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DROUGHT IN TURKEY

Levent Kurnaz

Drought is primarily caused when a geographic region receives little rain for an abnormally long time. A meteorological drought occurs when a drought is combined with increased temperatures and lower humidity. A drought can turn into an agricultural drought when irrigation water and soil moisture are insufficient for agriculture A hydrological drought develops when there is a reduction in river flow and underground water. Turkey is currently experiencing a severe meteorological drought in 2013-2014. The drought we have recently been experiencing is progressing from a meteorological drought to an agricultural and hydrological drought due to a significant reduction in the winter precipitation. The increased frequency and severity of meteorological droughts in Turkey are caused by changes in global climate patterns. We can expect global climate changes will bring about drought as a normal part of daily life. As a result, Turkey needs to make plans for its drinking water requirements, meet its demand for hydroelectric energy from sustainable alternatives, and implement agricultural irrigation methods that can withstand droughts.

April 2014

IPC | ISTANBUL POLICY CENTER
SABANCI UNIVERSITY
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Cover Design: MYRA; Implementation: grafikaSU
1.Edition: 2014
Printed by: Ege Reklam Basım Sanatları Ltd.Sti.
ISBN 978-605-4348-80-0

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Levent Kurnaz*

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What is Drought?

The United Nations Intergovernmental Panel on Climate Change (IPCC) is composed of scientists and government representatives who are actively researching climate change. Since climate change was included in the global agenda in the 1990s, IPCC has been reviewing all relevant published scientific studies and preparing reports that inform the public about the current status of climate change. The latest report on the physical basis and effects of climate change published in September 2013 leads us to alarming conclusions about the expected changes in Turkey and the Mediterranean basin. The most striking conclusion is related to the anticipated continuation of the existing drought experienced in our region.

Drought is defined as a natural event that occurs when the amount of precipitation is significantly less than normal, causing severe hydrological imbalances that negatively affect land resources and production systems.[1]

Four main approaches can be used to measure drought: Meteorological, agricultural, hydrological, and socioeconomic drought. In contrast to the other three approaches, socioeconomic drought does not study the measurable physical factors instead it studies the effect of drought on socioeconomic systems.

Meteorological drought develops based on two main factors. The first factor is a naturally expected change in precipitation patterns, which is when a region receives below-average precipitation for a period longer than normal. Below-average precipitation causes a drop in river and underground water levels and reduced soil moisture. Other factors associated with meteorological drought include high temperatures, increased wind speeds, low humidity, and fewer clouds leading to increased evaporation. In other words, the primary causes of meteorological drought are not only a decrease in precipitation but also higher temperatures and a decrease in humidity, all of which result in increased moisture loss.

However, agriculture is only affected by the loss in soil moisture if the changes in the region's precipitation and temperature patterns extend over a period of time longer than a meteorological drought. In other words, even if the moisture in the air and the amount of precipitation the soil receives are reduced, the water in the ground is not immediately lost.

For this reason, **agricultural drought** usually occurs after a long period of meteorological drought and may cause severe reductions in agricultural yield.

Because there are periodic changes in humans' needs for activities requiring water such as agriculture and energy production, meteorological drought may not occur at the same time as **hydrological drought**. Hydrological drought is defined as a reduction in the flow of rivers as well as a drop in the level of dams, lakes, and underground water. Since people decide when to use water, the point at which the water input decreases may not be the same as when people need water and realize that it is not available.

Socioeconomic drought constitutes the effect of drought on agriculture and living beings as well as its effect on water sources and on industries that use these resources. In this context, we need to study the economic, social, and environmental effects of drought from a holistic perspective. [2]

Previous Droughts in Turkey

When looking at changes in precipitation annually and during the winter season (when rain and snow are more frequent in Turkey), the longest and most severe droughts in the past 40 years occurred in 1971-1974, 1983-1984, 1989-1990, 1996-2001 and 2007-2008. [3-12] The longest of these

droughts began as meteorological drought and later developed into agricultural and hydrological drought. During the most recent drought of 2007-2008, which began in November/December 2006 and continued until December 2008, many areas in Turkey experienced below-average precipitation for long periods of time, particularly during the fall and winter months. [13] This caused a series of new meteorological droughts, followed by agricultural, hydrological, and socioeconomic droughts (for example, losses in agricultural yield, shrinking and insufficient underground and above-ground water sources, and water rationing and drinking water shortages in large cities like Istanbul and Ankara). The effects of the drought in 2007-2008 were felt in the Marmara, Aegean, Central Anatolian, and Mediterranean regions of Turkey. Attempts were made to overcome water shortages in large cities by transferring water from sources such as the Melen and Kızılırmak rivers.

The simplest way to scientifically study droughts is to investigate the reduction in total precipitation and the number of days with precipitation. However, there are a variety of indices and methods used to identify, quantify, and monitor droughts.

Some drought indices are based on precipitation series and are related to meteorological droughts, while others measure hydrological or agricultural droughts and water deficits in urban water supply systems. The most commonly-used drought indices used around the world today include the Standardized Precipitation Index (SPI), the Normalized Precipitation Anomaly Index (NPAI), the Palmer Drought Severity Index (PDSI), and rainfall deciles. [13]

Figure 1 shows the severity and the distribution of drought regions during the drought observed from November/December 2006 to December 2008 based on the Modified Standardized Precipitation Index (MSPI). [10] This map clearly shows the severe, long-lasting drought that hit the western and southern regions and the inland regions to the north, which usually receive precipitation during the fall, winter, and spring [7] MSPI values for the 360 months prior to December 2008 (Figure 1d) is arguably a more important factor. The MSPI values highlight the fact that there has been a trend in drought in the past 30 years in Turkey's western and southern regions, which fall under the Mediterranean precipitation regime.

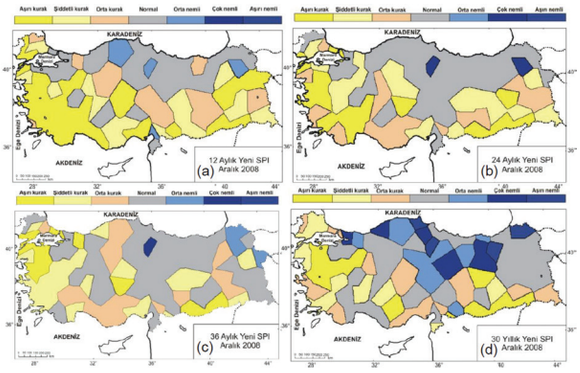


Figure 1: December 2008 12-month data (a), December 2008 24-month data (b), December 2008 36-month data (c) and December 2008 30-year (360-month) data for the geographical distribution of drought (moisture) across the regions of Turkey. [7]

What are the Causes of Drought in Our Region?

Solar energy is not evenly distributed across the earth as it warms the equatorial region more than the poles. As a result, air at the equator warms and rises, causing a low-pressure zone. In contrast, air cools at the poles and descends, causing high-pressure zones. Although air rises from the equators and moves toward the poles, the rapid rotation of the earth keeps the air from reaching the poles. The air sinks downward at around 30˚ latitude in the northern and southern hemispheres, causing another high-pressure band to form at

those latitudes (Figure 2). Although this high-pressure band and its causes are not discussed in much detail in our education system, they might explain the presence of deserts and drought zones. The best-known deserts in the world are caused by this movement in the atmosphere, such as the central latitudes of the Arabian Peninsula, the African Sahara, Namibia and northern South Africa, the states of Arizona and New Mexico in the USA, and central Australia.

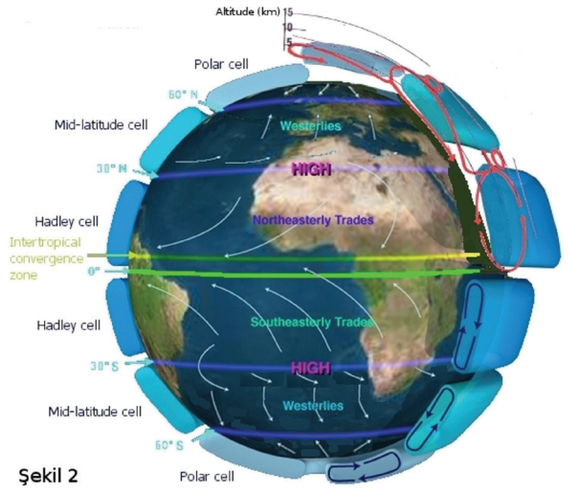


Figure 2: Major air currents in the world's atmosphere (Wikimedia Commons)

Perhaps the major consequence of climate change with regard to Turkey and the Mediterranean region is the northward shift of this high pressure band to around 30 ° latitude as the world's average temperature increases. [14-17]

The implications for Turkey are clear. The country's central, southern, and southeastern regions are currently in a semi-arid climate band and are faced with the risk of desertification. Climate change will continue to have a greater impact, turning the climate of the southern half of Turkey into a climate similar to that of Syria and Iraq, while the climate of central and northern Turkey will become similar to the current climate of southern Turkey. For Turkey, this means there will be an increased risk of drought and desertification throughout the country.

Winds that bring moisture from the Atlantic Ocean are the most significant source of precipitation for Europe. The direction and force of these westerly winds are determined by a low-pressure center located over Iceland and a high-pressure center located over the Azores. The locations and relative severity of these systems change from year to year with no particular periodicity. This change is called the North Atlantic Oscillation (NAO). The positive phase of NAO occurs when the high pressure centre over the Azores causes stronger winds from the Atlantic Ocean. These moisture-bearing winds bring precipitation to northern and southern Europe (Figure 3a). In the negative phase, winds reach Turkey via the Mediterranean, causing an increase of precipitation (Figure 3b). For this reason, most of the severe and extensive winter droughts in Turkey occur when the NAO has a strong positive index phase. [8, 9, 13] As a result of the increased severity of climate change, the NAO index will remain positive for longer periods of time and a higher index. [18] It is predicted that this will in turn cause reduced precipitation in the Mediterranean region. [19]

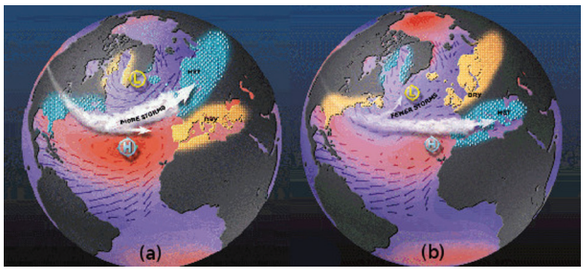


Figure 3: North Atlantic Oscillation (a) positive (b) negative phase.

The Drought of 2013-2014

The above-average precipitation levels in Turkey in the years following the drought of 2007-2008 led to a weakness in drought preparedness. For the reasons described above, the norm in Turkey is expected to shift from precipitation to drought. As proof of this, meteorological droughts began to be felt in 2012 in some inland areas of central and eastern Anatolia. These droughts combined with dry summers, which are normal for the Mediterranean climate, caused droughts in 2013 that varied from moderate to severe across large areas of Turkey (Figure 4 and 5). [13] The cumulative precipitation for all of Turkey between October 1, 2013 and January 17, 2014 was 37.0% less than the long-term average and 47.4% less than the average for 2013. [13] Figure 5 shows how the drought, which began in 2012 in the inland regions of central and eastern Anatolia, spread to the central Mediterranean, eastern Mediterranean, eastern Marmara, and central Black Sea regions in 2013.

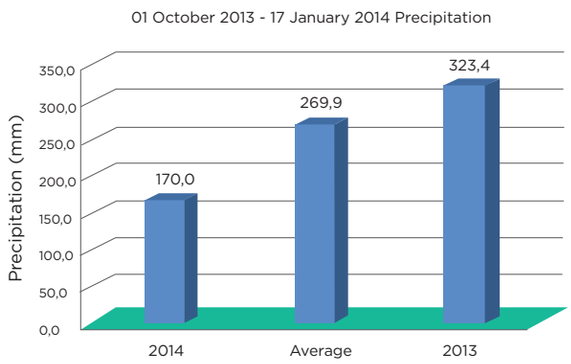


Figure 4: Comparison of the total precipitation for all of Turkey between October 1, 2013 and January 17, 2014 with the long-term average and the 2013 average. [13]

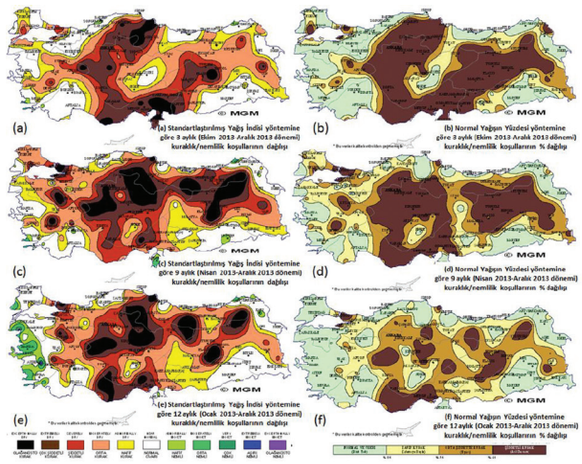


Figure 5: Geographic distribution patterns for Turkey of drought/moisture conditions (high and low precipitation anomalies compared to the long-term average and normal precipitation) calculated for 3 months (October 2013-December 2013), 9 months (April 2013-December 2013) and 12 months (January 2013-December 2013) of 2013 based on the Standardized Precipitation Index (SPI) (maps a, c and e) and the Normal Precipitation Percentage methods (maps b, d and f). [13]

The meteorological drought that began in 2012 began to affect sources of drinking water, agricultural irrigation, and other hydrological systems used to generate electricity. Data from the State Water Works General Directorate indicates that as of January 2014, 12% less water had accumulated behind the dams that provide drinking water to the four largest provinces (Istanbul, Ankara, Izmir, and Bursa) compared to 2013. Of these cities, only Izmir's dams had a water level higher than those recorded in January of 2013. The water level of Istanbul's dams had dropped to half of what they were the previous year. [13] Data from the State Water Works also reveal that the water level of 88 dams currently used to generate electricity was at 44.6% in January 2014. These dams are located in 18 different drainage basins, and the dams in 14 of those basins had water levels

lower than in 2013. The water level of 204 dams currently used for irrigation is 45.5%. In this case, the water levels of 19 out of 23 different drainage basins are lower than that of the previous year. [13] In particular, the water level of energy-generating dams in the eastern Mediterranean, western Mediterranean, Antalya, Seyhan, and Marmara drainage basins are approximately 60% less than the previous year. This fall in water level is the result of an overall drop in precipitation in these regions, which caused reduced water flow to the reservoirs in these basins.

The Effects of Climate Change

It is important to note that climate change will bring drier weather and increased temperatures to the Mediterranean region where Turkey is located. According to the IPCC RCP 8.5 scenario, this temperature increase is expected to be 2˚C (especially during the summer and in southeastern Turkey) in 2020-2050 compared to the average temperatures during 1970-2000 (Figure 6).

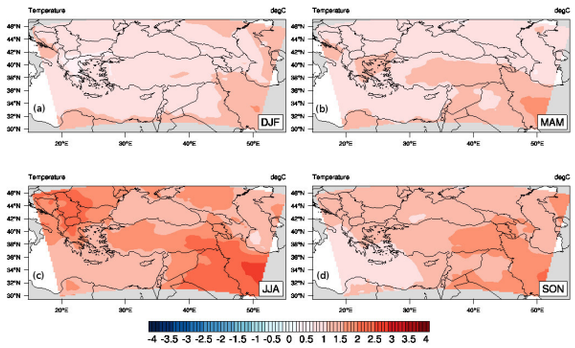


Figure 6. Geographical distribution patterns of average air temperature changes for Turkey and its environs calculated for the (a) winter, (b) spring, (c) summer and (d) fall seasons of 2020-2050 according to the climatology of the RegCM regional climate model's 1970-2000 reference period, based on the output of the RCP 8.5 emissions scenario in the Max Planck Institute's Earth system model MPI-ESM-MR.

When looking at total precipitation forecasts for 2020-2050 in Turkey compared with the climatology of Turkey from 1970 to 2000, a simulation carried out using the MPI-ESM-MR (Max Planck Institute) climate model and the RCP 8.5 emissions scenario predict that precipitation will to drop by 2 mm/day (negative change) in southern Turkey in the winter and spring seasons but will increase by 0.8 mm/day (positive change) in the southeast during the winter season. In contrast, it appears that precipitation during the summer will change only slightly in the negative direction, while there will be milder changes in the spring and fall than in the winter (Figure 7).

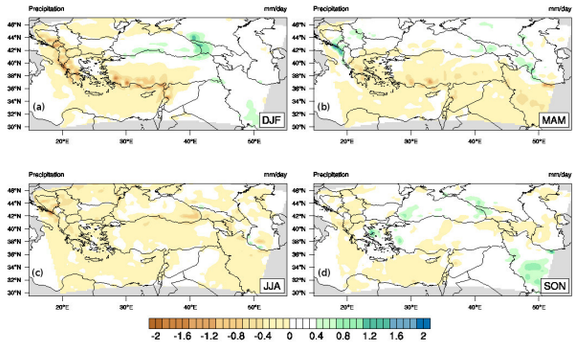


Figure 7. Geographical distribution patterns of total changes in precipitation for Turkey and its environs calculated for the (a) winter, (b) spring, (c) summer and (d) fall seasons of 2020-2050 according to the climatology of the RegCM regional climate model's 1970-2000 reference period, based on the output of the RCP 8.5 emissions scenario in the Max Planck Institute's Earth system model MPI-ESM-MR.

It is clear that Turkey will be at a higher risk of experiencing meteorological droughts as well as these droughts turning into agricultural and hydrological droughts in the near future.

When we look at soil moisture at plowing depth (Figure 8), an important factor for agricultural drought, it is apparent that the level of soil moisture is falling in most locations in Turkey when plants are sprouting, which is when seeds need the most moisture. Because of the loss of soil moisture, agriculture can only be sustained with irrigation in addition to precipitation. However, as

mentioned previously, meteorological drought not only reduces the amount of water in dams used for irrigation, it also speeds up the rate of loss of moisture from the soil through condensation and evaporation. Because of these conditions, Turkey's agricultural sector will face hard times in the next 30 years.

Taking control of agricultural water usage as soon as possible is the only way Turkey can endure this imminent agricultural problem with minimum damage. Every year approximately 70% of Turkey's fresh water sources are used for agricultural irrigation. A significant amount of this irrigation is done by simply letting water flow onto the fields. When we consider the losses in irrigation canals and the evaporation of water from the surface of the fields, it is apparent that a significant amount of our fresh water reserves is being wasted. There are two important precautions that need to be taken. The first is to minimize water losses in irrigation channels by switching to enclosed water canals. The second is to use more effective irrigation methods in order to stop wasting water. In order to determine the efficiency of the system, we first need to be able to measure the amount of water used. Farmers oppose this measurement, fearing it will lead to future water rationing. However, the fact that we do not measure the water used for agriculture means that it is impossible to measure productivity or any increase in productivity. The starting point for improving the system is to correctly identify the current status so that any steps we take in the future can be measured. Humans started tilling the ground thousands of years ago in this part of the world. Until now, it was possible to raise crops primarily with rain water and a small amount of irrigation because there were few droughts. Current economic conditions, the increase in population, and the impact of climate change render it impossible to continue using agricultural methods that have been around for thousands of years. As a result, new agricultural systems need to be developed urgently and our agricultural processes must be adapted to the dry world we now live in.

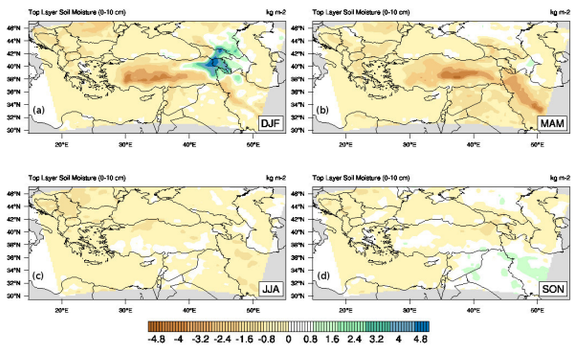


Figure 8. Geographical distribution patterns of changes in soil moisture at plowing depth for Turkey and its environs calculated for the (a) winter, (b) spring, (c) summer and (d) fall seasons of 2020-2050 according to the climatology of the RegCM regional climate model's 1970-2000 reference period, based on the output of the RCP 8.5 emissions scenario in the Max Planck Institute's Earth system model MPI-ESM-MR.

Conclusion

As we have described above, a variety of meteorological data and drought indices indicate that after going through a drought in 2007-2008, Turkey is now experiencing a significant meteorological drought in 2013-2014. The drought we are currently experiencing is progressing from a meteorological drought to an agricultural and hydrological drought due to the significant drop in winter precipitation. Because of imminent climate change, we can expect these droughts to change in the long term from simply being a periodic natural event to becoming part of daily life. As a result, we must not only make plans for Turkey's drinking water, but also shift the demand for hydroelectric energy to alternative energy generation systems that can handle the reduction in precipitation as well as bring agricultural irrigation methods in line with drought conditions.

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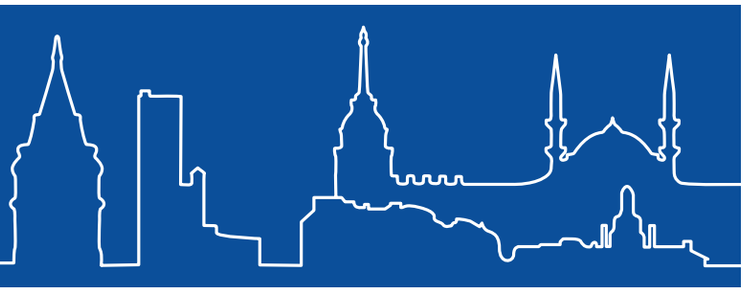
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ISBN 978-605-4348-80-0

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