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Impacts of Covid-19 on Water Consumption and Reservoirs: A Case Study in Ankara, Turkey

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Abstract

Monthly water reservoir levels and water consumption in Ankara, as well as the effects of Covid-19 on the water environment, were analysed in this study. Changes in reservoir levels were more steady in Camlidere and more responsive to rainfall and water usage in Kurtbogazi, which might be explained by different reservoir capacities and areas. Even if the population growth rate decreased in 2020, water consumption in March, April, May, and June was higher than it was from 2016 to 2019, most likely as a result of national guidance and regulations related to the Covid-19, with an emphasis on handwashing and other public health measures. Given the pressures on water systems arising under climate change or through further pandemics, it is critical to have publicly accessible real-time water data and to analyse them on a regular basis. This will help in the early detection of any stress on water resources and assist authorities in developing sustainable management plans.

Keywords: Ankara, Covid-19, Reservoir Levels, Water Consumption, Water Resources.

1. Introduction

The World Health Organization (WHO) stated that the accessibility of drinking water is a principal condition for individuals' well-being. Unsafe water has been associated with epidemics since ancient times. During the Covid-19 pandemic, WHO stated that drinking water, given the lack of evidence for the survival of Covid-19 in the water environment, is an important factor in improving hygiene and limiting the spread of the Covid-19 virus, for instance by frequent hand washing (Balacco et al., 2020; WHO, 2020). However, as the accessibility of water in developing and under-developed countries is limited (even in some regions with limited access to drinking water), these regions have already been under the threat of the fast spread of Covid-19. It is hard to mitigate and control Covid-19 in highly populated areas (Sivakumar, 2011, 2021).

In addition, the impacts of climate change on precipitation and increasing water demand have increased the risk of water scarcity all over the world, and it has become one of the most critical problems in the 21st century (Locosselli et al., 2020).

Freshwater availability is a fundamental precondition for human survival and nations' economic developments (Gao et al., 2019). Water resource scarcity affects many parts of the world. It is expected to be more severe due to increasing population, industrialisation, dependence on irrigation, lack of infrastructure and high variability of precipitation and discharge (Shu et al., 2020). It is very important to regularly monitor water levels and the storage capacities of dams, lakes, and rivers for the effective use of water resources (Thakur et al., 2020). Changes in water levels in dams and lakes reflect the impacts of human activities and climate change on regional water recourses accurately, which is vital for the effective management of water resources and a better understanding of the impacts of climate change on various economic and social sectors (Shu et al., 2020; Ye et al., 2017).

Based on five different global temperature datasets, it was expected that 2020 would be one of the three warmest years on record, and the average temperature would increase by 1.2°C compared to the 1850-1900 baseline (WMO, 2020). In 2020, the third-warmest year since 1971, the average temperature (14.9 °C) was above the average of 1981-2010 (13.5 °C). In addition, in Turkey, monthly precipitation in 2020 was above the normal of February, March, April, May and June and was below the normal of other months (TSMS, 2021b).

In terms of drought assessment in Ankara, while the average severity of drought events increases during extreme droughts, mild drought episodes are predicted to have a longer duration and milder average severity, implying that projection scenarios may face more significant precipitation shortages than the reference period (Afshar et al., 2020). Mehr and Vaheddoost, (2020) indicated that Ankara experienced five severe drought periods between 1971 and 2016 and suggested a minor declining tendency in the reported drought episodes when the SPEI was used (not in SPI)

A combination of factors contributing to some changes in daily domestic water consumption patterns will give a better understanding of how water consumption and the Covid-19 pandemic are related. In other studies, home water usage (from randomly selected 2,000 USA homes with

"smart meters") increased by %21 from Feb 1 to April 30, 2020, and changes in work patterns resulted in a delayed morning water consumption from 7 am to 9 am (TechRepublic, 2020). Similarly, in Germany, daily water consumption was %14.3 higher during the first lockdown in 2020 than in previous years.

Additionally, there were changes in demand patterns with a time shift for the morning peaks and higher evening demands (Lüdtke et al., 2021). Similar to this study, when looking at Istanbul water reservoirs levels, it was found that the years of 2007, 2008, 2014, and 2020 were the driest and that monthly reservoir levels in 2011, 2013, 2019, and 2020 did not increase again throughout the year after the decrease starting from the spring months. Additionally, the recovery of Istanbul water reservoir levels at the beginning of the year was delayed for up to two months (Yilmaz et al., 2020).

The Covid-19 Pandemic's influence on two major water reservoirs supplying drinking water to the city centre and on water use in Ankara, Turkey, is discussed in this study. Additionally, the paper examines temporal analyses of reservoir levels and their relationship to water usage.

2. Study Area, Data and Methodology

2.1 Data

Water reservoir levels (%) and water consumption (m^3) data were obtained from Ankara Water and Sewerage Administration (ASKI). Sector-wise water consumption data were not available for the city of Ankara. In this study, two different water reservoirs, named Camlidere and Kurtbogazi, were selected due to restricted data access. Both reservoirs are used actively to supply fresh water to Ankara's city centre and are in the north part of the city (Figure 1).

Figure 1. The locations of water reservoirs, Camlidere and Kurtbogazi.

The total capacity of Kurtbogazi and Camlidere reservoirs is 92.053.000 m^3 and 1.220.380.000 m^3, respectively. Detailed information regarding reservoirs was given in Table 1. Both reservoirs were constructed in the mid-late 20th century with the aim of supplying drinking water and agricultural uses.

2.2 Data Analyses

Data sets were reproduced using Microsoft Excel and Python to see the observed temperature and rainfall changes in Ankara. Water reservoir levels and water consumption values were analysed seasonally, monthly, and yearly, and data sets were visualised. Matplotlib is a Python plotting library generating and customising various types of plots as a way of visualisation. Seaborn is a plotting package that builds on top of the Matplotlib library. To visualise water consumption data, the Seaborn plotting package has been used (Waskom, 2021).

3. Results and Discussion

According to TSMS, (2021a), long-term total precipitation in Ankara from 1926 to 2020 is 393.2 mm. It is seen that most rainfall throughout the province occurred between October and March (Figure 2). June to September was much drier. This situation indicates the periods when the reservoir levels are likely to increase with intense rainfall. In addition, it is seen that the average temperature is 22 °C in summer and varies between 0 °C and 3 °C in winter.

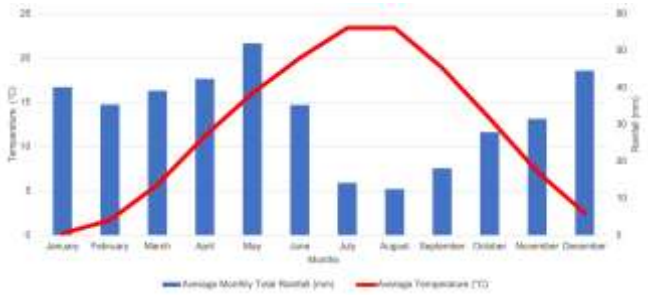

Figure 2. Average monthly total rainfall (mm) and temperature (°C) in Ankara from 1926-2020.

When looking at the average temperature and precipitation of the last two years (2019 and 2020) (Figure 3), the highest temperature in the summer of 2020 was a period with little or no rainfall, and the absence of precipitation in July and August 2020 was notable. It is observed that the precipitation was low in 2020 compared to the previous year and the long-term trends (Figure 2), but there was a substantial increase in February (NOAA, 2021).

Figure 3. Monthly total rainfall (mm) and temperature (°C) in 2019 and 2020.

3.1 Monthly Reservoir Levels

Ankara's monthly water reservoir levels from 2000 were shown in Figure 4 and Figure 5. It is noted that while reservoir levels reach the highest level in winter and spring, the lowest level is observed in the summer with increased consumption and lower rainfall. Changes in reservoir levels were more stable in Camlidere, and more sensitive to rainfall and water consumption in Kurtbogazi, which might be the result of different reservoir capacities and areas. While the area of Camlidere reservoir is 3.524 ha, Kurtbogazi reservoir is 812 ha. It is observed that the years of 2007, 2008, 2009, 2017, 2018 and 2019 were relatively dry, and reservoir levels

decreased to the lowest levels in records, especially in 2007, 2008 and 2009.

Table 1. Water reservoirs in Ankara.

Reservoir	Total Capacity (m^3)	Current Capacity (m^3) as of 13 May	Live Capacity (%)	Distance to Drinking Water Treatment Plant (km)	Construction Time
Camlidere	1.220.380.000	364.840.000	29.90	59.6	1976-1985
Kurtbogazi	92.053.000	51.739.000	56.21	47	1963-1967

Table 2. Percentage of the live reservoir capacities in Ankara..

Reservoir	Capacity (million m^3)	Oct 2020	Nov 2020	Dec 2020	Min Dec	Year of Min	Dec 2019	Diff 2020-2019
Camlidere	1.220	23.82	21.52	20.13	6.47	2008	18.21	1.92
Kurtbogazi	92	32.02	32.84	34.39	10.23	2007	37.32	-2.93

As of December 2020, the current reservoir levels (%) in Camlidere and Kurtbogazi were 20.13 and 34.39, respectively. As mentioned above, the years when the lowest level of December was observed were 2008 for Camlidere (%6.47), and 2007 for Kurtbogazi (%10.23). Reservoir levels at the end of December 2020 and how the levels changed compared to last year were given in Table 2.

When looking at the last 5- and 20-years' monthly reservoir levels (Figure 6), it is seen that the average of last 5 year is lower than the last 20 years in Camlidere, and is lower or equal in Kurtbogazi, except January, February, and March. Compared to long-term averages, the average of 2020 was very low in Kurtbogazi. The average of April, May, June, and July 2020 in Camlidere was higher, and the average of 2020 was between short and long-term averages. To observe any changes in recovery time of reservoirs, significant changes in short-, if not long-term, averages might be expected. However, there is no evidence showing the changes in the recovery of reservoir levels at the beginning of recent years in both reservoirs.

Figure 7 shows how the reservoir levels changed seasonally in Camlidere and Kurtbogazi. It is seen that both reservoirs reached their highest levels in the spring months. Camlidere reservoir is not much sensitive to the changes, and there are not many differences between seasonal levels. However, Kurtbogazi reservoir is more sensitive to the changes, and there are significant differences between seasonal levels.

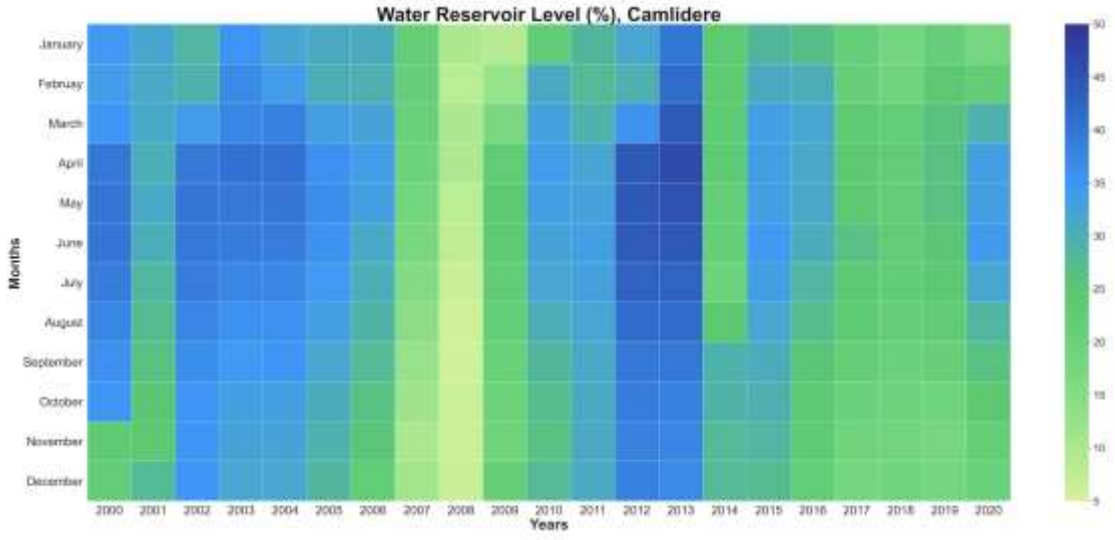

Figure 4. Monthly water reservoir levels (%) from 2000 to 2020 in Camlidere.

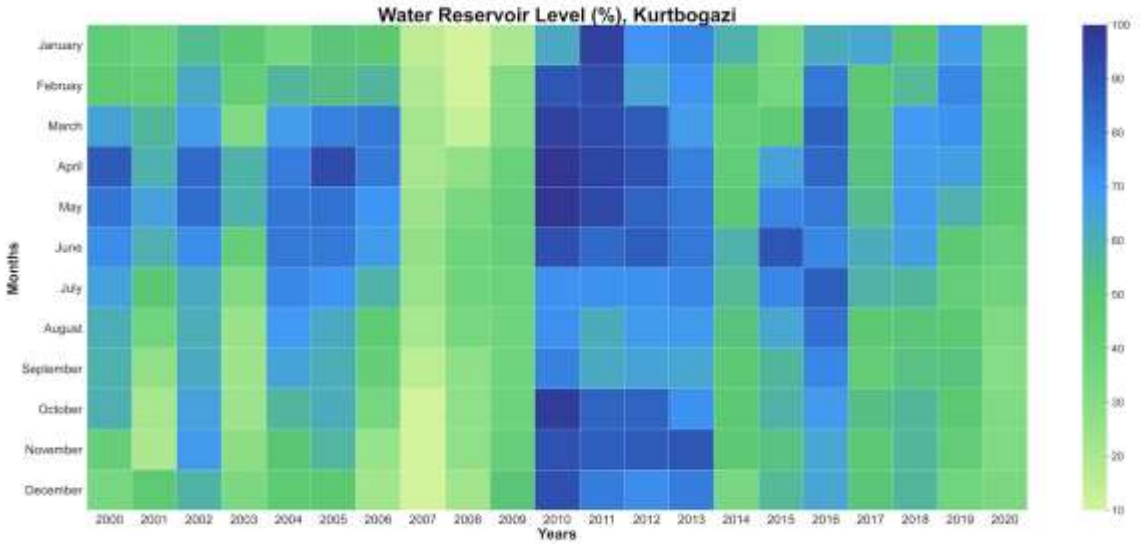

Figure 5. Monthly water reservoir levels (%) from 2000 to 2020 in Kurtbogazi.

3.2 Water Consumption

Water consumption data included billed consumptions from homes, industries, and other customers such as schools and government buildings. Unbilled consumptions such as charity organisations were not included as provided by ASKI. Monthly water consumption in Ankara was given in Figure 8.

With increased temperature, it is noted that water consumption in August has been very high, and the lowest consumption has been observed in December and January since 2016. While the average water consumption from 2016 to 2019 is 16.494.308.65 m^3, the average of 2020, when many restrictions were announced due to the Covid-19 pandemic, is 19.231.697 m^3 increased by %16.59. Water consumption and annual change in Ankara were given in Table 3.

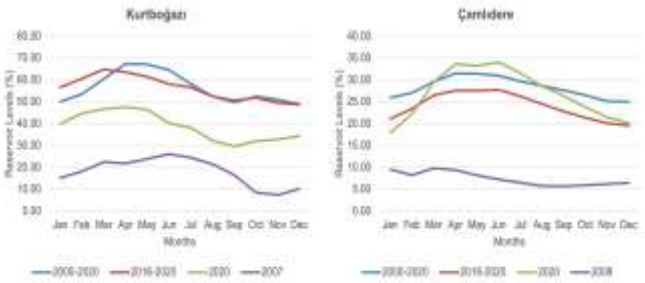

Figure 6. The average water reservoir levels (%)

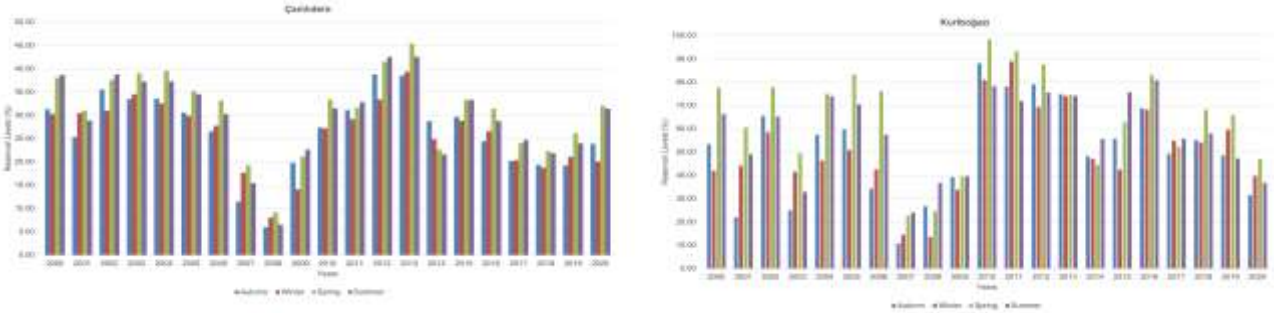

Figure 7. Seasonal water reservoir levels (%)

During the summertime period (2020), water consumption is higher than other months due to higher temperatures. Especially, consumption is at peak (38.806.083 m^3) in August and September. Increased consumption leads to a decrease in the reservoir levels after April and May. It is noted that water consumptions in March, April, and May 2020 were exceptionally lower than previous years. Due to the Covid-19 pandemic and governmental restrictions, ASKI decided not to read meters, and only billed usages as %80 of February bills. When the government announced normalization in June 2020, ASKI read all meters with remained usages, and usages peaked sharply.

As mentioned above, due to non-billed usages (c. perhaps %20 of total) during Covid-19, it was hard to say how the Covid-19 affected water usages in lockdown periods in Ankara. It will be worth looking at the first lockdown months (March, April, May, and June) together in comparison with previous years, but a more detailed study is required to determine real changes in use. While the annual population growth rate (‰) for 2018-2019 is 24.2 in Ankara, the yearly population growth rate (‰) for 2019-2020 is 4.3 (TURKSTAT, 2020), which shows how the population growth rate decreased in 2020.

When looking at the population and water consumption in March, April, May, and June 2020 (Figure 9), even if the

population growth rate decreased when compared to previous years, total consumptions in these months (73.443.256 m^3) were higher than the trend of 2016-2019 (60.818.636 m^3).

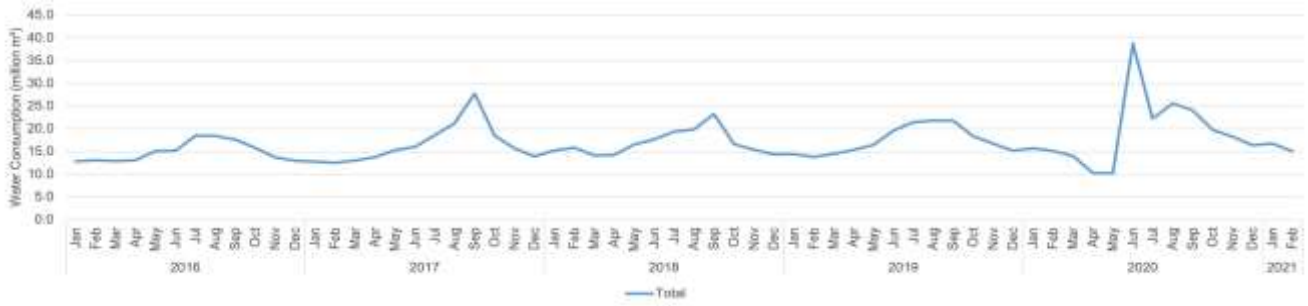

Figure 8. Water consumption (million m^3) vs Population.

Table 3. Average water consumption and annual change in Ankara.

Years	Average Water Consumption (m^3)	Annual Change (%)
2016	14.961.818	-
2017	16.623.967	+11.11
2018	16.909.830	+1.72
2019	17.481.618	+3.38
2020	19.231.697	+10.01

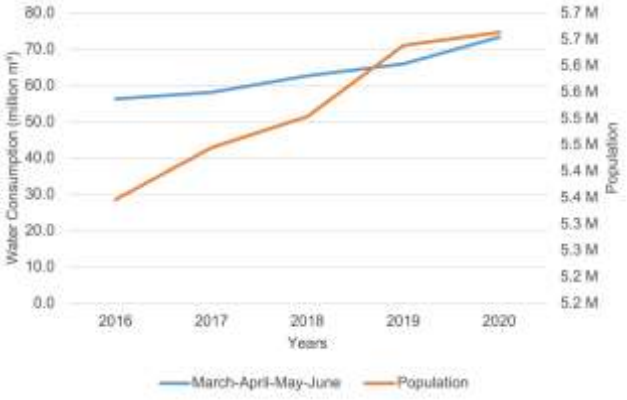

Figure 9. Water consumption (million m^3) vs Population.

4. Conclusions and recommendations

In this study, two different water reservoirs, named Camlidere and Kurtbogazi, are used actively to supply fresh water to the city centre of Ankara, and water consumption data, including billed consumption from homes, industries and other customers such as schools and government buildings were analysed.

Rainfall and temperatures in the Ankara province vary significantly across the year, with higher temperatures and lower rainfall in the summer months and higher rainfall and lower temperatures during the autumn to spring period. In addition, it is seen that the average temperature is 22 °C in summer and varies between 0 °C and 3 °C in winter. Precipitation was low in 2020 compared to the previous year and the long-term trend, but there was a substantial increase in February.

It is noted that while reservoir levels reach the highest level in winter and spring, the lowest level is observed in the summer with increased consumption and lower rainfall. Changes in reservoir levels were more stable in Camlidere, and more sensitive in Kurtbogazi to rainfall and water consumption, which might be the result of different reservoir capacity and area and to variations in river inputs. It is observed that the years of 2007, 2008, 2009, 2017, 2018 and 2019 were relatively dry, and reservoir levels decreased to the lowest levels in records, especially in 2007, 2008 and 2009. In addition, it is seen that the average of the last 5 years is lower than the last 20 years in Camlidere and is lower or equal in Kurtbogazi, except for January, February, and March.

With increased temperature, water consumption in August has been very high, and the lowest consumption since 2016 has been observed in December and January. Water consumption in March, April, and May 2020 was exceptionally lower than previous years. Due to the Covid-19 pandemic and governmental restrictions, ASKI decided not to read meters and only billed usages as %80 of February bills. When the government announced the normalisations in June 2020, ASKI read all meters with remained usages, and usages peaked sharply.

The population and water consumptions in March, April, May, and June 2020 were in (Figure 9), even if the population growth rate decreased compared to previous years, consumptions in these months were higher than the trend of 2016-2019. This increase in water consumption was the result of the Covid-19 pandemic.

During lockdowns, real-time usages were not billed due to governmental statements and restrictions (to protect workers and public health). Consequently, municipalities' revenues were disrupted, which might worsen in a further pandemic or unexpected pressures (such as those that might arise under climate change). The policy of not reading meters during Covid-19 restrictions led to significant apparent shifts in water consumption. All this suggests there are grounds for switching to more intelligent systems for billing the consumption and detecting errors remotely. This would avoid

the delays in the payments that may cause economic difficulties (such as cash flow disruptions) for municipalities and help manage water resources better. Given the pressures on water systems that may arise under climate change or through further pandemic periods, it is essential to have publicly available real-time water data sets and analyse them regularly. Such systems would help in the early detection of any stresses on water resources and help authorities have sustainable management plans. This could form a basis for an argument that municipalities could update their systems, such as smart meters, remote billing, pressure sensors, etc., to be ready for further stresses on water reservoirs and water systems. Sector-based data (industry, home, school, etc.) and up-to-date data should be analysed regularly, and be publicly available, which would help authorities have sustainable management plans for water resources and help communities understand their water use and how to conserve this valuable resource.

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Data Availability

The data that support the findings of this study are available from Ankara Water and Sewerage Administration (ASKI). Restrictions apply to the availability of these data used under the license for this study.

Conflict of Interest

The authors have no conflicts of interest to declare. All co-authors have seen and agree with the manuscript's contents, and there is no financial interest to report.

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