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Water Scarcity in Kocaeli/Turkey: Problems and Measures

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Abstract Because of water scarcity at the Yuvacik Reservoir and the other water resources in 2006 and 2014, there could be a difficulty in raw water storage and supply of these resources which would result in water problems on demand side. Therefore, a water pipeline with 5 pumps was constructed from Lake Sapanca to Yuvacik Water Treatment Plant. But the ecological system of Lake Sapanca was affected negatively. In July 2014, new water resources were added to public supply system of Kocaeli Metropolitan City (KMC), and water amount used from Yuvacik Dam and Treatment Plant decreased to the level of 121 Mm^3 while it was 129 Mm^3 and 122 Mm^3 in 2013 and 2012 respectively.

This paper aims to call the attentions the importance of the planning regarding the climate change and water scarcity and to reveal that drought will be able to overcome on the scale of KMC.

Keywords Water scarcity, water management, water consumption, problems and measures, Kocaeli case

1. Introduction

Water is essential for human security and one of the engines of sustainable socio-economic development. At the same time, water is a precious resource which is gradually getting scarcer although it is a basic element for the eradication of poverty and hunger. More than half of the world population will be living with water shortage within 50 years because of a worldwide water crisis, according to a report issued by the United Nations Environment Program. In other words, it is highly unlikely that there is going to be enough water for everybody unless the necessary steps are taken at regional and global level. Population growth, industrialization, urbanization and rising affluence in the 20th Century resulted in a substantial increase in water consumption. While the world's population grew three fold, water use increased six fold during the same period. The demand on water resources will continue to increase during the next twenty-five years. The problem is further aggravated by the uneven water distribution on earth [1].

On the other hand climate change or variability is also truly global issues, and affect the whole water cycle as well as water is a vital and renewable resource to sustain life on the planet [2-3]. Possible scenarios indicate that summers would be longer/drier and warmer, winters would be shorter and wetter, extreme weather events/disasters such as drought and sudden/unexpected flooding, and seasonal droughts would be more frequent [4]. The impact of these changes would be felt across all parts of the water business. For example, reductions in river flows during summer periods are likely to reduce the amount of water available for public water supply. The natural recharge of aquifers from abstracted groundwater is likely to start later in the season, which may impact on water availability. Inundation of water treatment works by river water due to extreme weather events and resilience of the water supply system to multi-season droughts would be the most important problems to be faced in the near future [5].

Turkey is located between 26°-45° eastern longitudes and 36°-42° northern latitudes (Figure 1).Turkey occupies a total area of about 78 million ha, of which about 1.1 million is inland lakes. The country forms an elongated rectangle roughly 1.650 kilometers in an east-west direction and 1.000 kilometers north to south. On the east,

Turkey has borders with Iran, Azerbaijan, Georgia and Armenia. On the southeast, Turkey's neighbors are Iran, Iraq and Syria. On the south and west, the country surrounded with the Mediterranean and Aegean Sea. On the northwest, Turkey has borders with Bulgaria and Greece. The Black Sea lies in the north of the country. Anatolia, except its eastern parts, is surrounded by seas and has a total coastline of 7.816 km, not including that of the islands. Turkey forms a bridge between Europe and Asia, with about 3% of its land (the Trace) in Europe. The average altitude (1.132 m) of Turkey is higher than that (1.050 m) of Asia and three and a half times higher than that (330 m) of Europe. The elevation of Turkey increases from the west to the east [6].

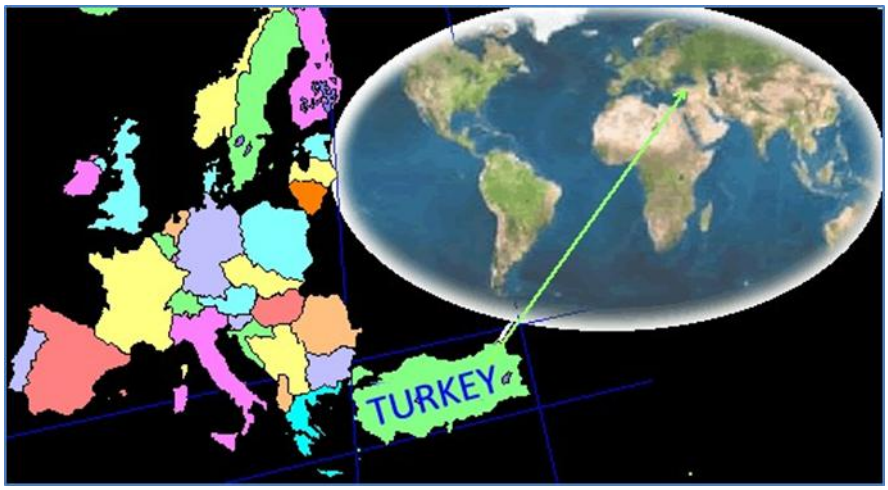

Figure 1: The location of Turkey in the World

The mountainous coastal regions receive abundant precipitations (1.000-2.500 mm/year) especially. Precipitation is 500-1.000 mm/year in the Marmara and Aegean regions and in the plateau of East Anatolia whereas most parts of Central Anatolia and Southeastern Anatolia have precipitation only 350-500 mm annually. Snow falls in almost every region of Turkey, but the number of days on which it snows and the durations of snow cover vary considerably with regard to the regions. It snows less than one day a year in the Mediterranean Region while more than 40 days in Eastern Anatolia on average. The duration of snow cover is less than one day in the Mediterranean and Aegean coastal fringes, 10-20 days in the Marmara and Black Sea coastal areas, 20-40 days in Central Anatolia, and 120 days in the Erzurum and Kars provinces in Eastern Anatolia. Throughout the four seasons, higher parts of the mountains retain snow, which melts slowly, feeding rivers and ground waters [7-9].

Annual mean precipitation in Turkey is 643 mm, which corresponds to 501 billion m^3(Bm^3) of annual water volume in the country. A volume of 274 Bm^3 water evaporates from water bodies and soils to atmosphere. 69 Bm^3 of volume of water leaks into groundwater, whereas 28 Bm^3 is retrieved by springs from groundwater contributing to surface water. Also, there are 7 Bm^3 volume of water coming from neighboring countries. Thus, total annual surface runoff amounts to a volume of 193 Bm^3 of water. Including 41 Bm^3 net discharging into groundwater (covering safe yield extraction, unregistered extraction, emptying into the seas, and trans-boundary), the gross renewable water potential (surface and groundwater) of Turkey is estimated as 234 Bm^3. However, under current technical and economic constrains, annual exploitable potential has been calculated as 112 Bm^3 of net water volume, as 95 Bm^3 from surface water resources, as 3 Bm^3 from neighboring countries, as 14 Bm^3 from groundwater safe yield (Figure 2). In this case, Turkey is not a rich country in terms of existing water potential. On the contrary to the general perception, Turkey is neither a country rich in freshwater resources nor the richest country in the region in this respect [6-9].

Turkey is early in the list of the countries that would be affected by climate change or variability [6-10]. Turkey, as the most arid from climate change to take place in the Mediterranean Basin will be affected in terms of more frequent and intensified among countries. The temperature increase of 2 degrees in the Mediterranean Basin is expected to average 20-50 years. This increase in unpredictable weather events for Turkey, the decline in rainfall, heat waves, the decline in tourism revenues, yield losses in crops that require regular watering,

biodiversity loss, forest fires increase and due to the decrease in precipitation groundwater, wetlands and losses in water storage stands.

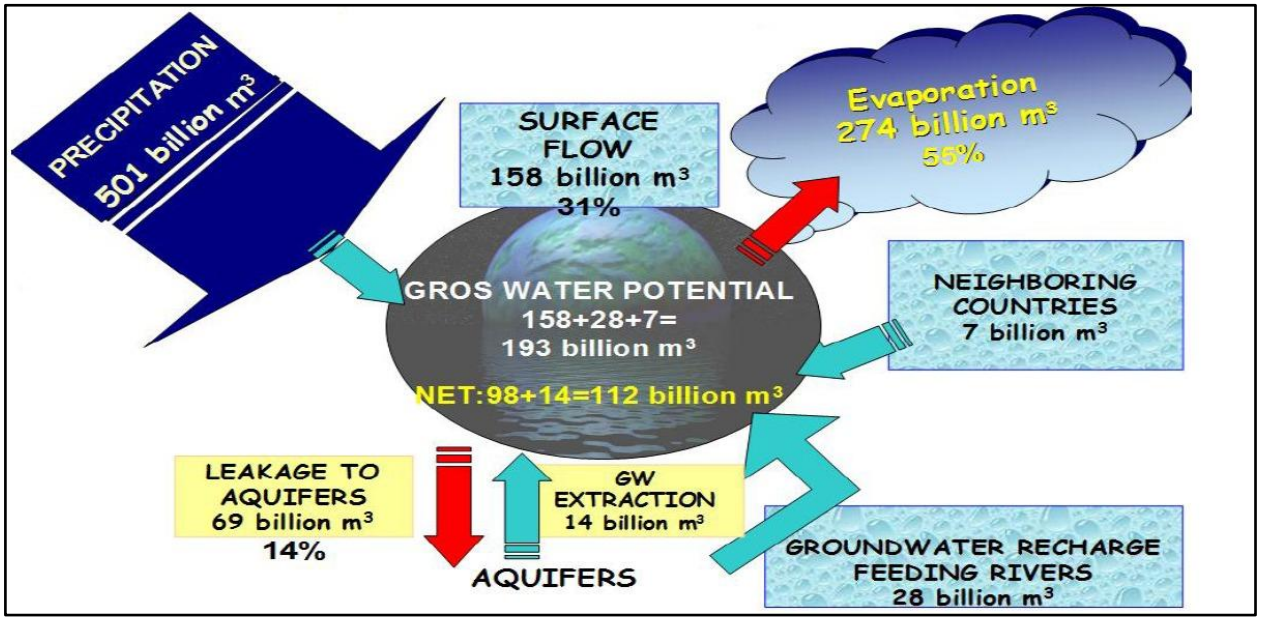

Figure 2: Water potential of Turkey

A water-stressed country status to Turkey's future in 2030, most of the Central Anatolia region will be affected - the Mediterranean, Aegean and Marmara regions are estimated. In Turkey, while in 1963, 140 experienced about floods, more than 160 floods occurred in 2010. Around 200 average as a result of flood disasters every year, an annual average of $100 million in property loss occurred. Thus, the financial losses caused by floods in Turkey in 1995, approached rapidly increasing losses caused by the earthquake in recent years. In Turkey, the number of storms that occur due to high winds there is a significant increase [11].

Turkey is situated in a semi-arid region, and has only about one fifth of the water available per capita in water rich regions such as North America and Western Europe. Among the effects of climate variability, drought can be regarded as the most dangerous and the most difficult to cope with disasters. In agricultural products, reduction of pasture and forest products; increase in fire; decrease in water level; increases in livestock and wild animals Climate Change Risk Management mortality rate in Turkey. The damage observed in wildlife and fish species are among the direct impact of drought on the environment. Water rich countries are those which have 10,000 cubic meters (m^3) of water per capita yearly. In fact Turkey is a water stress country according to annual volume of water available approximately 1500 m^3 per capita [2, 10]. Furthermore, the annual available amount of water per capita with increasing population of Turkey will be about 1000 m^3 by 2030 [7-9].

The anticipated impact of climate change/variability, as well as the likely increase in population in the Eastern Marmara of Turkey, will compound an already difficult situation in an area that is water stressed.

Indeed Turkey is one of the water rich countries of the Mediterranean, but due to an enormous population increase from 28 million in the 1960's to 79 million in 2015 the availability of water resources has already decreased from around 4000 m^3 to 1430 m^3 per capita/year today. Water demand in Turkey approximately has doubled in the second half of the last century. The overall water demand in Turkey continues to increase, even more in the light of the effects of drought or climate change. Turkey will suffer from water scarcity in the next years.

With an increasing population, when considering the global climate change Turkey will have a more arid climate due in 2050, an amount of water per person per year in Turkey is expected to fall to 700 cubic meters. In other words, changing climate and growing population of Turkey by 2050 may be one of the water-poor countries [11]. Moreover, World Meteorological Organization (WMO), according to the survey which was conducted among 87 member countries result, it was determined that the 74 drought-affected countries, including Turkey also found. Again, from 87 countries in 59 (69%) are experiencing water scarcity problems.

Asian continent to the west of the country, including Turkey and the Middle East and Africa, is one of the areas that are the most sensitive to increasing water scarcity problem [12].

Another point is that Turkey's water is not always in the right place at the right time to meet present and anticipated needs. Certain regions of Turkey such as the Black Sea region have ample but unusable freshwater, while some of the more heavily populated and industrialized regions such as the Marmara and the Aegean regions lack sufficient fresh water.

Kocaeli Metropolitan City (KMC) is located on the Eastern Marmara Region, and one of the most industrialized cities of Turkey (Figure 3).

Figure 3: Location of Kocaeli Metropolitan City in Turkey

The great part of the domestic and industrial water needs of KM Cwas being supplied from Yuvacik Dam and Treatment Plant operated and maintained by private companies until 2014. The reservoir started impounding on 5th June 1998. The potable water and industrial water requirement was projected as 142 Mm^3/year and the regulation rate was 64.3%. As of January 2014, the operation of this dam and treatment plant which was being operated by Thames Water was transferred to Kocaeli Metropolitan Municipality. Due to water scarcity at the Yuvacik Reservoir and the other water resources, there could be a difficulty in raw water storage and supply of these resources which would result in water shortages on demand side. In fact, the water requirements of KMC can be supplied by Yuvacik Dam and Reservoir only. But this reservoir could not meet the water requirements of KMC in 2006 [2, 13-15]. The inlet flow data to the Yuvacik Reservoir of the last 40 years indicate that 5th driest year was experienced among October 2004 to February 2005. The average of the total flow to the reservoir is 55% below the average flows of the latest years. The 3rd driest year of the last 40 years was experienced as for the cumulative total of the inlet flow to the Yuvacik Reservoir during October-November-December 2004. It is 80% below the average flows to the reservoir both in monthly and the cumulative basis. Normally, there used to be a 70% useful reservoir filling in Januaries. It was at 12% which is the lowest rate of all in January 2005. KMC was subjected to water supply crisis on December 2006 although the water potential was adequate for domestic and industrial usage. That is, drought or water scarcity was whispering that "it is coming". Furthermore, one year before water crisis in 2006, Kocaeli Drought Management Plan (KDMP) have been established with the participation and support of all the related authorities and parties on 31st May, 2005.Although KDMP was including all necessary subplots, programs and procedures to effective and practical dealing with the drought and the subsequent water conservation and the restrictions, it was not applied on time and completely. So, the public and industry could not find water sufficient to be used for utilities for ca. 30 days of December, 2006. After drought problem in 2006, KDMP was not revised and renewed. In spite of KDMP, Strategy for Combating Drought was prepared by Izmit Water Corp. and Kocaeli Metropolitan Municipality. But nobody has known about this strategy.

After water shortage and drought problem encountered in 2006, a water pipeline with 5 pumps, a long of 26 km approximately, was constructed from Lake Sapanca to Yuvacik Water Treatment Plant. So, the water needs of KMC was tried to be supplied for a short term. In July 2014, Namazgah Dam and a lot of deep wells were added to public supply system of KMC as the water resources. People living in KMC did not suffer from waterless in 2014 but all water and aquatic system were affected negatively in terms of quality and quantity.
This paper aims to call the attentions to the importance of the planning regarding the climate change/variability and water shortage and to reveal that drought problem encountered in 2014 will be able to overcome on the scale of Kocaeli Metropolitan City.

2. Water Potential of Kocaeli Metropolitan City

Turkey is geographically divided into twenty-five hydraulic basins. These basins differ widely in terms of their respective water potential and the Euphrates-Tigris basin alone makes up about 28 % of the total water potential of all basins [DSI 2015]. KMC is located between 2 and 12 fresh water basins (Figure 4).

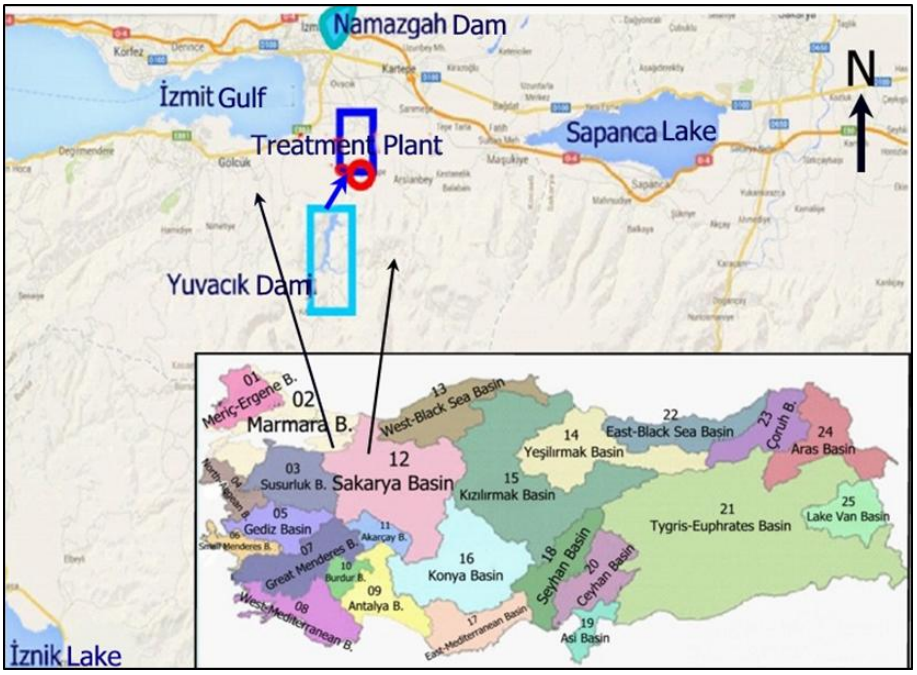

Figure 4: The freshwater basins of Turkey and main water resources of Kocaeli

In general, potential water resources of KMC can be divided into two categories: Ground water and surface water. The potential of ground water is 74 Million m^3 per year (Mm^3/yr) and that of surface water 1491 Mm^3/yr, and the total water potential is 1565 Mm^3/yr (Table 1) [13, 16-17]. Total area of surface water is 1125 hectares (ha). The surface water resources of KMC are rivers, lakes and ponds. KMC has 32 running waters. Kirazdere of these is the longest one with a length of 47.5 km.
Lake Sapanca is located between Sakarya and KMC. The Lake is an important source of water utilities. The circumference of the Lake is 39 km and 7 km of that remains inside KMC area [19-20].
Before Yuvacik Dam and Reservoir was constructed in 1999, domestic and industrial water requirements of KMC were being supplied from various water resources, esp. wells, springs and Lake Sapanca, Gökçe Dam and Reservoir located on Yalova City.
Construction of Yuvacik Dam and Reservoir started in 18th April 1996 and the project was commissioned on 17th January 1999. Yuvacik Dam and Reservoir supplies raw water to the project and is situated 7 km south east of Izmit at a longitude of approximately 32° 57' 30" E and latitude of 40° 39' 0" N. The reservoir started impounding on 5th June 1998.Yuvacik Dam and Reservoir are a vital component of the Izmit Domestic and Industrial Water Supply Project designed to meet the water needs of KMC. The potable and industrial water requirements were projected as 142 Mm^3/year and the regulation rate was 64.3%. The total reservoir volume at the top water level of 169.68 m ASL is 52.03 Mm^3. The surface area of the reservoir at the top water level of

169.68 m ASL is 1.75 km^2 [13, 18-20]. After water crisis in 2006, Namazgah Dam and a water pipeline with 5 pumps were constructed to meet industrial and domestic water demand of KMC. In mid-2014, KMC had four main water resources: Yuvacik Dam and Reservoir, Namazgah Dam and Reservoir, Lake Sapanca and local water resources.

Table 1: Water Potential of Kocaeli Metropolitan City

Resource	Amount (Mm^3/year)
Surface Water (Streams)	1491.0
Bickidere	18.0
Cinarlidere	15.0
Kirazdere	195.0
Kumcağizdere	22.0
Parganlidere	10.0
Sarisudere	10.0
Sazdere	5.0
Seymenlidere	10.0
Dildere	34.0
Yalakdere	72.0
Freshwater coming from various small creeks (as to calculations of DSI)	1100.0
Groundwater	74.0
İzmit Plain	37.0
Golcuk Plain	6.5
Sapanca Plain	20.5
Tutunciftlik-Yarımca-Derince Plain	4.5
Gebze-Dilovası Plain	2.5
Gebze-Cayirova Plain	3.0
Sum Total	1565.0

3. Reasons of Water Shortage

In fact, all water requirements of KMC could be supplied by Yuvacık Dam and Reservoir only till 2006. But this reservoir could not meet the water requirements of Kocaeli Metropolitan City in 2006 because of the decrement in precipitation and increase in water demand. The inlet flow data to the Yuvacik Reservoir of the last 40 years indicate that 5th driest year was experienced between October 2004 and February 2005. The average of the total flow to the reservoir is 55% below the average flows of the latest years. The 3rd driest year of the last 40 years was experienced as for the cumulative total of the inlet flow to the Yuvacık Reservoir during October-November-December 2004. It is 80% below the average flows to the reservoir both in monthly and the cumulative basis. Normally, there used to be a 70% useful reservoir filling in Januaries, It was at 12% which is the lowest rate of all in January 2005. KMC was subjected to water supply crisis on December 2006 although the water potential of KMC was adequate for domestic and industrial usage. For these reasons, a water pipeline with 5 pumps was constructed from Lake Sapanca to Yuvacik Water Treatment Plant, a long of 26 km approximately [21].

Whatever Local Water Authorities have taken practical lessons from the drought and water shortage encountered by relevant local institutions and organizations in 2006, they could not manage the water resources well despite of Kocaeli Drought Management Plan prepared in 2005 and later on, Strategy for Combating Drought prepared by Kocaeli Metropolitan Municipality. In this regard, the reasons of water scarcity and insufficient water supply can be divided into four headings: Decrement in precipitation and filling rate of dams, population growth and increase in water demand, water losses and management problems.

3.1. Decrement in Precipitation and Filling Rate of Dams

According to 56-year meteorological data among 1960 and 2016, the mean precipitation of Kocaeli is 771.7 mm. The daily precipitation was measured as 169.4 mm on July 2nd, 1942. The precipitation is maximum with 105.1 mm in December and minimum with 36.8 mm in August.

34.8 percent of annual precipitation falls in winter season and 28.1 percent of that in autumn-season, 20.8 percent of that in spring season and 16.3 percent of that in summer season. Kocaeli undergoes 8.4 day of the

year snowy and the duration of snow cover is average 9 day of the year. The mean annual precipitation of Yuvacik Watershed was found as 1038.7 mm by DSI and Thames Water. December is the rainiest month of the year with 159.5 mm. The precipitation of January and November is 115 mm and 113.7 mm respectively. A great part of precipitation(33 %) rains in winter season and, Autumn, Spring and Summer follows Winter season with the precipitation of 27.4 %, 23.2 % and 16.4 % respectively. So, Yuvacik Catchment receives precipitation more than that of KMC in general [7-8, 19-20, 22-23]. The inlet flow data to Yuvacik Reservoir of the last 45 years indicate that 5th driest year was experienced between October 2014 and February 2014. In 2014, the similar lack of rainfall in 2006 was realized. In winter season among2013 and 2015, the similar decrease in precipitation was observed in Yuvacik Catchment (Figure 5) and the filling rates of Yuvacik Dam and Reservoir (Figure 6) and the usable water amount in Reservoir decreased dramatically. Filling rate of Yuvacik Dam and Reservoir was diminished excessively among October 2013 and March 2014(Figure 7).

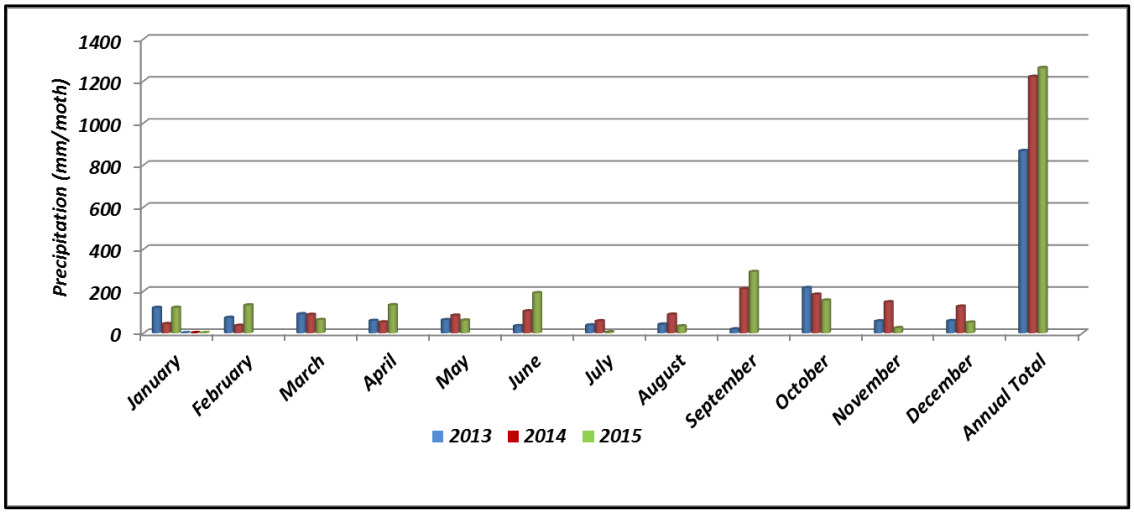

Figure 5: Variations in precipitation of Yuvacik Catchment among 2013 and 2015

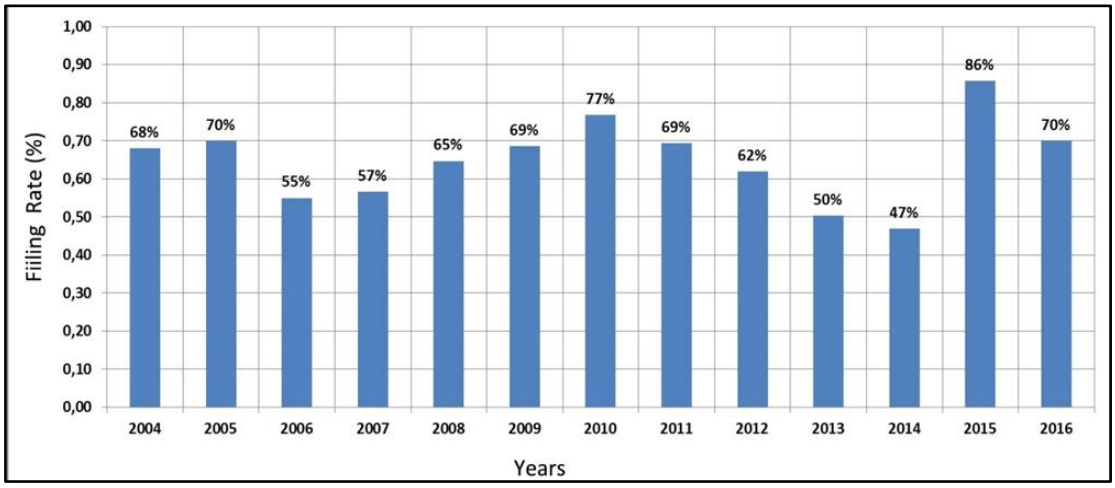

Figure 6: Mean filling rates of Yuvacik dam and reservoir among 2004-2016

Since Yuvacik Dam and Reservoir could not founder especially in 2014, Local Water Authority have had to take measure in urgent. ISU (İzmit Water Corporation-a unit of Kocaeli Metropolitan Municipality) drilled tens of new deep wells (ca 88 new wells). Besides, 415.000 m^3, 3.750.000 m^3, 16.250.000 m^3 and 46.870.000 m^3 of total used water among 2011 and 2014 respectively were drawn from Lake Sapanca. And the water obtained from deep wells and Lake Sapanca was canalized to Yuvacik Water Treatment Plant (ISU 2015; ISU Strategic Plan 2015). So, water amount used from Yuvacik Dam and Reservoir decreased to the level of 121 Mm^3 while it was 129 Mm^3 and 124 Mm^3 in 2013 and 2012 respectively and 125 Mm^3 in 2015(Figure 8). In 2015, freshwater from Lake Sapanca and deep wells to Yuvacik Water Treatment Plant was not transferred.

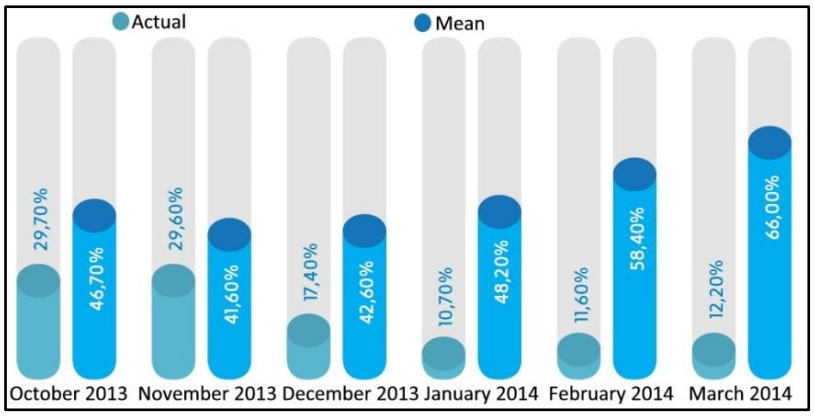

Figure 7: Actual and mean filling rate of Yuvacik Dam and Reservoir between 2013 and 2014

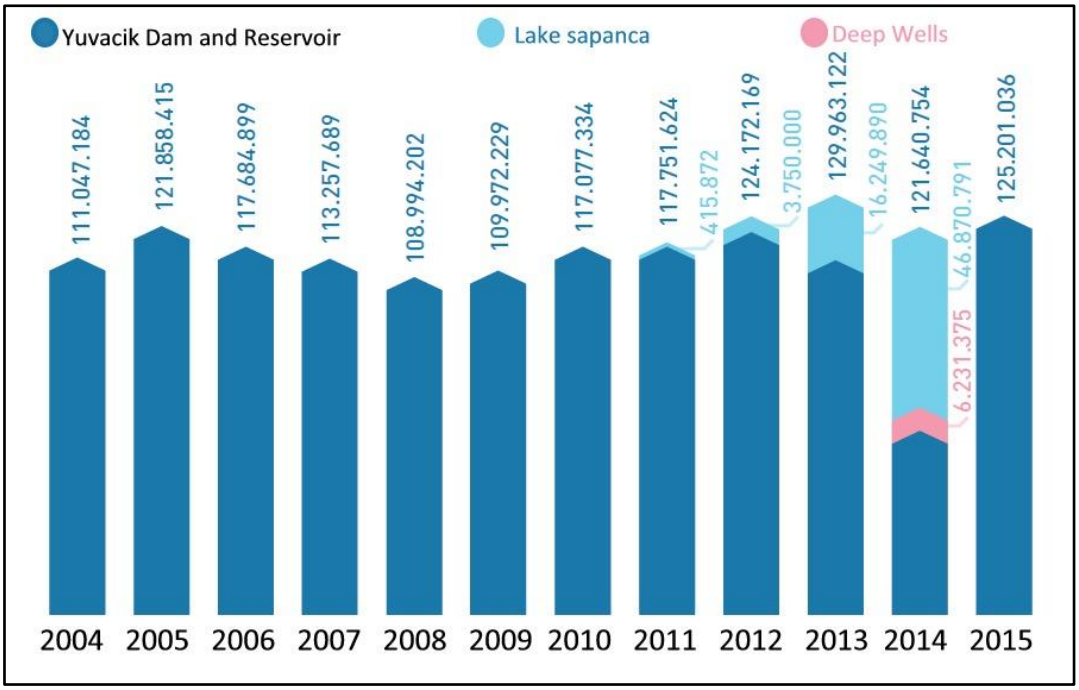

Figure 8: Water amount supplied from various resources to Kocaeli Metropolitan City (m^3)

Due to extreme water withdrawn from Lake Sapanca, the ecological balance of the Lake was deteriorated and the mortalities of fish and other aquatic species, and eutrophication were observed some places of Lake Sapanca (Figure 9).Otherwise, about more than half of inflow to Yuvacik Dam and Reservoir was discharged because of rainfall excessively in some years without 2007 and 2014 (Figure 10), especially in 2015 (Figure 11). This non-steady inflow/outflow shows that the climate and precipitation have extremely changed by years.

Figure 9: The various pictures from Lake Sapanca in 2014 (a) lake-shore, (b) plants in lake, (c) Eutrophication (waterweeds and dead mussels) (d) dead fish

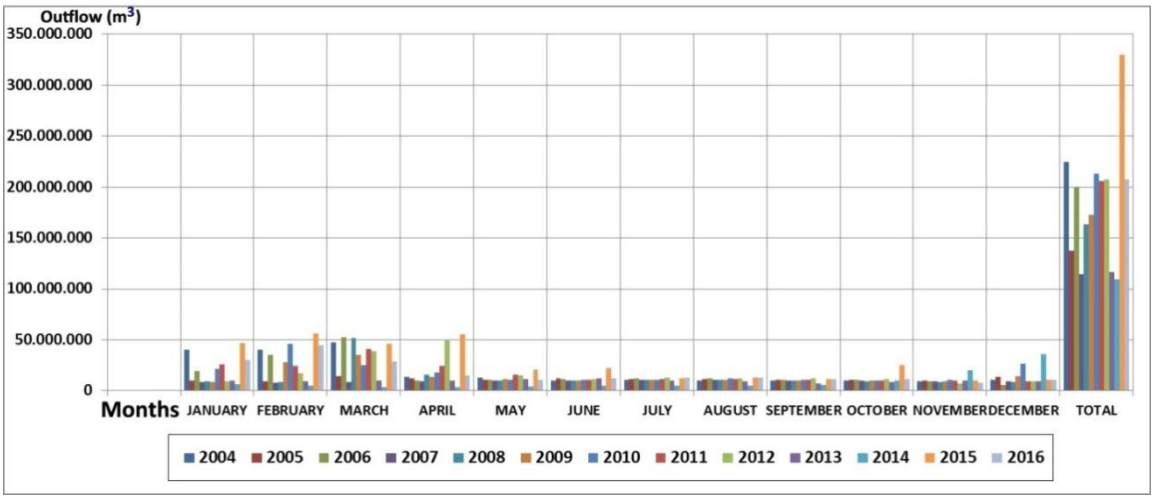

Figure 10: Outflow data to Yuvacik Dam and Reservoir among 2004-2016

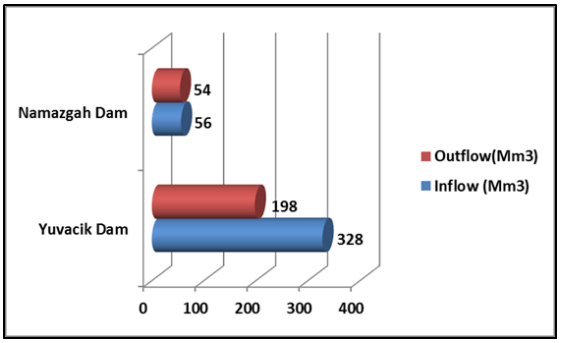

Figure 11: Inflow and outflow to dams of Kocaeli in 2015

3.2. Population Growth and Increase of Water Demand in Kocaeli Metropolitan City

The current population and economic growth rate will alter water consumption patterns. As population increases, annual allocated available amount of water per person will decrease. Population in Kocaeli was doubled nearly due to industrial investments/plants, increase in birth rate and internal migrations since 2006. According to the last census based on address records, the population of KMC is 1.780.055 and density of population per km^2 is 491 (Figure 12) [23]. Therefore, industrial and domestic water demand has increased since 2006. Population growth and increase in water demand were a predictable increment. But, local water authorities have not endeavored adequately for development of water resources and water supply. Demand stimulating politics were implemented instead of water demand diminishing. So, water shortage and scarce have occurred in 2014 again [19-21].

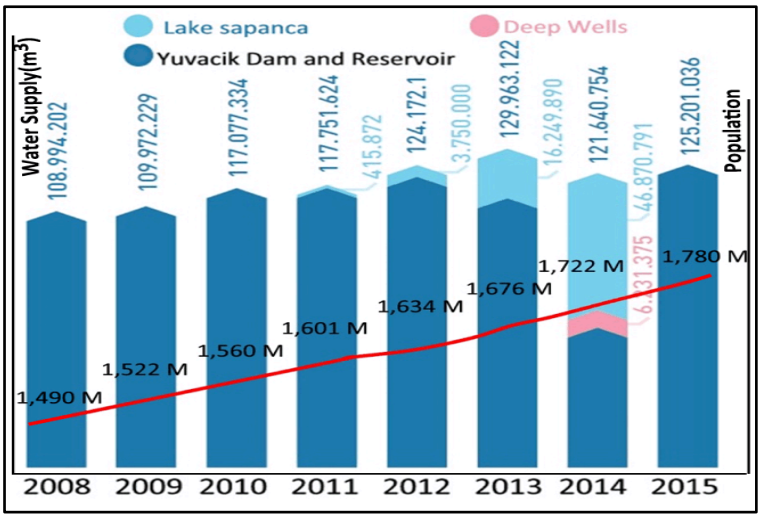

Figure 12: Development between population and water supply

The rate of water subscription in KMC realized 4.4 % in 2016 while the rate of population growth remained 3.3 % (Figure 13). This distinction shows that water subscription has increased much more than rate of population growth in general.

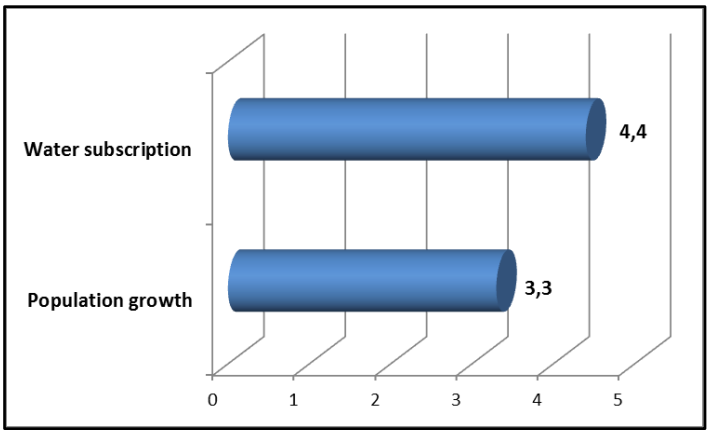

Figure 13: The comparison of the rate in population growth and water subscription in 2016

3.3. Water Loss

Water loss (WL) is the difference between the water entering the supply system and water used (sold to customers or used for free). All systems experience some water loss as an ordinary part of operation. Since the earthquake in 1999, water loss could not be decreased insufficiently by ISU.

According to ISU, the rate of water losses in KMC is 39 and 37 % respectively in 2014 and 2015 (Figure 14a) [8-20]. Indeed, this rate is much more than 37 % and approaches 50 % in consideration of total water amount used in KMC (Figure 14b.) Although accrued water amount by years has increased, it is not enough to mitigate water losses (Figure 15).

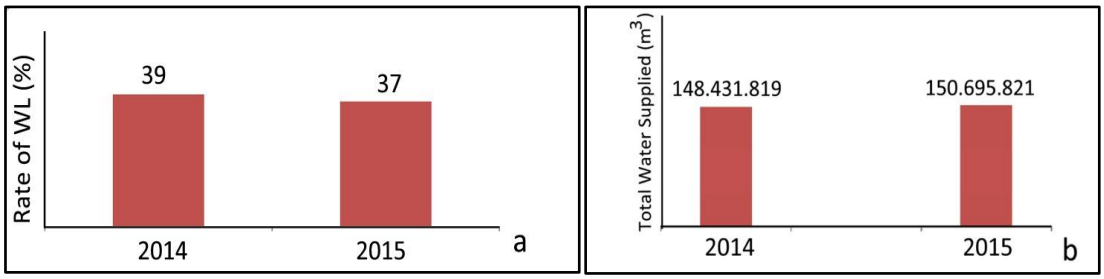

Figure 14: Rate of Water Loss (a) and Total Water supply from Yuvacik Dam and Local Water Resources (b)

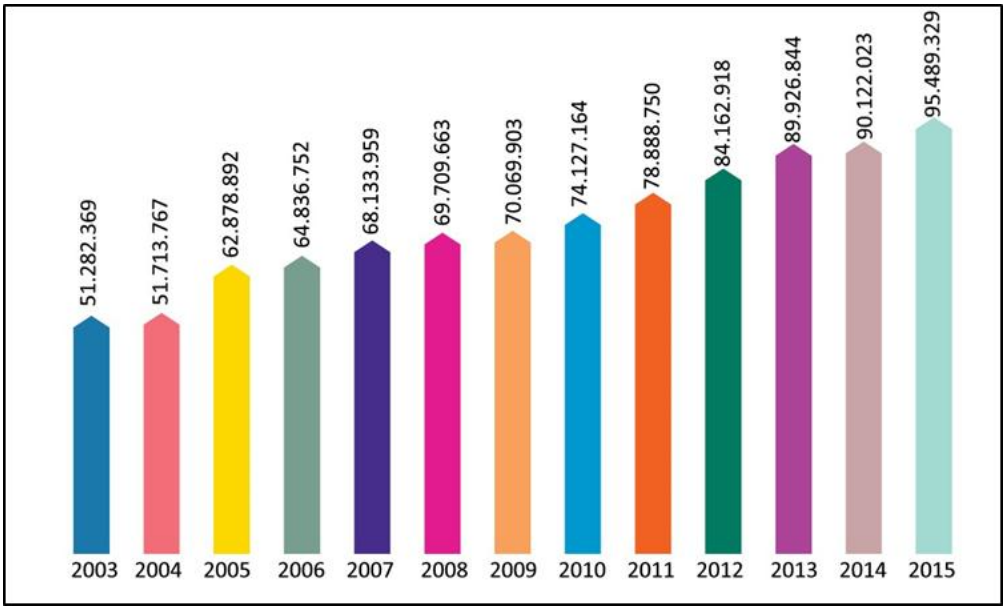

Figure 15: Accrued water amount (m^3) in KMC by years

When analyzed Figure 14b and 15, it will be sawn that the rate between total water supply and accrued water amount is much more than 60 % in 2014 and 2015 respectively, and WL is more than 60 % hence.

In order to mitigate WL, ISU started a project in 2015. WL would be abated by 20% using some innovative methods such as loss detection at nights, ground imaging devices, isolating of water supply networks, water pressure management system integrated with SCADA system. Water pressure management system is a pressure control system commonly used in water distribution systems. Pressure control in water distribution systems remains a significant concern for water utilities. This process can provide significant benefits for the two main segments of water distribution: water companies and end users. Effective pressure adjustment throughout the day provides sufficiently high pressure that ensures a constant and adequate service to customers while reducing it to an extent that avoids background leakages or breaks at night. In this context, the term pressure management (PM) emerged to refer to this kind of activity. PM may involve a large number of activities with different regulation elements: pump control, tank regulation, and pressure reduction by using automatic valves, among others. In particular, the use of pressure-regulating valves (PRVs) to reduce excessive pressure at certain times of the day is an increasingly widespread practice used by companies. So, water savings of ten billion m^3 have been planning [18-19].

3.4. Management problems

After the Yuvacik Dam and Reservoir was constructed in 1999, a number of wells and other water resources were closed by local water authority. For example, the water supply from Gökçe Dam and Reservoir in Yalova City to Karamürsel Town and that from Omerli Reservoir in İstanbul to Gebze were stopped by ISU. Due to the Marmara Earthquake on 17 August 1999, WL averages 65 per cent in KMC. Up to now this rate could not have seriously decreased with some measures taken by ISU.

All the visual and objective evaluations show that the inefficient and unnecessary water uses grow up drastically due to possible increase in domestic and industrial water needs, and in recreational irrigation during drought in 2006 and 2014. These can only be explained by excessive water withdraw from Yuvacik Reservoir without applying the Kocaeli Drought Management Plan developed in 2005 and Strategy Against Drought prepared by Kocaeli Metropolitan Municipality later on, and without any meteorological forecasting in advance for further years.

All the outputs briefly refer a wrong water management plan of local authority (ISU) and Kocaeli Metropolitan Municipality.

In 2014, Kocaeli Metropolitan Municipality had four usable water resources: Yuvacik Dam and Reservoir, Namazgah Dam and Reservoir, Lake Sapanca and local water resources. When drought was started in 2014

autumn, Local Authorities applied the supply side policies again and the water of 46 Mm^3 was canalized to Yuvacik Water Treatment Plantfrom Lake Sapanca. In this circumstance, Lake Sapanca was exposed to negative ecological conditions. Furthermore, tens of deep-well was sunk due to mitigation of drought effects and this time the quantity and quality ground water have deteriorated and ground water level decreased because of extreme draw-off. Besides, Yuvacik Water Treatment Plant had not been designed for treatment of various qualities of water coming from different resources. And therefore, the quality of potable water has reduced and the manganese and nitrogen amount in water have increased, and the people of Kocaeli could not drink the domestic water because of its taste and poor quality, and extreme chlorination. KDMP might not sufficient or perfect against drought contingency, but it was better without drought management plan at least [21, 24].

4. Conclusion and Recommendations

Because of water scarce occurred in Kocaeli, the public and industry could not find water sufficient for utilities through ca. 30 days of December, 2006. After these dramatic days, ISU have taken some measures such as reopen of wells closed previously, and supporting water supply of Kocaeli with Gökçe Reservoir in Yalova and Omerli Reservoir in Istanbul. This water crisis occurred in 2006 costs to public a lot. Due to insufficient water supply price of bottled water have been increased and private water companies gained high profit. In addition, invisible cost of this crisis can be counted as an increase in epidemical sickness because of non-hygiene conditions.

Local Water Authorities taken lessons from this crisis in 2006 has tried to take some measures. In strategic plan of Local Water Authority (ISU) future projections show that the water requirements of KMC will increase 168 Mm^3 in 2020 and 191 Mm^3 in 2040. This requirement would be met by constructing new two dams. But the water management on supply side failed in 2014 again without local and national water savings.

Since Turkey would be faced a possible climate change/variability and drought even in the near future, it is very important considering meteorological forecasting data in advance and applying Drought or Water Management Plans on time for local, regional and governmental water authorities. However, water saving should be an important part of public obligations and WL should be minimized with precautions.

Educational programs and works on water use and conservation should be started without delay. Furthermore, droughts can cause disasters unpreventable but they are the natural and manageable events. Besides, the water management plans or strategies are advised to be developed within the scope of including temporary or permanent water emergencies and shortages that will occur because of other causes such as earthquake, inundation, big explosions, shut-down, infrastructure failure and sanitation.

Future plans should examine more fully a process for dealing with water use conflicts, declaring "**limited**" or regional water conservation emergencies and providing more detailed guidance in the development of local and user specific water shortage management plans. Future planning for drought management should allow for full participation by public water systems, industry, and agricultural community.

A conceptual shift from crisis management to risk management should be ensured by means of Water Management. It is necessary to have storage facilities in order to ensure domestic, industrial and agricultural supply, and hydropower generation as well as to find new water resources for Turkey. Besides, Turkey has to have the plan B to be on the alert against water shortage and drought risk in the near future. In this regard, to know the reasons and results of water shortage are vital to mitigate water related problems and to take measures against natural disasters.

The main reasons of water related problems are rapid and unplanned urbanization depending on population growth, industrialization, intense agricultural activities, misuse of the lands and climate change. KMC is a city encountering all these problems. But the real problem is related on "**Integrated Management**" which is developed by the targets such as planned and economical usage of water which is a natural resource and has no alternative.

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