COVID-19 and Urban Water Consumption

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This article examines the impacts of COVID-19 restrictions on water usage in California, using anonymized customer water consumption daily data from a mid-sized city in Northern California (City). Results suggest increases in residential use and reductions in non-residential use. However, from June 2020, daily usage became stable and similar to the 2018–2019 levels.

On January 11, 2020, China reported its first death from COVID-19, and on January 26, California reported its first case. On February 25, San Francisco Mayor London Breed announced a state of emergency, requiring city officials to step-up preparedness. As the numbers of positive COVID-19 cases rose and the first death occurred, on March 4, Gov. Gavin Newsom declared a state of emergency in California.

By mid-March, most of the schools and businesses in California were shut down. On March 19, Gov. Newsom announced a statewide order to shelter-in-place, which restricted all non-essential travel and activities outside of the home. After almost two months, on May 8, the state started the reopening process. However, as the number of cases began surging again by mid-July, the governor partially closed some businesses, such as bars, hair and nail salons, barbershops, and indoor dining. All counties with elevated rates of COVID-19 infections, hospitalizations, and deaths that were on the Department of Public Health County Data Monitoring list for three consecutive days were required to shut down certain industries and activities unless they could be modified to operate outdoors or through pick-up.

These measures have changed urban water consumption patterns. In this article, I explore changes in water usage during the COVID-19 pandemic by examining data from the City from January 2018 to the end of July 2020. I investigated these changes by customer type, including single-family residential (SFR), multifamily residential (MFR), schools (SC), and commercial, industrial, and institutional (CII).

Understanding the impacts of COVID-19 on urban water consumption using disaggregated high-frequency data is beneficial for water managers and policymakers. First, it offers insights on how COVID-19 impacted the water bills of residents, especially for disadvantaged communities, as well as the revenue and finances of water agencies. In addition, measuring real-time changes in sectoral water consumption during COVID-19 can provide timely information on local short-run economic activities—compared to traditional indicators of economic activities that are available with substantial lags at the national and state levels.

Examples of proxies on short-run economic activities include when significant drops in CII water consumption occurred after the lockdowns, how quickly it returned to normal levels after the start of the reopening, how people responded to the stay-at-home orders, and what the heterogeneities are in the response by community characteristics (e.g., by income, education, etc.).

Data and Methods

I analyzed anonymized daily water usage from customers of the City. The City's water agency is equipped with Advanced Metering Infrastructure (AMI), also known as smart meters, which provide real-time daily water usage data from January 2018 through the end of July 2020.

Summary statistics for the data used in this analysis are presented in Table 1. The City's water service area has more than 20,000 single-family residential accounts, constituting 85 percent of the total. The March–July water usage in the service area increased from 2,470 million gallons in 2019 to 3,050 million gallons in 2020 (roughly by 23%). The average water consumption for each account from March through July of the 2018–2019 baseline period was 768 gallons per day. This number increased to 918 gallons per day during the same period in 2020. The data show that, as one might expect, residential water use increased while non-residential use decreased.

The subsequent analysis estimates the changes in water consumption during the COVID-19 pandemic while considering several factors affecting consumption, including seasonality, fluctuations in weather, and account-specific factors. For

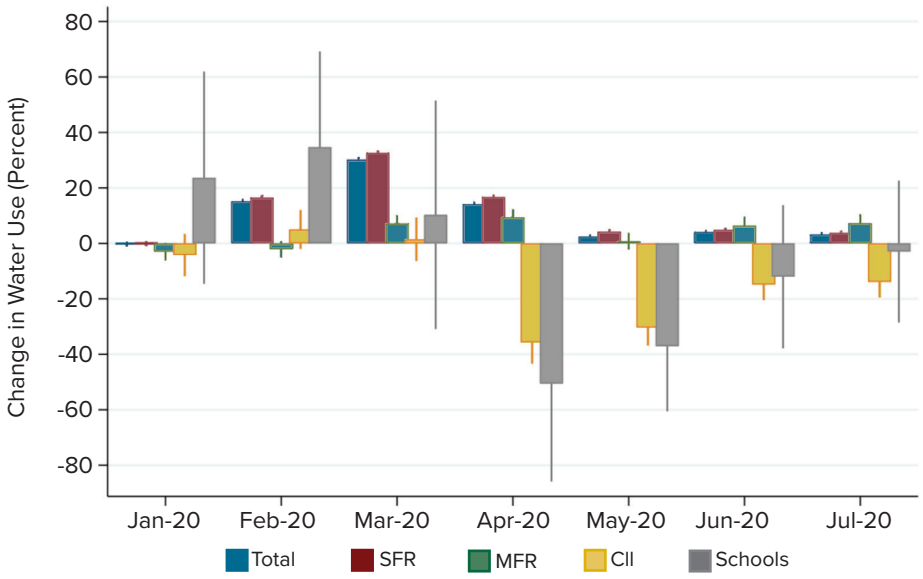
Table 1. Summary Statistics of Data Used in the Analysis

	Total	SFR	MFR	CII	Schools
Number of Accounts	24,408	20,693	1,322	1,152	50
Average Daily Water Use (gallons)					
March-July 2018 and 2019	767	487	777	4,460	12,440
March-July 2020	918	533	958	3,466	11,746
Percentage Change (%)	20	9	23	-22	-6

Source: Author's calculations

Note: * Percent change does not control for factors such as household characteristics and weather.

Figure 1. Estimated Monthly Impact of COVID-19 on Water Use by Sector in 2020



Notes: Lines associated with the boxes are the 95% confidence intervals clustered at the account level. Estimated impacts are according to the fixed-effects regression model with controls for calendar month, account-specific characteristics, and weather.

this regression analysis, I organized a panel dataset of customers' daily usage from January 2018 to July 2020 and controlled for the week of the year, day of the week, and account-specific characteristics (e.g., lot size, income). Using PRISM Climate Group data, I also controlled for weather variations (e.g., daily minimum and maximum temperature, and total daily precipitation). The analysis measured usage during a specific day/week and how it differed from the same day/week of prior years (2018–2019) while taking into account weather conditions.

Results

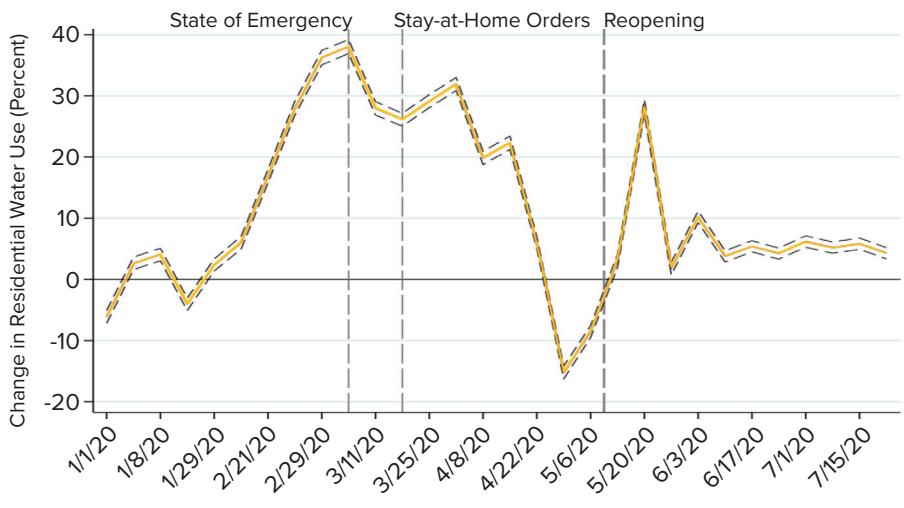
First, I estimated a fixed-effect regression model with an indicator for the dates after the shelter-in-place orders. The regression results indicate that after the shelter-in-place orders, total daily water consumption within the water service area, on average, increased by 10.79% from March to the end of July, compared to the same period in 2018–2019. As expected, breakdown by customer type showed that SFR and MFR sectors increased by an estimated 11.8% and 6.36%, respectively. Note that increases in the MFR sector could potentially be due to increases in indoor water use; however, increases in the SFR could be due to the rise in indoor use as well as outdoor use. I estimated, on average, reductions of 18.39% and 19.52%, respectively, in CII and schools.

I also explored monthly changes to measure how different restriction levels, including emergency orders, shelter-in-place, and the reopening affected consumption in different sectors. As expected, I did not observe any significant difference in water use in January 2020, compared with January 2018–2019 levels. I observed that total water use started to increase in February 2020, reached the peak in March, and continued to increase but in much smaller amounts in May, June, and July 2020 (Figure 1).

The residential (SFR and MFR) sector is the primary driver of the changes in total use. As indicated in Figure 1, residential use followed the same pattern as the total. CII and schools showed the largest reductions in use in April and May 2020. Note that even though households (SFR and MFR) were in some sense resuming normal activities, CII use remained down through June and July, indicating that economic activities are not fully restored.

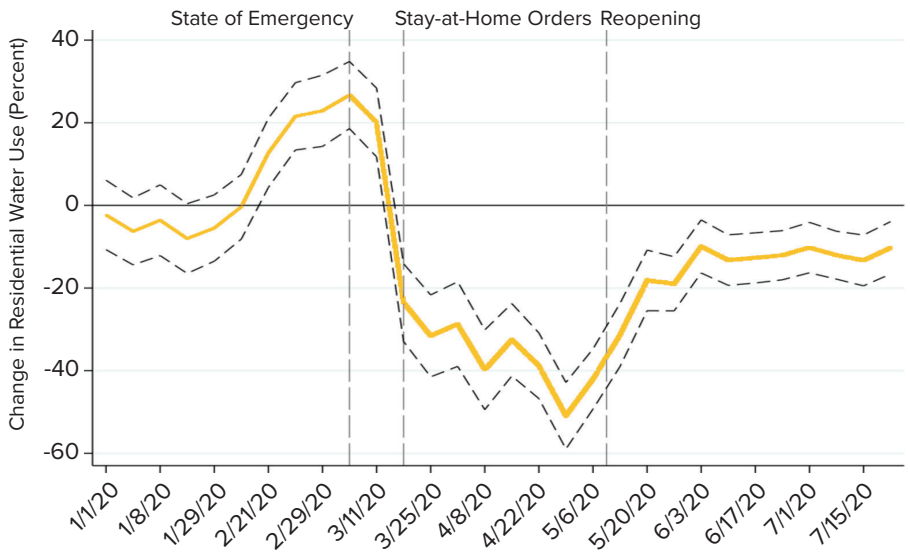
Next, I explored daily changes in use from January 2020 through July 2020, compared to the same levels in 2018–2019. Figure 2 shows the changes in daily water consumption (gallons per day) by sector for the beginning of January to the end of July in 2020, compared to the average in 2018 and 2019. Vertical dashed lines indicate the

Figure 2. Estimated Impact of COVID-19 on Residential Daily Water Use in 2020



Notes: Dashed black lines indicate the 95% confidence interval. The gold solid line is the estimated impact of COVID-19 on residential water use, according to the fixed-effects regression model, with controls for the week of the year, day of the week, household-specific characteristics, and weather.

Figure 3. Estimated Impact of COVID-19 CII and Schools' Daily Water Use in 2020



Notes: Dashed black lines indicate the 95% confidence intervals clustered at the account level.

The gold solid line is the estimated impact of COVID-19 on CII and schools water use according to the fixed-effects regression model, with controls for the week of the year, day of the week, account-specific characteristics, and weather.

emergency order by Gov. Newsom on March 4, the shelter-in-place orders on March 19, and the start of the reopening on May 8.

Figure 2 shows that residential use, compared to 2018–2019 levels, started to increase in early February and reached a peak increase in March 2020. Figure 2 also shows a rise in consumption immediately after the reopening in May. The residential use was stable during June and July, and similar to the 2018–2019 levels—a roughly 5% increase in use compared to June and July 2018–2019.

Figure 3 indicates the regression results for daily water use change in 2020, compared to 2018–2019 levels. Similar to the residential sector, we observe an increase in use by CII and schools in February. The use starts to decline after the emergency orders and reaches the largest reductions in late March and during April. Usage began to return to normal levels after the reopening in May.

The observed changes early on during the pandemic were due to people staying at home and, as a result, using more water for indoor (e.g., personal hygiene, cooking) and outdoor (e.g., gardening) purposes. Also, most businesses were closed (e.g., restaurants, bars), which resulted in less water use by CII and schools. The data indicate that usage became stable in June and July. Residential use is still slightly higher than the 2018–2019 levels (5% higher), but CII and schools are lower than the 2018–2019 levels (10% lower). The net effect of COVID-19 on total water use, in this case, was positive, but other districts' use depends on the restriction levels and mix of the accounts (number of residential and non-residential).

Since the pandemic's extent and duration are still uncertain, analyzing real-time changes in water use is valuable for the water agencies, water managers, and policymakers. To summarize, our findings indicate that residential water use has increased while non-residential use has decreased. These changes were particularly large during the early months (March-May) of the pandemic and are slowly returning to the pre-pandemic levels.

The large increases in residential water use have likely increased customers' water bills, at a time when many are also experiencing economic hardships such as job loss. Understanding the changes in water bills due to COVID-19 are especially crucial for districts with the tiered or budget-based rate structure (i.e., customers pay higher rates for these additional units of consumption) and those with a high proportion of low-income customers. Currently, Gov. Newsom's executive order protects homes from water shutoffs, but this could be problematic later on.

This study finds that the effect of COVID-19 on total water use is positive for this specific water agency. However, the net impact of COVID-19 on water use for other water districts depends on the relative proportion of residential and non-residential accounts. Regardless of the net effect, these massive consumption changes could affect water agencies' operational conditions, revenue, and finances. Besides, changes in water use have important implications for wastewater agencies. Some water and wastewater agencies are facing higher operating costs (e.g., additional training and supplies) and loss of revenue that could put further pressure on the agencies.

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