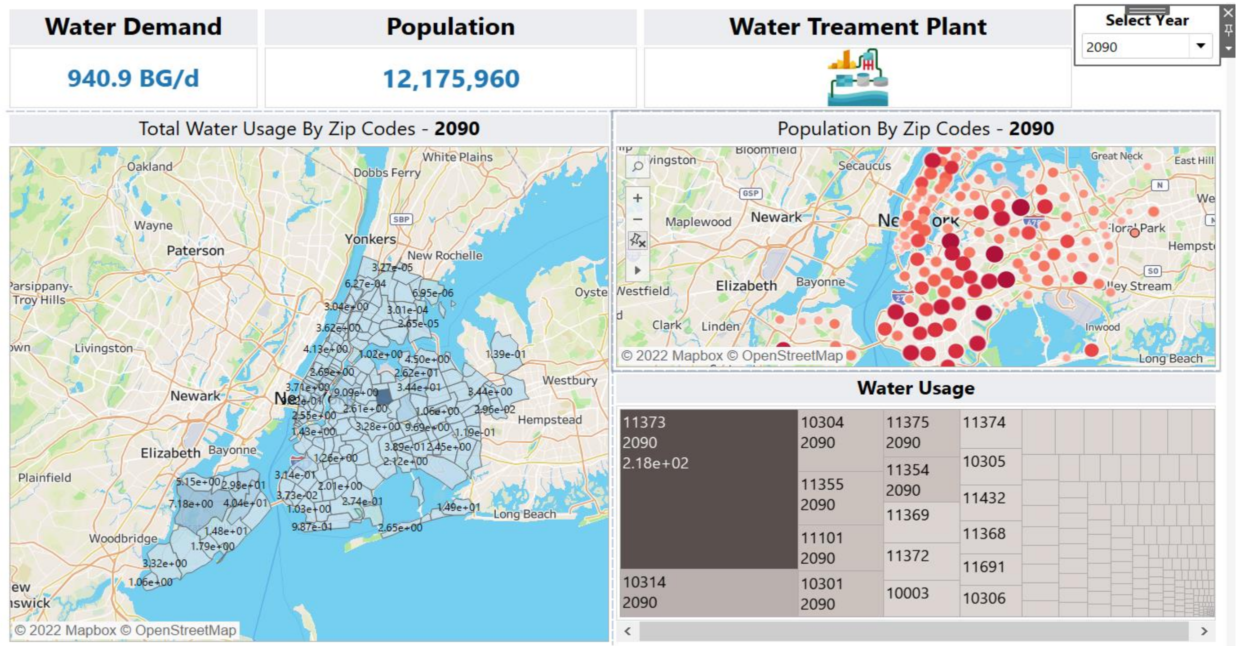
Visualizing Scenario from CUSP Capstone Project:

Hardening New York City's Interdependent Energy and Water/Wastewater Infrastructures Against Climate Change and Cyberattacks

Final project | wcl311 | CS-GY CUSP-GX 6006 6313 2022 Spring A



<u>Motivation and Current Scenario Description</u>

In New York City and around the world, extreme events like natural hazards and man-made disruptions have been causing havoc throughout many years. Electricity and water/wastewater infrastructure operations are interdependent, where water needs large amount of energy to move around from a reservoir to a water treatment plant and out into distribution system. This fact opens up high risk of structural breakdown whenever there is a disruption in the power sector and natural hazards like hurricanes, floods, and cyberattacks stress regional water and electricity infrastructures beyond their limits at an increasing rate and intensity [1]. Notable natural hazard is Hurricane Ida, where more than 7-inchs of downpour overwhelmed sewer systems and water systems, causing more than 57,000 power outages [2], at least 10 deaths and total damage of ~$95 billion [3]. There was also a cyberattack in Florida's water treatment plant in 2021, where unknown hackers breached into the system and attempted to raise the sodium hydroxide level by more than 100 folds, where it was used to control water acidity and is considered poisonous at high levels [4]. Our project aims to study water/wastewater and electricity infrastructures in New York City, identify their vulnerability points, understand water-energy interdependencies, and analyze preventive or mitigation strategies against natural or man-made disasters.

Half-way through the project, before we make further scenarios that highlight mitigation strategies, the faculty mentor suggested a visualization scenario to show when New York City would need another water treatment plant added in order to meet the projected increase water demand in relation to the projected increase in population (in %), and also show water demand and population values on a map based on zip code.

Problems and Difficulties

1. Lack of Data

   Projected water demand/consumption per NYC zip codes was not quite available. We had access to daily water use per NYC zip codes for 2015, and that was what was mainly used to calculate our projection. This was a similar case for population, but there was thankfully projected increase in % in a research article as a table [5].

TABLE 1

Projected Total New York City Population by Borough, 2000–2030

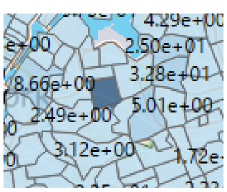
	2000	2010	2020	2030	CHANGE 2000–2010		2010–2020		2020–2030		2000–2030	
					Number	Percent	Number	Percent	Number	Percent	Number	Percent
NYC	8,008,278	8,402,213	8,692,564	9,119,811	393,935	4.9	290,351	3.5	427,247	4.9	1,111,533	13.9
Bronx	1,332,650	1,401,194	1,420,277	1,457,039	68,544	5.1	19,083	1.4	36,762	2.6	124,389	9.3
Brooklyn	2,465,326	2,566,836	2,628,211	2,718,967	101,510	4.1	61,375	2.4	90,756	3.5	253,641	10.3
Manhattan	1,537,195	1,662,701	1,729,530	1,826,547	125,506	8.2	66,829	4.0	97,017	5.6	289,352	18.8
Queens	2,229,379	2,279,674	2,396,949	2,565,352	50,295	2.3	117,275	5.1	168,403	7.0	335,973	15.1
Staten Island	443,728	491,808	517,597	551,906	48,080	10.8	25,789	5.2	34,309	6.6	108,178	24.4

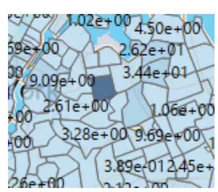
2. Projection Calculation and Extrapolation

   After discussing with the faculty mentor, we decided to calculate the approximate water demand accordingly with the increase in population % mentioned above. For example, the expected increase in population % from 2020-2030 is about 4.9%, so this would also apply to the water demand, multiplying 1.049 to the water demand value of 2020. Now, since projection in population was only available until 2030, we decided to keep the latest increase % value of 4.9% consistent throughout each of the upcoming 10 years. We figured this would be the most appropriate considering the lack of data, but not quite likely to be highly accurate.

3. Visualization in General

   What I mean by this is that the visualizations don't quite show the drastic change as time goes by, since water demand and population values are increasing at a constant value. There is different intensity of colors to show which location has the highest to lowest water demand or population per zip codes, but it was definitely a challenge to portray this drastic change in visualization. From the example below, we can observe that only the values change, and not quite in terms of color.



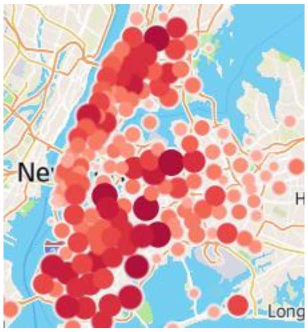


4. Portraying the Values

   Throughout using the Tableau, when I displayed water demand values in the map in a default setting, some values would be shown as 0.0, since some of the values are so small in size like 0.000311 because they are in billion-gallon (BG) unit. We decided to keep BG as our universal unit for any water measuring unit, so I had to go ahead and turn the values in scientific notation, to show that they all have their designated values.

Implementation

1. Geo Map

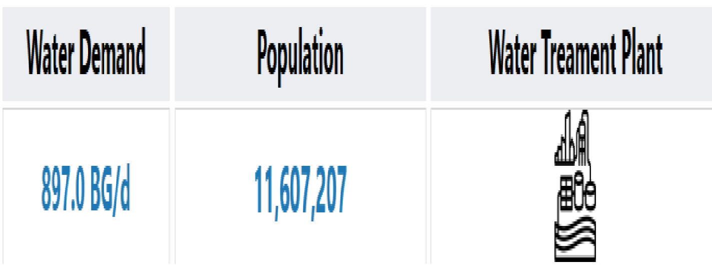


Algorithm: SUM (continuous)

Interaction: zoom, highlight (select, drag), portrays value when hovering with mouse

Framework: Tableau

2. Value Table/Image

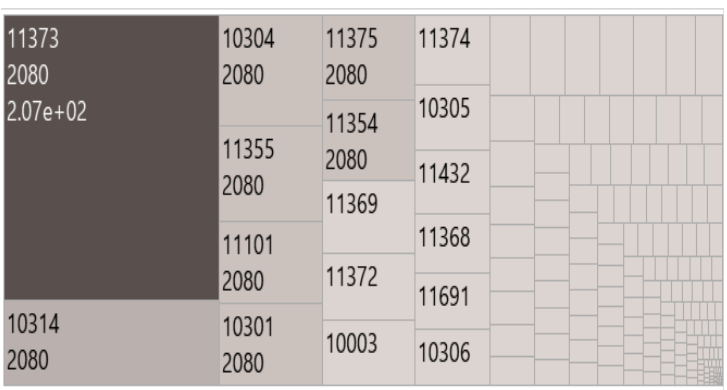


Algorithm: SUM (continuous)

Interaction: Hover to show **value** for water demand and population. Hover to show **Need**/**no need** for water treatment plant

Framework: Tableau

3. Tree Map



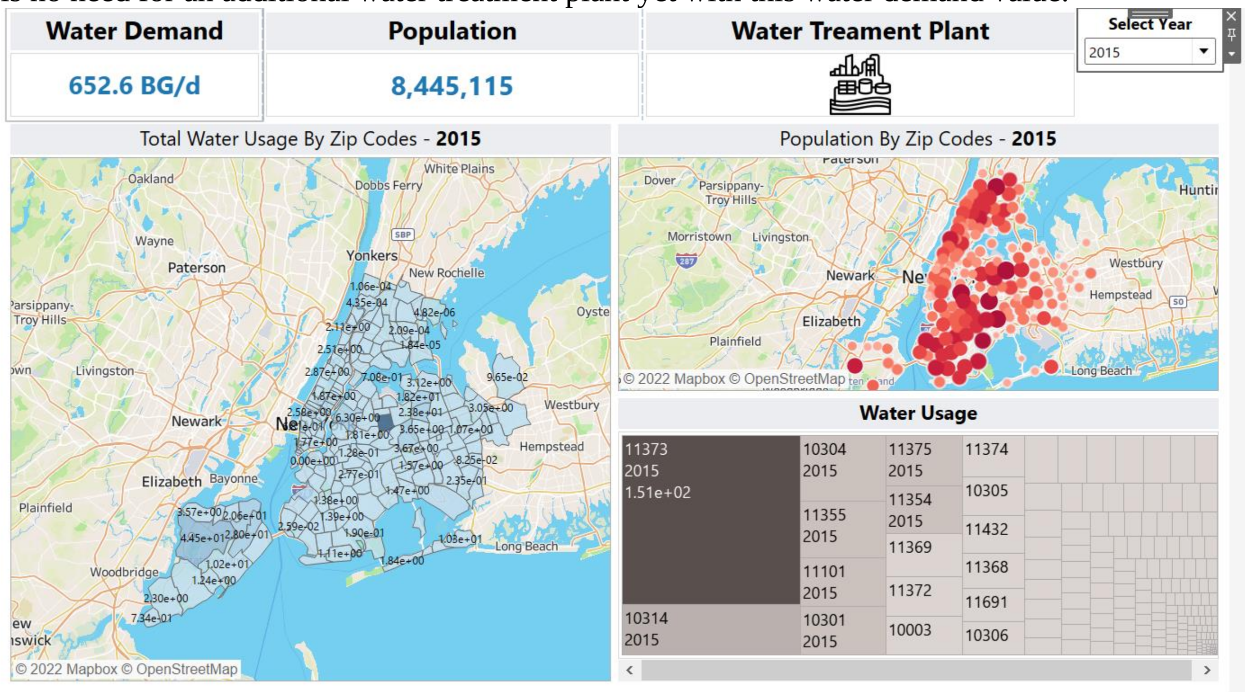
Algorithm: SUM (continuous)

Interaction: highlight (select, drag), portrays value when hovering with mouse

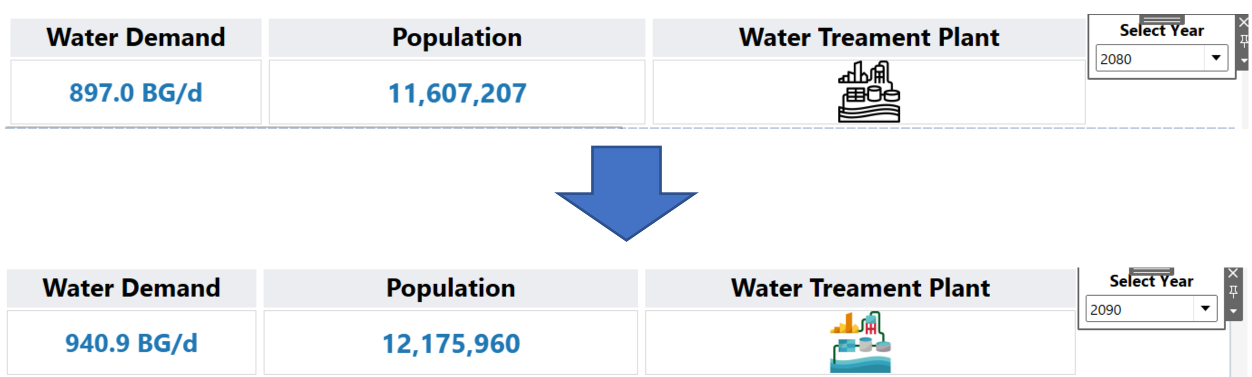
Framework: Tableau

Main Story of this Visualization

From the initial 2015, it is important to look at the water demand, which is 652.6 BG when there is population of 8,445,115. The water treatment plant image is in grey, which signifies that there is no need for an additional water treatment plant yet with this water demand value.



NYC has two water treatment plants, which filter up to 923.45 BG in a year based on our calculation, so as long as water demand is under this value, building another water treatment plant won't be necessary. We see here for 2080, the value is about 897 BG, and about 940 BG in 2090, which means that there should be a water treatment plant somewhere in between 2080-2090, and there should definitely be one at year 2090.



We can observe here that the water treatment plant image has lighted up, indicating the need for water treatment plant.

Work Cited

[1] S. Acharya, Y. Dvorkin and R. Karri, "Public Plug-in Electric Vehicles + Grid Data: Is a New Cyberattack Vector Viable?" IEEE Transactions on Smart Grid, vol. 11, no. 6, pp. 5099-5113, 2020.

[2] J. Jiménez and M. Levenson, "Ida Drenches New York and New Jersey," The New York Times,1 September 2021

[3] M. Puleo, "Death toll rises after 'most significant flash-flooding' in NYC history," AccuWeather, 2021.

[4] Jenni Bergal, "Florida Hack Exposes Danger to Water Systems", PEW, 10th March 2021

[5] M. Bloomberg and A. Burden, "New York City Population Projections by Age/Sex & Borough 2000-2030," NYC GOV, December 2006