TSKB THEME LOOK

Water Is the Next Diamond

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Abbreviations

bcm: billion cubic meters
DSİ: the General Directorate of State Hydraulic Works
EPA: the U.S. Environmental Protection Agency
GDP: gross-domestic product
mcm: million cubic meters
MIT: Massachusetts Institute of Technology
m^3: cubic meters
WTA: withdrawal-to-availability ratio

The Diamond - Water Paradox

Water, the vital ingredient of life on Earth, is an essential precious environmental resource, which can exist in the form of a solid, liquid or gas. Water is a source of life, livelihoods and prosperity, is finite and continuously flows between ocean, atmosphere and land. As it becomes increasingly scarce relative to demand, developing and managing water resources to achieve water security remains at the heart of the struggle for growth, sustainable development and poverty reduction. This is true for developed countries as it is for developing countries.

When this is the case, why are diamonds, a luxury item, more valuable than water, a prerequisite for the sustainability of life? The diamond-water paradox, proposed by Adam Smith (Smith, 1776), states that people do not value what is vital for them and critical for their life, such as water, but choose to pay more for items that have no value to human life, such as diamonds.

This contradiction leads to the conclusion that "the real price of everything, what everything really costs to the man who wants to acquire it, is the toil and trouble of acquiring it," as Adam Smith says. As mentioned in the law of supply and demand, if the demand is great, or if a man is willing to go to great toil and trouble to acquire it, the price will rise.

Since our food and energy owe their existence to water, the biggest danger lies when the amount of water is insufficient in a region. Hence, the real question is what we should do to prevent water becoming a diamond. Which regions are in more danger and how can we prevent water from being scarce?

Global Water Resources

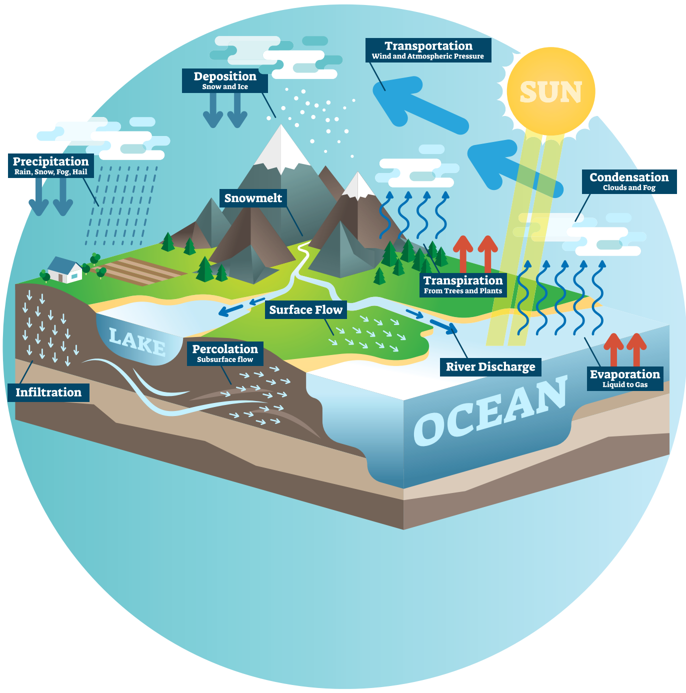
Water is one of the most widely distributed substances to be found in the natural environment and constitutes the earth's oceans, seas, lakes, rivers and underground water sources.

The total amount of water on Earth is approximately 1.4 billion cubic kilometers. Although 75% of the Earth is covered by oceans in the form of sea water, only 2.5% of all water on Earth is freshwater. The freshwater on Earth is in the form of ice in glaciers, the polar ice caps or as underground water in aquifers. Water never sits still, since there is an existing water cycle; the amount of water does not diminish, water moves from one place to another and from one to another.

The water cycle[1] describes how water evaporates from the surface, rises into the atmosphere, cools, condenses to form clouds, and falls again to the surface as precipitation.

On land, water evaporates from the ground, mainly from soils, plants (i.e., evapotranspiration), lakes, and streams. In fact, approximately 15% of the water entering the atmosphere is from evaporation from the Earth's land surfaces and evapotranspiration from plants. Evaporation helps to cool the Earth's surface and the lower atmosphere, and to provide water to the atmosphere in order to form clouds.

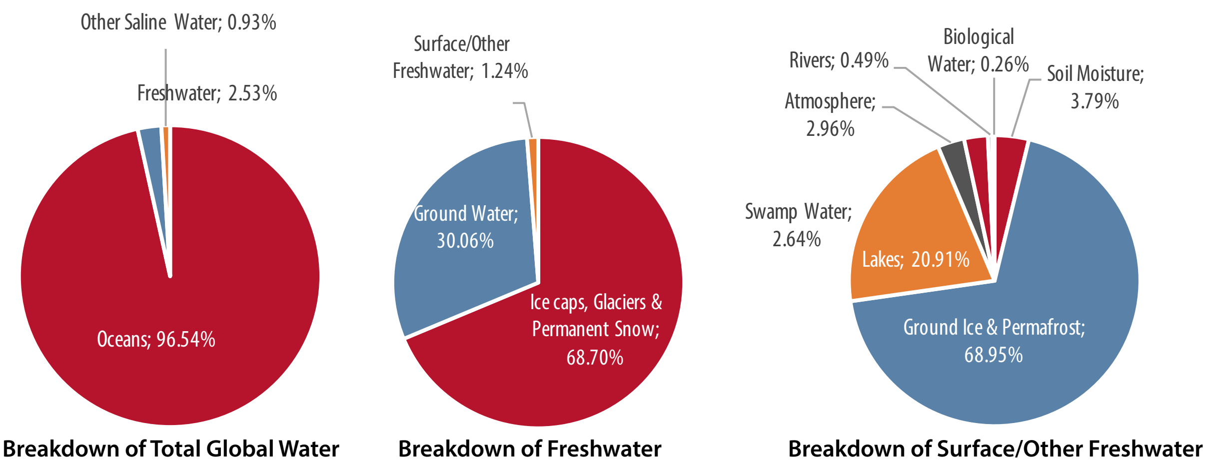
Figure 1. Water Cycle



As presented in **Graph 1**:

- Almost all of the freshwater is locked up in the ice or is in the ground,
- Only about 1.2% of the freshwater is on the surface,
- Just over 21% of the surface freshwater is found in lakes and rivers, where people derive a large portion of their water.

Graph 1. Water Resources on Earth



Source: U.S. Geological Survey (https://water.usgs.gov/edu/earthwherewater.html), TSKB Economic Research

[1] Water Cycle Isometric Flat Color Illustration, https://www.istockphoto.com/tr/vektör/the-water-cycle-isometric-flat-color-illustration-gm527216050-92730635

Which Sectors Drive Water Consumption?

Most water is consumed by agriculture (irrigation), energy, industry, household usage and ecosystem usage. Globally, approximately 69% of water resources are consumed for agricultural purposes, followed by 19% for industrial purposes and 12% for household purposes[2].

According to the United Nations, global water consumption has increased by a factor of six over the last 100 years (Y. Wada, 2016) and water consumption is expected to grow as a function of population growth, economic development and changing consumption patterns, among other factors.

Water is essential for the production of agricultural goods and services, which generate income and create national wealth. Globally, the agricultural sector is the largest and one of the most inefficient users of water. In agriculture, water is needed for irrigation, pesticide and fertilizer applications, crop cooling, and frost control. According to World Bank Data, in most regions of the world, over 70% of the freshwater is used for agriculture. However, this share varies significantly by country. For many countries, specifically developing countries, the agricultural sector contributes relatively little income to the country. Despite this, the sector consumes the largest amount of water.

The second largest water consumer in the world is energy, commercial and industrial sectors. These sectors account for approximately 20% of global water use. As with agriculture, water use in the industrial sector varies by country. The share of the industrial sector is more than 50% in developed countries where the role of the agricultural sector plays a minor role in these countries.

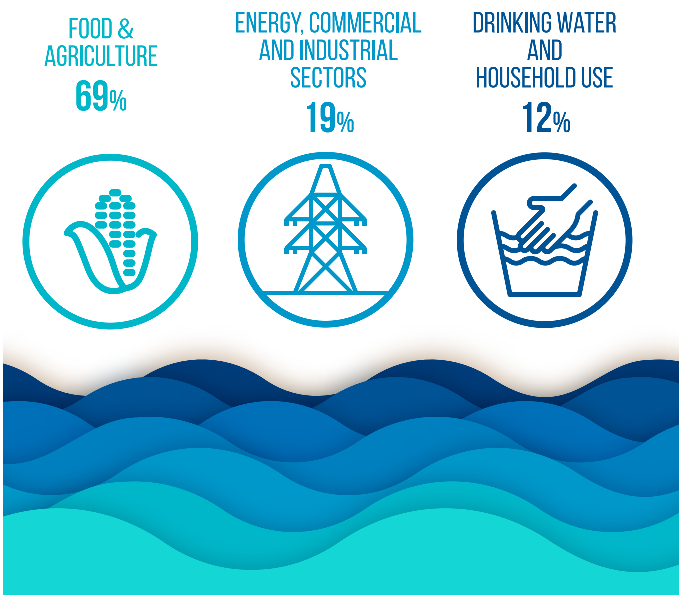
Globally, which industries use the most water?

Energy sector accounts for the lion's share of water use in the commercial and industrial sectors with a share of approximately 75%. Producing energy consumes a great deal of water, with water used at every stage of energy production, including pumping oil, removing pollutants in power plants, generating steam to run turbines, and in cooling power plants. According to the World Energy Outlook (WEO, 2018), in 2016, the energy sector withdrew around 340 billion cubic meters (bcm) of water and consumed roughly 50 bcm of water. The energy sector is responsible for the majority of water extraction, with the once through cooling systems in coal-fired power generation accounting for over one-third of energy-related water extraction. Primary energy production is responsible for more than two-thirds of water consumption, with the production of fossil fuels and biofuels responsible for roughly one third. In recent years, the extraction of shale gas oil wells has involved hydraulic fracturing, which requires significant volumes of water and causes additional greenhouse gas emissions compared to conventional gas wells. Approximately five million gallons of water are required to drill and frack a well, the equivalent of 1,000 water truck movements (Accenture, 2012).

The **textile industry** is known to be another intense consumer of water in the world. According to the U.S. Environmental Protection Agency (EPA), it takes 10,000 liters of water to produce a single pair of jeans[3]. Another water user industry is the **meat production and beverage industry**. According to the Water Footprint Network[4], nearly 130 liters of water is needed to produce the ingredients to make a single cup of coffee. The global **automotive industry** is another major consumer of water for various production processes. According to some estimates, producing a car uses over 39,000 gallons of water[5].

Water in **households** is mainly needed for cleaning, washing and personal hygiene. Water use in households varies enormously between different regions: while around 20 liters per capita and day are used in the rural arid regions in Africa, each person in the U.S. consumes an average of almost 300 liters per day[6].

Figure 2. Global Water Consumption by Sector



[2] Food and Agriculture Organization of the United Nations, http://www.fao.org/nr/water/aquastat/infographics/Withdrawal_eng.pdf
[3] Scientific American, "How big is your water footprint?", https://www.scientificamerican.com/article/how-big-is-your-water-footprint/
[4] Water Footprint Network, http://www.project-platforms.com/files/productgallery-new.php
[5] Automotive World est. 1992, "Water, water, everywhere in vehicle manufacturing", https://www.automotiveworld.com/articles/water-water-everywhere-vehicle-manufacturing/
[6] Water Uses and Human Impacts on the Water Budget, "Water demand and water use in the domestic and industrial sectors – An overview", http://www.klima-warnsignale.uni-hamburg.de/wp-content/uploads/2016/01/scheele_malz.pdf

What is Water Scarcity?

An ecosystem includes all living things (plants, animals and organisms), as well as their interactions with each other, and with their non-living environments (weather, earth, sun, soil, climate, atmosphere). Water is the most important component of an ecosystem, and is named as the power of the ecosystem. **Water need in the ecosystem** is also a vital component of the global water use.

Water is essential for all socio-economic development and for maintaining healthy ecosystems. Even though the amount of water on Earth has remained steady over the years, as population and the need in the groundwater and surface water for domestic use, agricultural use and industrial use increase, the pressure on water resources deepens. Thus, imbalances between supply and demand creates a global issue named **water scarcity.**

Water scarcity, an international term, is the point at which the total impact of all users strikes on the supply or the quality of water under viable institutional arrangements to the extent that the demand by all sectors cannot be fully satisfied[7]. Water scarcity involves water stress, water shortage or deficits, and water crisis.

Water scarcity can be separated into two: physical (absolute) water scarcity and economic water scarcity, where physical water scarcity is a result of inadequate natural water resources to supply a region's demand, and economic water scarcity is a result of poor management of the sufficient available water resources. Although water scarcity often occurs in areas with low rainfall, human activities add to the problems in particular areas with high population density, tourist inflow, intensive agriculture and water demanding industries.

According to a study conducted by Massachusetts Institute of Technology (MIT) researchers (Schlosser et al., 2014), approximately 50% of the world's projected 9.7 billion people is projected to bear moderately stressed water resource conditions by 2050.

Recently, water vulnerability is considered to be a growing threat for regions with uncertain political futures. According to an article by Julie C. Padowski (2015), water vulnerability is not only a concern but a fact in 119 low-income countries[8]. The results of the study show that water vulnerability was identified as a big issue in twenty-five countries. Jordan, Djibouti and Yemen were found to be the most vulnerable countries. Vulnerability arises from an overall lack of water resources and management issues and can often be reduced by economic investment (such as, desalination, importing water from distant locations). The study suggests that institutional issues, especially corruption, are the most common factors generating water supply vulnerability, affecting approximately 40% of the low-income nations. A lack of precipitation does not necessarily equate with water supply vulnerability. Another striking result of the study is that water vulnerability is becoming a crucial issue as the population increases.

Focus: Water Scarcity in Credit Ratings Decisions

In recent years, water scarcity has played a major role in corporate credit ratings decisions. According to a study by S&P Global Ratings (2018), water risk is a broad environmental factor, all-embracing water stress, water quality risks that generate water scarcity, weather events and other risks. As mentioned in the report, the impact of water risk on credit ratings can be both direct and indirect, such as through variable agricultural commodity prices creating supply chain risk. There were two categories of water factors studied, event-driven and continuous factors. Event-driven factors consist of droughts, heavy precipitation, water pollution and leakages, flood and poor water quality whereas, the continuous factors include inherent weather and water risks and issuers that offer water solutions. According to the study, water factors were considered in an important manner in 197 out of approximately 9,000 cases. Among these cases, 28 rating actions were found in which water factors were a key reason for raising and lowering ratings, revising outlooks and placing on CreditWatch. 33 out of 197 cases ended up with downgrades while only 24 of these cases resulted with upgrades. Table 1 details a breakdown of water-related rating actions between 2015 and 2017.

Table 1. Water-Related Rating Actions Breakdown

Positive Rating Actions	Number	Negative Rating Actions	Number	Neutral Rating Actions	Number
Upgrade	24	Downgrade	33	Ratings Affirmed	87
Outlook Revised to Positive	6	Outlook Revised to Negative	8	New Ratings Assigned	28
Outlook Revised to Stable from Negative	6	Outlook Revised to Stable from Positive	3	CreditWatch Developing Placement	-
CreditWatch Positive Placement	1	CreditWatch Negative Placement	1		

Source: S&P Global Ratings COP24 Special Edition: Shining A Light On Climate Finance (2018), TSKB Economic Research

[7] United Nations Department of Economic and Social Affairs (UNDESA), http://www.un.org/waterforlifedecade/scarcity.shtml
[8] Countries with GDP less than 10,725 USD in 2005 dollars are assumed as low-income countries.

How to Measure Water Scarcity?

Water scarcity has become an important issue in the world, and it is predicted to continuously expand over greater territories and to affect a greater share of the world population and environment. Since the end of the last decade, water scarcity research has attracted many shareholders, both public and private. Several indicators have been developed to point out the status of water scarcity around the world.

a. Falkenmark Indicator

In 1989, Swedish water expert Falkenmark developed the Falkenmark Water Stress Indicator (Malin Falkenmark, 1989), one of the most widely used indicators to measure water stress. The Falkenmark indicator is based on the measure of water availability per capita per year within the country or region.

The Falkenmark Indicator for a specific country/region is calculated by the ratio of the available water resources of the determined country/region to the number of people living in the specified country/region. In order to define the water stress and water scarcity, the classes were determined by Falkenmark.

$$\text{Falkenmark Indicator} = \frac{\text{Available Water Resources}}{\text{Population}}$$

Water availability of more than 1,700 m^3/capita/year is defined as the threshold above which water shortages only occur irregularly or locally. Availability below this level results in varying levels of water scarcity; volumes below 1,700 m^3/capita/year would involve water stress appearing regularly, while volumes below 1,000 m^3/capita/year indicate that water scarcity would be a limitation on economic development and human health and well-being; where volumes are less than 500 m^3/capita/year water availability is a main constraint to life.

Table 2. Falkenmark Indicator Classes

Index (m^3/capita/year)	Class Name
>1,700	No Stress
1,000-1,700	Stress
500-1,000	Scarcity
<500	Absolute Scarcity

Source: Macro-Scale Water Scarcity Requires Micro-Scale Approaches (1989), TSKB Economic Research

b. Withdrawal-to-Availability Ratio

Another index in order to measure the water scarcity is the Withdrawal-to-Availability (WTA) Ratio (Simon Damkjaer, 2017). The WTA is defined as the ratio of total annual withdrawals in a region to annual supply within the region.

Conducted as regional scales, a region is considered as having **"Medium Risk"** if its annual withdrawals are between 20% and 40% of annual water supply, and would be considered as having a **"High Risk"** if the ratio exceeds 40%.

$$WTA = \frac{\text{Total Available Withdrawals}}{\text{Annual Water Supply}}$$

Table 3. Withdrawal-to-Availability Ratio Classes

Index (%)	Class Name
<10%	Minimal Risk
10%-20%	Moderate Risk
20%-40%	Medium Risk
>40%	High Risk

Source: The Measurement of Water Scarcity: Defining A Meaningful Indicator (2015), TSKB Economic Research

Water Stressed Countries

Even though the Falkenmark Indicator depends negatively on the population, there are some populated countries with high Falkenmark Indicators **«higher being better»**. As presented in **Table 4,** some highly populated countries such as Russia, Brazil and the United States have higher Falkenmark Indicators meaning that they do not encounter water stress problems. Canada, a country known for its forests, has the highest Falkenmark Indicator due to its relatively low population. Even though China hosts one of the most abundant supplies of renewable freshwater resource in the world, China has a lower Falkenmark Indicator because of its high population. Despite a moderate level of renewable freshwater resources, Algeria is in absolute scarcity due to its population. Malta, an island country in the Mediterranean, faces absolute scarcity because of its low level of renewable freshwater resources. As presented in **Table 4**, Israel has the lowest Falkenmark Indicator within the group of countries detected. Even though Israel is home to more renewable freshwater resources than Malta, its relatively high population places Israel at the end of the list.

Table 4. Falkenmark indicators of Selected Countries

Country	Renewable Freshwater Resources (mcm)	Population	Falkenmark Indicator (2015)
Canada	2,902,000	35,832,513	80,988
Norway	289,927	5,166,493	56,117
Brazil	8,233,000	205,962,108	39,973
Russia	4,525,000	144,096,870	31,402
Croatia	114,550	4,225,316	27,110
Sweden	222,833	9,747,355	22,861
Serbia	159,185	7,114,393	22,375
Congo	1,283,000	76,196,619	16,838
Ireland	71,786	4,677,627	15,347
Bulgaria	105,982	7,202,198	14,715
Slovakia	66,601	5,421,349	12,285
Albania	30,818	2,885,796	10,679
United States	3,069,000	321,039,839	9,560
Hungary	91,697	9,855,571	9,304
Bangladesh	1,227,000	161,200,886	7,612
Switzerland	51,173	8,237,666	6,212
Nigeria	950,000	181,181,744	5,243
Netherlands	81,802	16,900,726	4,840
Spain	162,392	46,449,565	3,496
France	196,846	66,456,279	2,962
China	2,840,000	1,371,000,000	2,071
Romania	34,827	19,870,647	1,753
Germany	132,000	81,197,537	1,626
Turkey	111,990	78,741,053	1,422
Poland	40,797	38,005,614	1,073
Czech Republic	10,020	10,538,275	951
South Africa	51,350	55,291,225	929
Algeria	11,670	39,871,528	293
Malta	98	439,691	223
Israel	1,800	8,380,100	215

Source: EUROSTAT (2015), World Bank (2015), TSKB Economic Research

Current Situation in Turkey

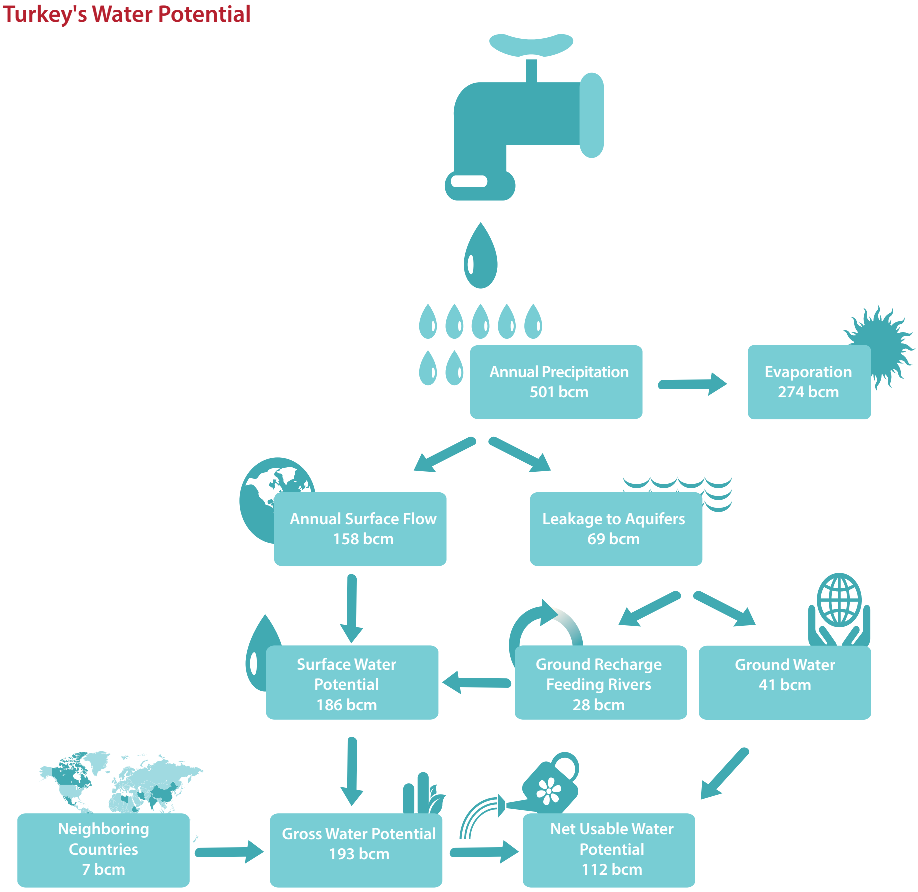
Despite its location, three sides surrounded by water, Turkey is known to be a **"water stressed"** country. Turkey is located in a **"semi-arid"** region with extreme temperatures. Turkey's water resources consist of natural lakes, rivers, reservoirs, and groundwater. There are more than 120 lakes, with Lake Van being the largest in area. Besides lakes, there are more than 700 reservoirs in Turkey. The largest reservoirs are Atatürk Dam, Keban Dam and Karakaya Dam.

The annual mean precipitation of Turkey stands at 643 mm, which is well below the global average. This amount corresponds to an average of 501 bcm of water per year. 274 bcm of this amount is returned to the atmosphere by evaporation while a 69 bcm feeds the groundwater through leakages. As a result, 158 bcm of water flows somehow into the seas and/or into the lakes in the closed basins via various sized streams. Twenty-eight bcm of leakages to the groundwater contributes to surface water through springs. With the inclusion of seven bcm of water from the neighboring countries, the gross water potential of Turkey is drawn as 193 bcm.

According to the General Directorate of State Hydraulic Works, the surface water potential, which can be consumed under current technical and economic conditions, is 98 bcm; 95 bcm from domestic rivers and 3 bcm from rivers from neighboring countries. With the addition of groundwater safe yield of 14 bcm, Turkey's net water potential is calculated as 112 bcm. Turkey aims to use the full potential of the net water potential until 2023.

As of 2017, the per capita water usable is 1,386 cubic meters[9], which was calculated as 1,422 cubic meters[10] in 2015. Looking at some other countries in Europe and in the World, Turkey is among those facing water shortages in terms of per capita usable water endowment. As a rule of thumb, a country with more than an annual of 5,000-cubic meter water potential per capita is accepted to be a **"water rich"** country. A country is known to be **"water stressed"** if the Falkenmark Indicator of the specified country is between 1,000 and 1,700 cubic meters per capita per year. "Water stressed" Turkey is expected to have 87 million population by 2023, which will bring the annual water potential down to 1,289 cubic meters per capita.

Figure 3. Turkey's Water Potential



Source: The General Directorate of State Hydraulic Works (DSİ), TSKB Economic Research

[9] Calculated with 2017 population of Turkey, 80,810,525.
[10] Calculated with 2015 population of Turkey, 78,741,053.

Water Use in Turkey

In parallel with global water use, most of the water used in Turkey is consumed by agricultural irrigation. The total water use in Turkey was recorded as 60.4 bcm in 2016, with 10.3% consumed by households and 18.4% by industrial sectors. Agricultural irrigation, which includes both groundwater and surface water usage, corresponded to 71.3% of the total water use in Turkey.

As presented in **Table 5,** an increase of approximately 50% was realized in water use between 2004 and 2016. Considering the effects of the rise in population and economic growth rate, there will be increasing pressure on Turkey's water resources in the future, provided that the existing resources are not depleted in 20 years. Therefore, Turkey will need to protect its water resources and use them efficiently in order to maintain a healthy and sufficient amount of water for future generations.

Table 5. Water Use in Turkey [11]

Year	Irrigation (bcm)	Households (bcm)	Industrial (bcm)	Total (bcm)
1990	22.0	5.1	3.4	30.5
2004	29.6	6.2	4.3	40.1
2008	33.8	5.8	6.0	45.6
2010	38.2	5.8	6.0	49.9
2012	41.6	6.0	8.4	56.0
2014	35.9	5.7	9.1	50.7
2016	43.1	6.2	11.1	60.4
2023	72.0	18.0	22.0	112.0

Source: The General Directorate of State Hydraulic Works (DSİ), TurkStat, TSKB Economic Research

For agricultural irrigation, Turkey has been using traditional methods, which prevent efficient use of water in agriculture. Conventional surface irrigation system is used for 94% of the irrigated area in Turkey, while modern sprinkler and drip irrigation systems are applied for the remaining 6% (Çağrı Muluk, 2014). The highest rate of water loss occurs through the conventional surface irrigation system.

In parallel with global trends, water use in Turkey for **energy production** has increased as energy demand has grown in Turkey. The share of industrial water use in Turkey has been increasing over the years from 11% in 2004 to 18% in 2016. The industries using water most intensively in Turkey are the **chemicals, petrochemicals, steel, textile, pulp & paper and food & beverages industries**.

Turkey aims to be able to fully use the current usable water potential of 112 bcm in 2023 up from 60.4 bcm in 2016. In addition to this, sectoral water use targets are determined as 64% in agriculture, 20% in industry and 16% in households. Including the usage of new irrigation techniques, 72 bcm of water is projected to be consumed in agricultural irrigation. Considering the population growth, urbanization and the rapidly developing tourism sector, it is predicted that the use of domestic water will reach 18 bcm in 2023 while water consumption in the industrial sector is expected to reach 22 bcm.

Regional Falkenmark Indicator in Turkey

Turkey comprises of 25 river basins with a total catchment area of 780,000 square kilometers. An average of 186 bcm of water flows into these river basins (DSİ, 2016). The Dicle-Fırat Basin, the largest basin with respect to its water potential, includes a number of large rivers within its catchment, resulting in a number of highly important water treatises between Turkey and its water-poor Middle Eastern neighbors. The Burdur and Akarçay Basins have the lowest water potential among the 25 basins.

[11] Irrigation values are the sum of surface and groundwater.

When expressed with the terms in the literature, some river basins are known to be "water rich" while the others are "water poor". Turkey's usable water potential is 112 bcm and its population in 2015 was approximately 78.75 million. Accordingly, Turkey's overall Falkenmark Indicator was calculated as **1,422.23 m^3/person/year in 2015**, placing Turkey as a country with a "Water Shortage". **In 2017, this value declined to 1,385.92 m^3/person/year due to the increased population.**

Table 6. Regional Falkenmark Indicators (2015)

Basin Name	Population (2015)	Usable Water Potential (bcm/year)	Falkenmark Indicator (m^3/person/year)	Definition
Meriç-Ergene	749,510	0.76	1,014	Water Shortage
Marmara	17,608,408	2.84	161.06	Absolute Scarcity
Susurluk	3,793,746	2.57	677.43	Scarcity
Kuzey Ege	1,112,098	0.88	791.3	Scarcity
Gediz	1,588,561	0.79	497.31	Absolute Scarcity
Küçük Menderes	4,168,415	0.46	109.15	Absolute Scarcity
Büyük Menderes	1,346,490	1.7	1,262.54	Water Shortage
Batı Akdeniz	908,877	3.87	4,258	No Water Stress
Antalya	3,341,962	7.03	2,103.55	No Water Stress
Burdur	680,105	0.17	244.08	Absolute Scarcity
Akarçay	709,015	0.31	437.23	Absolute Scarcity
Sakarya	7,262,833	4.03	554.88	Scarcity
Batı Karadeniz	1,879,209	5.09	2,705.93	No Water Stress
Yeşilırmak	2,721,221	3.1	1,139.19	Water Shortage
Kızılırmak	3,715,291	3.95	1,063.17	Water Shortage
Konya Kapalı	3,105,368	4.9	1,577.91	Water Shortage
Doğu Akdeniz	1,745,221	4.8	2,747.50	No Water Stress
Seyhan	2,183,167	3.55	1,626.08	Water Shortage
Asi	1,533,507	1.18	769.48	Scarcity
Ceyhan	1,609,483	3.81	2,367.22	No Water Stress
Dicle-Fırat	12,646,409	37.48	2,963.81	No Water Stress
Doğu Karadeniz	2,404,480	9.36	3,892.73	No Water Stress
Çoruh	246,920	4.46	18,064.15	No Water Stress
Aras	584,360	3.28	5,609.62	No Water Stress
Van Gölü	1,096,397	1.65	1,504.93	Water Shortage
Turkey (2015)	78,741,053	112	1,422.23	Water Shortage

Source: The General Directorate of State Hydraulic Works (DSİ), TSKB Economic Research, Author's Own Calculation

However, this is not the case for all river basins; due to the differing levels of population and water potential in each river basin, the Falkenmark Indicator differs significantly between the river basins. We, TSKB Economic Research, calculated the regional Falkenmark Indicators for each basin in Turkey, exhibited in **Table 6.**

In 2015, there were five river basins - Marmara, Gediz, Küçük Menderes, Burdur and Akarçay – which were facing an "Absolute Scarcity" problem. The biggest threat in the Marmara and Küçük Menderes River Basins was the population in the area. The Marmara region consists of parts of İstanbul, Kocaeli, Balıkesir, Bursa and Edirne. Among these cities, İstanbul and Bursa stand out with their high population.

The Susurluk, Kuzey Ege, Sakarya and Asi River Basins are classed as basins with "scarcity" problems with Falkenmark Indicators of between 500 and 1,000 m^3/person/year. If the population increases at the same rate in these basins, they will soon cross into the "absolute scarcity" category.

Seven out of the 25 basins are short of water. These include the Kızılırmak and Yeşilırmak River Basins, which each have major rivers. Most of these basins are likely to face "Scarcity" problems in the near future, due to increasing population.

Finally, there were nine river basins with no water problems in 2015. These were the Dicle-Fırat, Doğu Karadeniz, Aras, Antalya, Batı Karadeniz, Batı Akdeniz, Doğu Akdeniz, Ceyhan and Çoruh River Basins.

Withdrawal-to-Availability Ratio (WTA) by Municipality in Turkey

In addition to the Regional Falkenmark Indicator, water stress may be calculated through the withdrawal-to-availability ratio (WTA), which is the ratio of total annual withdrawals in a region to the annual supply within the region. We, TSKB Economic Research, calculated Municipality WTAs for both 2004 and 2016.

TurkStat Municipal Water Statistics have been used in order to calculate the WTA for each municipality in Turkey. The volume of water withdrawn is the water distributed to the final user (such as households, governmental organizations, commercial establishments, etc.) through the municipal water network. Water supplied is the water abstracted from resources (such as reservoirs, lakes, artificial lakes, rivers, springs, wells, the sea, etc.) by municipalities in order to be distributed through water networks.

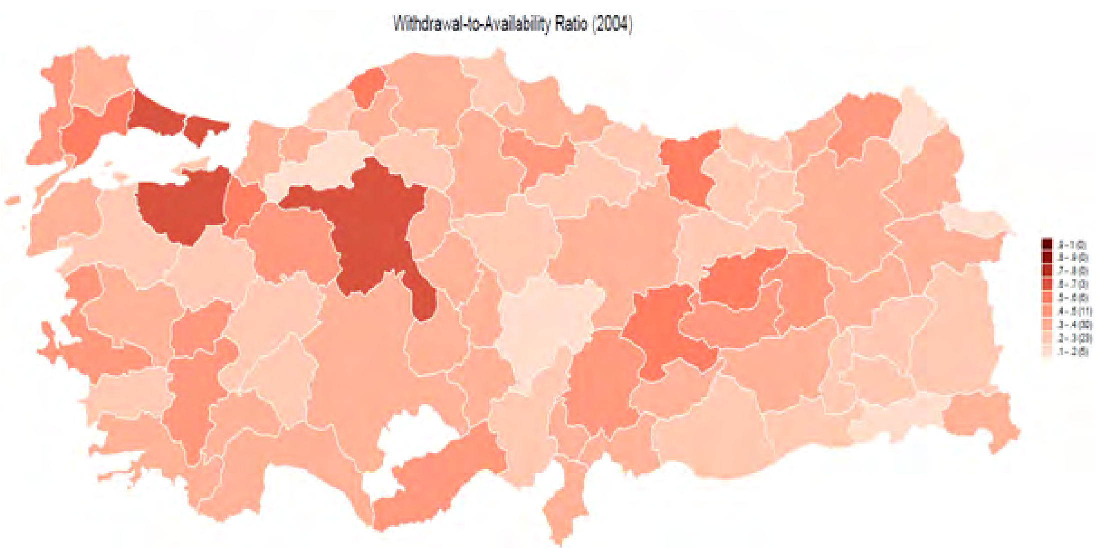
While the Falkenmark Indicator calculates the water potential per capita in a given region, the WTA offers an indication of how efficiently water is used within the municipality. Municipal Water Statistics exclude agricultural water use.

When the water use, with the exception of agricultural use, is analyzed by municipality, it is seen that Western Municipalities have been struggling over the years, mostly due to increased migration and a growing manufacturing industry.

$$\text{WTA} = \frac{\text{Withdrawal}_{\text{Households}} + \text{Withdrawal}_{\text{Gov. Org.}} + \text{Withdrawal}_{\text{Commercial}} + \text{Withdrawal}_{\text{OthersPopulation}}}{\text{Supplied}_{\text{Dam}} + \text{Supplied}_{\text{Sea}} + \text{Supplied}_{\text{River}} + \text{Supplied}_{\text{Lake}} + \text{Supplied}_{\text{Spring}} + \text{Supplied}_{\text{Well}}}$$

Graph 2 details the WTA of the municipalities in 2004 by TSKB Economic Research. Turkey's average WTA was calculated as 40.2% in 2004, having crossed the critical threshold of 40%. As presented in the map, there are only a few municipalities with a WTA of more than 60% WTA; these include Bursa (64.9%), Ankara (62.8%) and İstanbul (62.7%). In 2004, there were 61 municipalities with a WTA below the Turkey average.

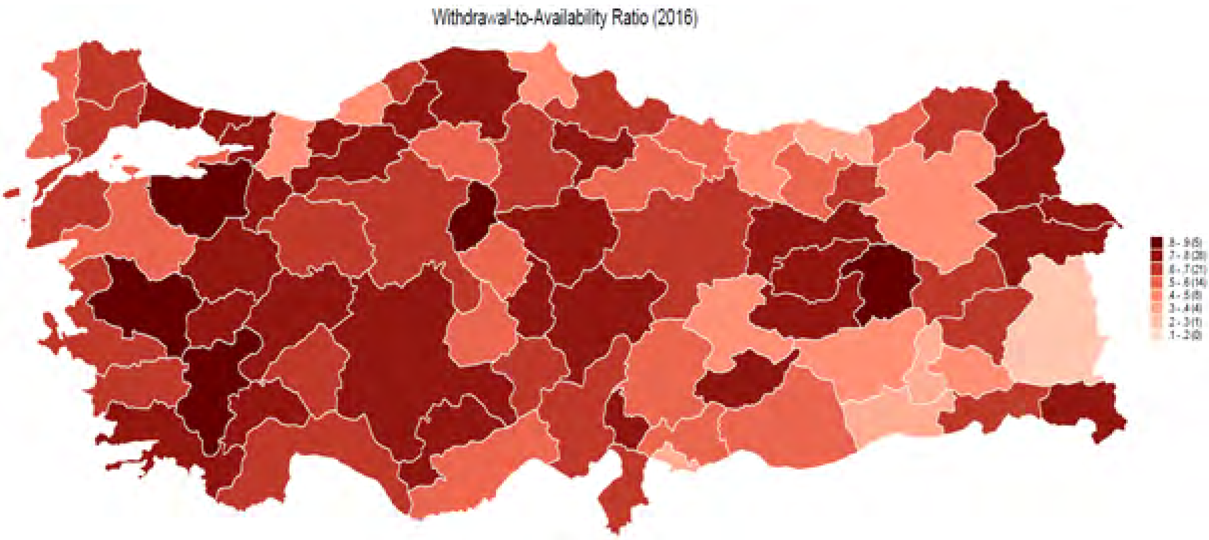
Graph 2. Withdrawal-to-Availability Ratio by Municipality (2004)



Source: TSKB Economic Research, Author's Own Calculation

An analysis of 2016 data paints a different picture. Over the last 12 years, Turkey's average WTA has increased to 64.9% with 46 municipalities having WTAs above the national average. In 2016, there were only five municipalities with a WTA less than 40%; Van (25.1%), Kilis (32.2%), Trabzon (32.8%), Batman (34.2%) and Mardin (35.7%).

Graph 3. Withdrawal-to-Availability Ratio by Municipality (2016)



Source: TSKB Economic Research, Author's Own Calculation

As presented in **Graph 3**, 76 of Turkey's 81 municipalities were in the **"high risk"** category in 2016.

Reasons for Regional Water Scarcity in Turkey

The reasons come in two categories; the supply side and the demand side. On the supply side, it is principally climatic reasons, such as precipitation, evaporation, soil erosion and desertification, which stand out. Precipitation and evaporation amounts are based on the climate change in the world. Since climate change is a global issue, Turkey will be affected through volatility in precipitation and evaporation amounts. Both soil erosion and desertification are the result of not having enough trees.

Flawed agricultural decisions and the low levels of water storage are the other two factors, which could be included in the supply side. Flawed agricultural decision are caused by having more water intensive crops planted in more water stressed regions.

The low level of water storage was also a reason for water scarcity in Turkey before the turn of the century; since the new millennium, a significant number of dams were constructed in river basins that resulted in a significant increase in the amount of stored-water.

On the demand side, the reasons for regional water scarcity consist of regional low-income levels, regional aggregation of water intense industries, inefficient irrigation methods and water losses due to a lack of investment in water networks and pipelines. Turkey has been facing regional aggregation of water intense industries, especially in the Western part of Turkey. Many industries are located in regions close to the sea and close to the airports for economic and logistical reasons. Population also moves with these industries.

What Actions are Needed to Reduce Water Scarcity?

Reducing water scarcity is a goal for many countries. In Turkey, water management is centralized. Water scarcity can be reduced mainly with synchronized public-private actions. The main actions would be to take collective measures and create awareness to improve savings in water consumption. Another possible action that the Government could take is to draft appropriate legislation and incentives aimed at increasing water efficiency in agriculture and industry.

Population intensity is another reason for water scarcity. Water scarcity could be reduced by migration to low populated areas, which could be performed by moving industrial employment from populated regions to non-populated regions.

Since the agricultural irrigation is the major contributor to water use in Turkey, any improvement in irrigation would directly affect the amount of water consumed. The use of sprinkler irrigation method and drip irrigation method may be increased to boost efficiency. As a rule of thumb, the sprinkler irrigation is considered to use 70% less water and the drip irrigation method 90% less than conventional methods.

Another solution for reducing water scarcity is agricultural planning with respect to water potentials of river basins. As mentioned earlier, not every river basin in Turkey is water rich. In order to achieve more efficient agricultural planning, each agricultural product should be analyzed with its water need and be planted in accordance with its water use.

Climate change and water scarcity are two phenomena, which will cause some of the biggest challenges to the economies. These two have a reciprocal relationship, identified by the Intergovernmental Panel on Climate Change (IPCC), in which, "water management policies and measures may influence greenhouse gas (GHG) emissions." Since one of the largest industries to use water intensively is the energy sector, the savings in water use can be carried out by producing alternatives to thermal power plants, such as bio-energy crops, hydroelectric and solar power plants.

The improvement of water networks and pipelines is likely to be a key focus, as will water treatment and sanitation plants. Meanwhile, the municipalities need to increase investment on reducing theft and loss ratios.

Water sewage and wastewater treatment is an integral part of the fight against water scarcity. In order to achieve holistically managed ecosystems, governments and communities should operate sewage treatment plants while clean energy producers use wastewater to fertilize algae and other biofuel crops.

Regarding household water use, it is imperative that governments, households, private sector players and municipalities invest more in education on the water scarcity problem, make regulations with respect to inefficient water consumption and guide households on how to reduce the water consumption with increased awareness and appliances.

Water Efficiency and Sustainable Development Goals

Water, the precious environmental resource, is vital to ensure the population's well-being and quality of life and to preserve the rural-agricultural sector. Turkey's regional water problem will worsen as its population increases. Therefore, action must be taken today.

In the light of these aforementioned facts, it is essential that **we have more efficient water management.** The Government and private sector players should invest in water efficiency in order to attain **extended regional water life, lower income disparity, greater employment, financial stability, migration back from metropolitan areas, limited climate change and sustainable and healthy ecosystems[12].**

Fighting with water scarcity is directly and indirectly related to the following sustainable development goals. Sustainable Development Goal 6 aims to ensure access to water and sanitation. Sustainable Development Goal 8 helps to promote inclusive and sustainable economic growth and employment. By efficient water management, economic growth and employment can be distributed more evenly. The main goal of Sustainable Development Goal 10 is to reduce inequality within regions and countries. Recently, climate change has become a global issue. Sustainable Development Goal 13 aims to combat climate change and its impacts. Efficient water management helps to achieve this goal by reducing flawed agricultural decisions.

[12] https://sustainabledevelopment.un.org/?menu=1300

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