hurricane Sandy was better than that during the Blizzard, keeping in mind both the volume of service requests and the response time.

To deal with this issue, we propose to compare the different results based on a new measure: the slope of the straight line from the origin to each event-specific point in Figure 4. The slope is calculated based on the average response time divided by the average number of service requests per day. Therefore, slope is a proxy for responsiveness of a municipality in fulfilling its residents service requests. A lower value of the slope means a lower response time when the number of service requests is fixed, or in other words a higher responsiveness. In support of this, Table 5 summarizes the average number of service requests per day, the average response time, and the calculated slope for each event. Since the slope can achieve any positive value in this context, we converted the slope amounts into degrees of elevation from the horizontal axis: degrees = $\tan^{-1}$(slope). Because both the average number of service requests per day and the average response time are positive, degrees can take on any value from 0 to 90, where 0 represents the ideal performance.

Based on Table 5, the performance of NYC municipalities during the 2012 Nor'Easter and Hurricane Sandy was better than the performance during other events. The worst instances of performance are related to the North American Blizzard and the Major Snowstorm. This is particularly interesting since we did not observe a significant increase in the number of service requests during the North American Blizzard.

Table 5. Summary of performance measures during the seven events

	Average number of service requests per day	Average response time	Slope	Degrees
2010 Nor'Easter	123.86	15.65	0.13	7.20
Brooklyn/Queens tornadoes	306.45	42.10	0.14	7.82
N. American Blizzard	9.82	11.46	1.17	49.41
Hurricane Irene	276.07	38.69	0.14	7.98
Major Snowstorm	80.93	42.05	0.52	27.46
Hurricane Sandy	947.90	15.27	0.02	0.92
2012 Nor'Easter	717.45	10.02	0.01	0.80

Comparing Performance of Different Boroughs

NYC consists of five county-level administrative divisions, known as boroughs: the Bronx, Brooklyn, Manhattan, Queens, and Staten Island. We can also extend our analysis to compare the service performance across these five boroughs. To this end, we first calculated the average number of service requests and the average response time for each borough, using formulas 2 and 3. Figure 5 shows the combined results for each borough and each event, and it provides several interesting observations. In order to compare the performances across the boroughs and events, we used the K-Means clustering method to divide the performances into six clusters. The clusters are shown with dashed rectangles in Figure 5. Cluster 3 (c3), which includes the performance of Queens in Hurricane Sandy and also in the 2012 Nor'Easter, shows the best performances. The worst performance belongs to cluster 6 (c6), which includes Manhattan's performance in Hurricane Irene, the Major Snowstorm, and the Brooklyn/Queens tornadoes, and Queens' performance in the Major Snowstorm.

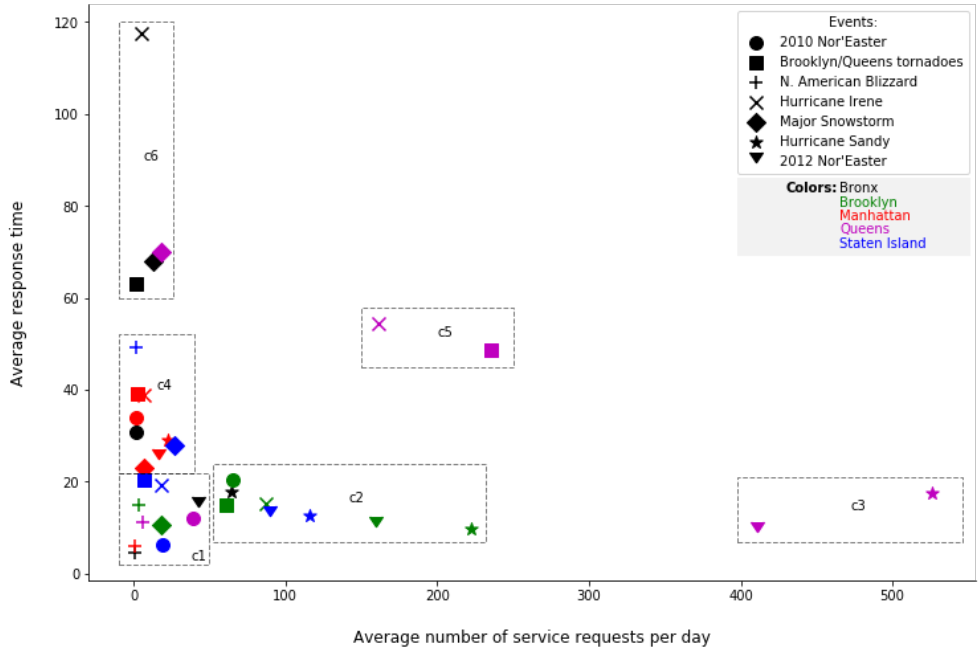

Figure 5. Average number of service requests and average service time for each borough and each event

We also calculated the degrees of elevation for each event in each borough. Table 6 gives the results of this, where the best and the worst results for each disaster event are highlighted in green and red, respectively. As can be clearly seen, the performance is best in Queens and Brooklyn, and it is worst in the Bronx and in Manhattan in three out of seven events each.

Table 6. Performance of boroughs based on the degrees of elevation

	Bronx	Brooklyn	Manhattan	Queens	Staten Island
2010 Nor'Easter	86.28	17.42	87.15	17.13	18.39
Brooklyn/Queens tornadoes	88.18	13.69	86.07	11.67	71.4
N. American Blizzard	75.83	76.82	79.7	61.16	88.5
Hurricane Irene	87.54	10.01	79.83	18.62	46.92
Major Snowstorm	79.15	30.49	72.75	75.21	45.9
Hurricane Sandy	15.43	2.49	52	1.92	6.24
2012 Nor'Easter	19.13	3.76	56.71	1.27	8.01

CONCLUSIONS AND FUTURE WORK

Local governments are responsible for providing public services that are essential for the normal functioning of societies. Natural disasters may significantly increase demand for these public services. Local governments should be prepared to continue delivery of such services even in case of natural disasters, and the monitoring and evaluation process can help governments to learn from prior disasters and improve their performance over time. This study developed a new method, based on the data available from 311 service centers, to evaluate the performance of municipalities during different disaster events. Using the NYC 311 dataset, we specifically assessed the performance of municipalities in NYC across seven different events between 2010 and 2012. Our results show that the NYC municipalities actually had better performance during Hurricane Sandy, although this event resulted in higher demand for public services compared to the other six events. We also evaluated the performance of individual NYC administrative divisions (boroughs) across the seven events. The results show that two of five boroughs in NYC had better performance than the other boroughs in almost all considered events.

Our preliminary work in this paper can be extended in a number of different ways. First, in this paper, we evaluated

the performance of boroughs without considering their available resources and budget. Although one borough may not have the best performance, its efficiency can be better than others considering its available resources and budget. Therefore, incorporating available resources and budget in evaluating performance can be one of the interesting future directions. Next, we measured the performance of municipalities based on response time. However, response time only shows one dimension of overall performance of municipalities. Other metrics of performance, such as quality of service, should also be considered alongside of the response time when evaluating overall performance of municipalities to disasters. Furthermore, in this study, we only considered response time related to Damaged Tree service request. It is possible that municipalities have different performance if we consider other complaint types correlated with disasters. Finally, different administrative divisions may have different organizational structures. Another interesting extension would be to evaluate the impact of organizational structure on performance of divisions.

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