

CAN WE PREDICT WHEN DROUGHTS WILL HAPPEN, OR AT THE VERY LEAST, SEE THE SIGNS OF ONE AND EXPECT IT, IS THERE A PATTERN OF WHEN THEY HAPPEN?



CLIMATE DETECTIVES



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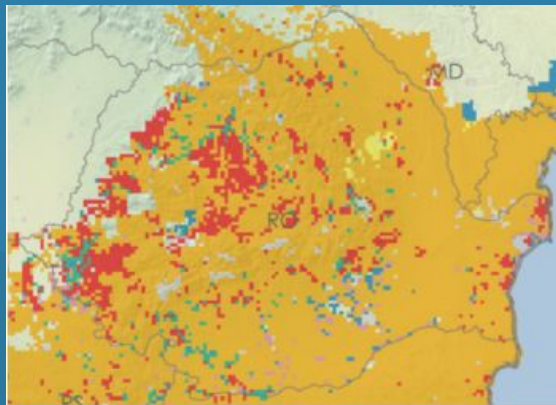


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INTRODUCTION

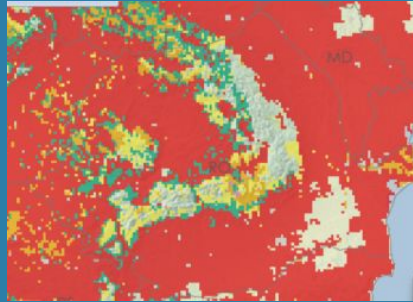
As part of our project, our research team collected a series of significant droughts that have taken place in Romania over the past two decades. Our aim was to link these events with pertinent climate change issues identified during the same period. Therefore, reflecting on the period from 2001 to 2023, it is evident that Romania has faced a number of drought-related challenges. Beginning in 2001, the first five months of the year saw the entire country teetering on the brink of drought, with small portions of Banat, Crisana, and Transylvania being on alert.



March 2001

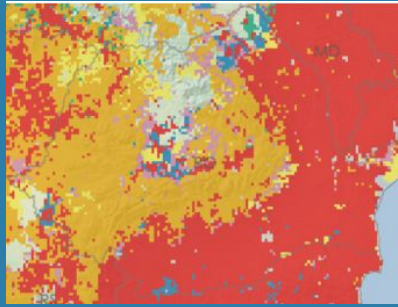
Source: [Geographic MapViewer - European Drought Observatory - JRC European Commission](#)

Despite some recovery of the soil, the southern region of Romania was hit hard by drought in the latter half of 2001, with an alert declared for the entire zone by July 2002. While the year ultimately ended on a positive note, with favorable conditions continuing into the following year, the respite was short-lived, as Romania was once again placed on alert for the next seven months due to drought.



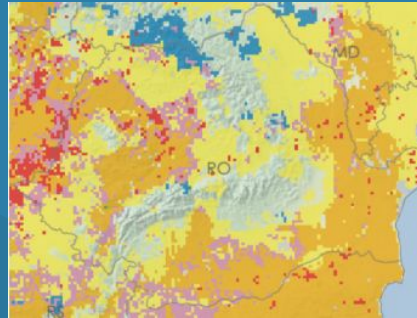
May 2003

Out of the years mentioned above, 2004, 2005, and 2006 were relatively mild in terms of drought occurrences, with minimal instances recorded during this period. However, this trend was short-lived, as droughts gradually returned, beginning with the regions of Muntenia and Oltenia and eventually spreading across the country.



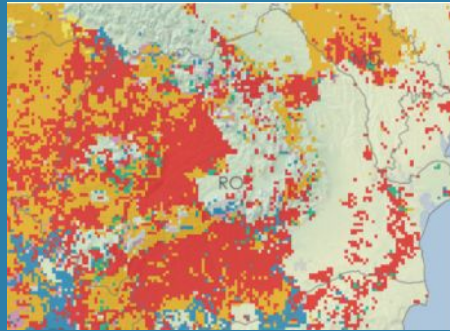
August 2007

Following this period of relative stability, there were no major droughts recorded in Romania up until the middle of the year 2009.



June 2009

After the drought-free period up until mid-2009, Romania experienced a period of seasonal and relatively mild droughts until November of 2011. However, this period of relative calm was shattered by the onset of severe droughts from November 2011 to January 2013, with warnings and alerts being issued every month during this time period.



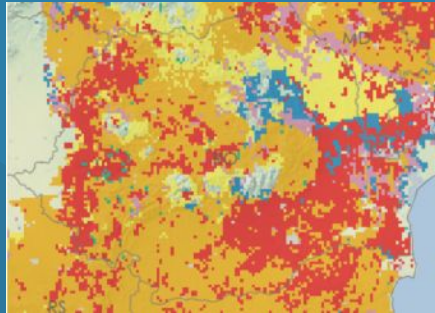
April 2012

In the two years following the severe droughts of 2011-2013, the regions most affected by droughts in Romania were Crisana, Banat, and Maramures, with Moldova also experiencing some impact for a brief period. Around the middle of 2015, the country as a whole was once again hit by a two-month period of droughts.



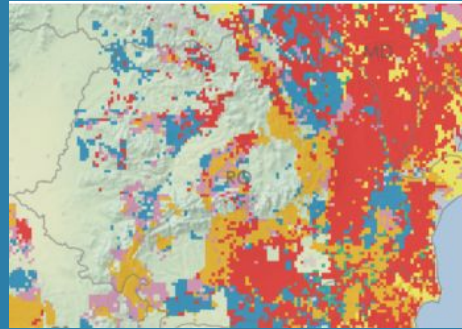
September 2015

From the beginning of 2018 up until the end of that year, Romania experienced only minor droughts affecting small areas for brief periods. However, towards the end of 2018 and the beginning of 2019, the country once again saw warnings and alerts issued due to worsening drought conditions. This trend continued into the end of 2019, with the country grappling with the effects of droughts during this period as well.



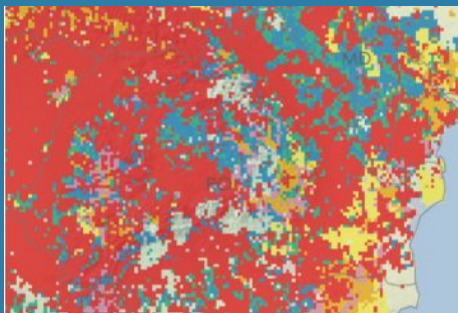
October 2019

The year 2020 was marked by numerous warnings and alerts throughout Romania, with the entire country impacted by drought conditions at various points during the year. By the end of the year, the eastern region of the country was particularly hard-hit by these conditions.



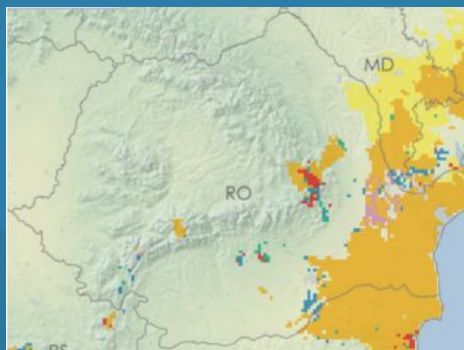
October 2020

Following the difficult year of 2020, Romania experienced a period of relative respite from major droughts until October of the following year, when a new drought struck the southern part of the country. From April to October of 2022, warnings and alerts regarding drought conditions were once again widespread across the country.



September 2022

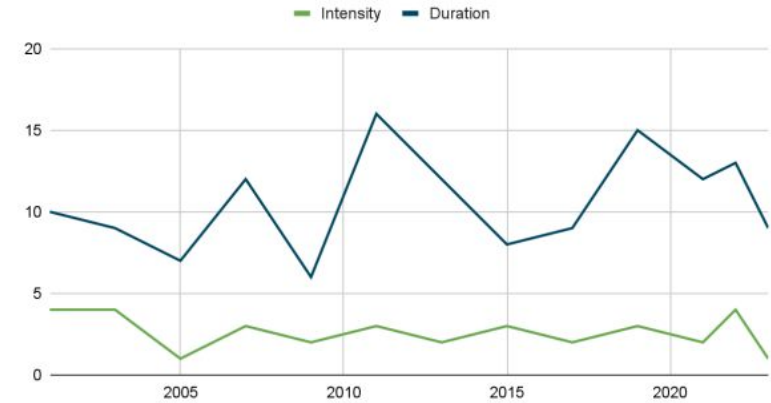
As of the current year, 2023, the only region of Romania that has been significantly affected by droughts is Dobrogea. However, it is important to note that the year is still ongoing and conditions may change over time.



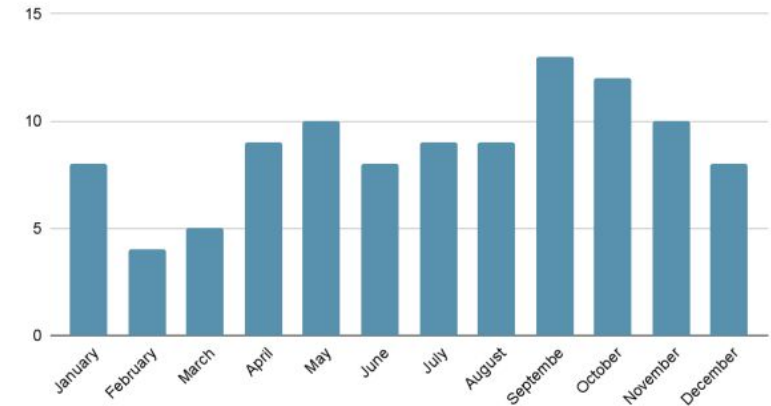
March 2023

The following graphs provide a summary of the information presented. The first graph is organized to display the intensity of droughts (measured on a scale of 1 to 4) and their duration (measured on a scale of 1 to 24, representing the number of consecutive months affected). The best years in terms of drought conditions were 2005-2007, 2009-2011, and 2023. The second graph shows that the most heavily impacted months are September and October, while February and March are the least impacted. Surprisingly, despite expectations that the summer months would be the most prone to droughts, this does not appear to be the case.

Each year



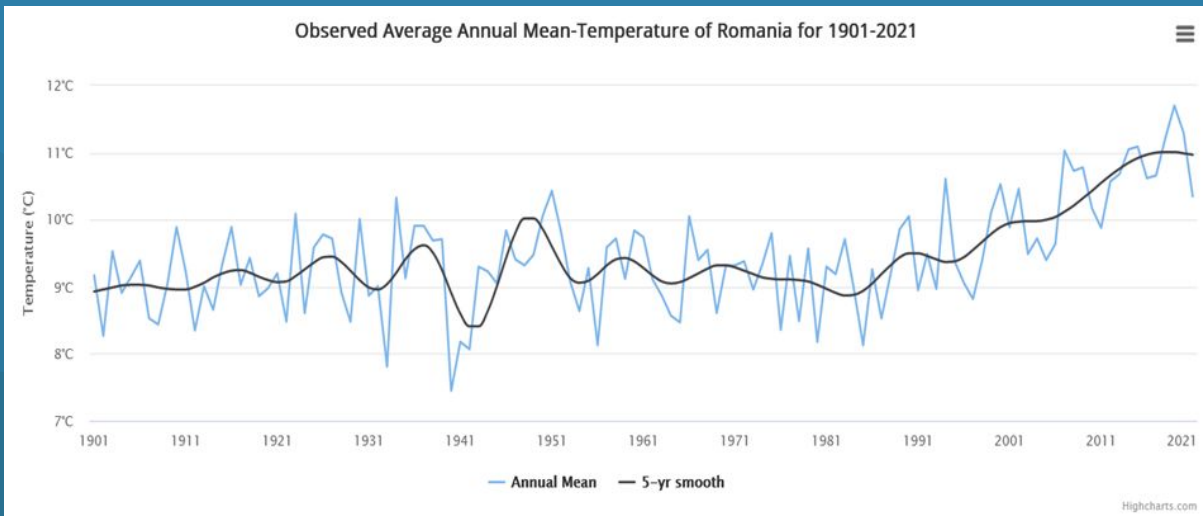
Each month

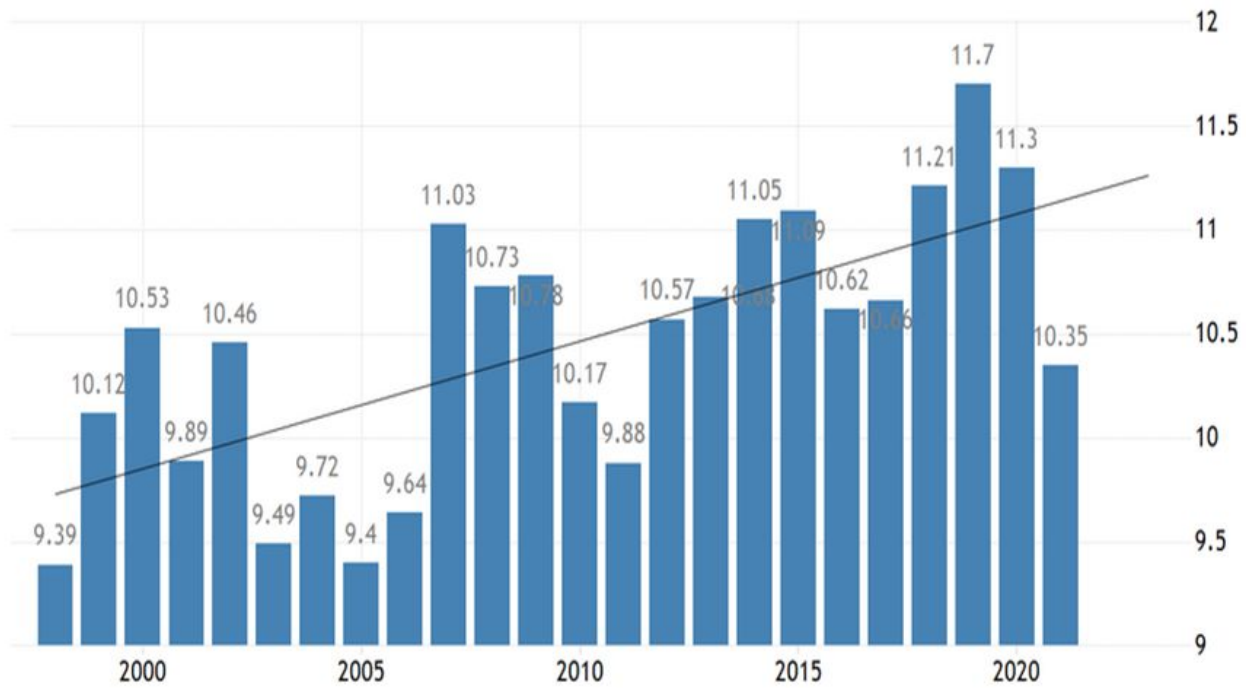




TEMPERATURE LEVELS

The first climate change issue that was studied was the temperature levels. As depicted in the following graphs, the temperature levels have steadily increased over the selected period of time. Furthermore, the higher values recorded in the last few years help to explain why droughts are more severe today than in the past.



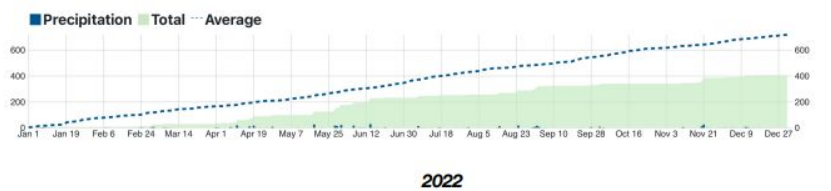
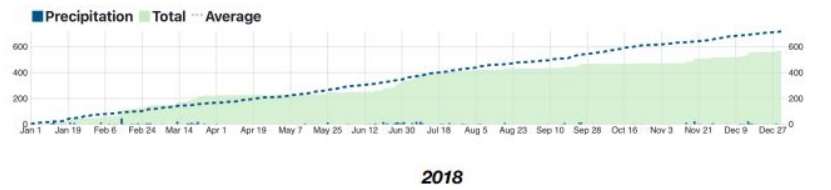
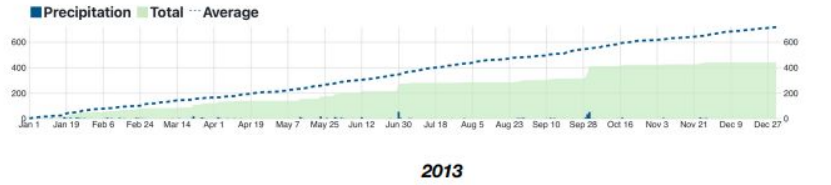
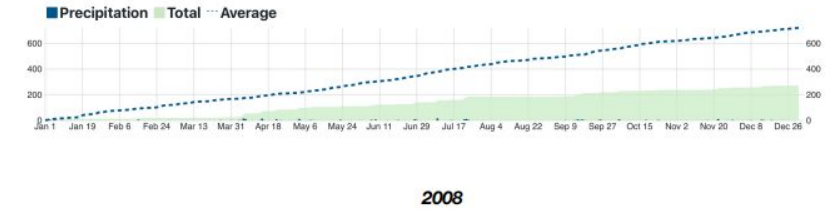
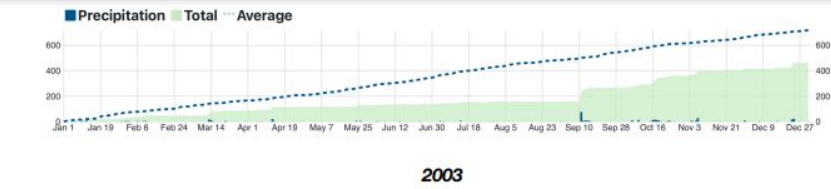


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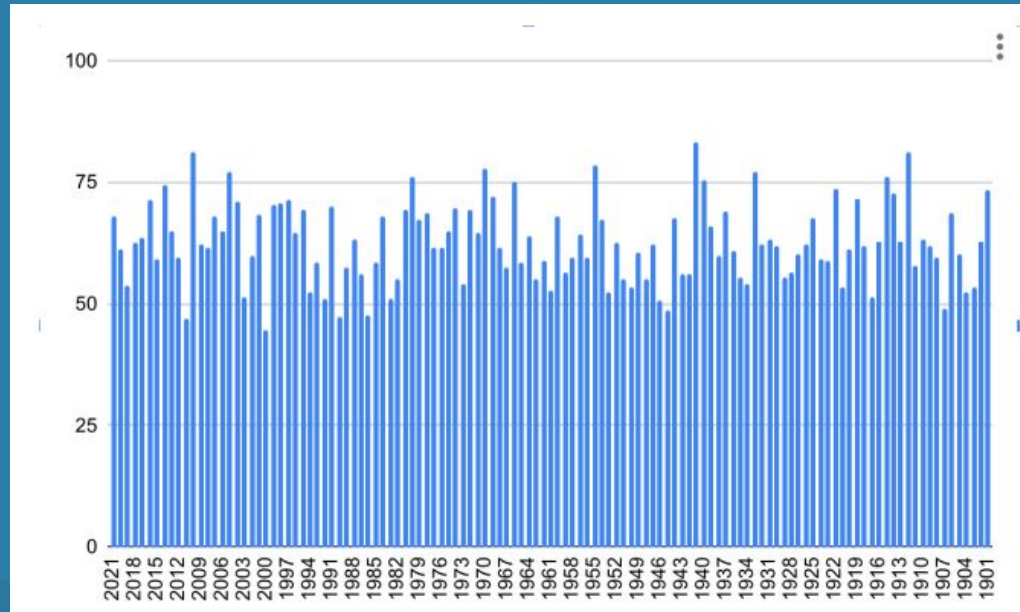


PRECIPITATION LEVELS

Moving on, following the analysis of temperature levels, our team gathered information on precipitation levels and presented relevant graphs for our study. Unlike other parameters analyzed, precipitation does not exhibit a stable or unvarying pattern. Thus, we have included precipitation graphs for the years 2003, 2008, 2013, 2018, and 2022.



Based on the specific examples of precipitation graphs we have presented, we can observe a significant amount of unpredictability in the patterns. This variability is illustrated in the following table, which displays the mean precipitation for each year between 2003 and 2023.



However, despite the unpredictable variability in the precipitation patterns, there is still a noticeable trend when it comes to the impact of constant warming. Over the years, there has been a slight increase in precipitation levels.

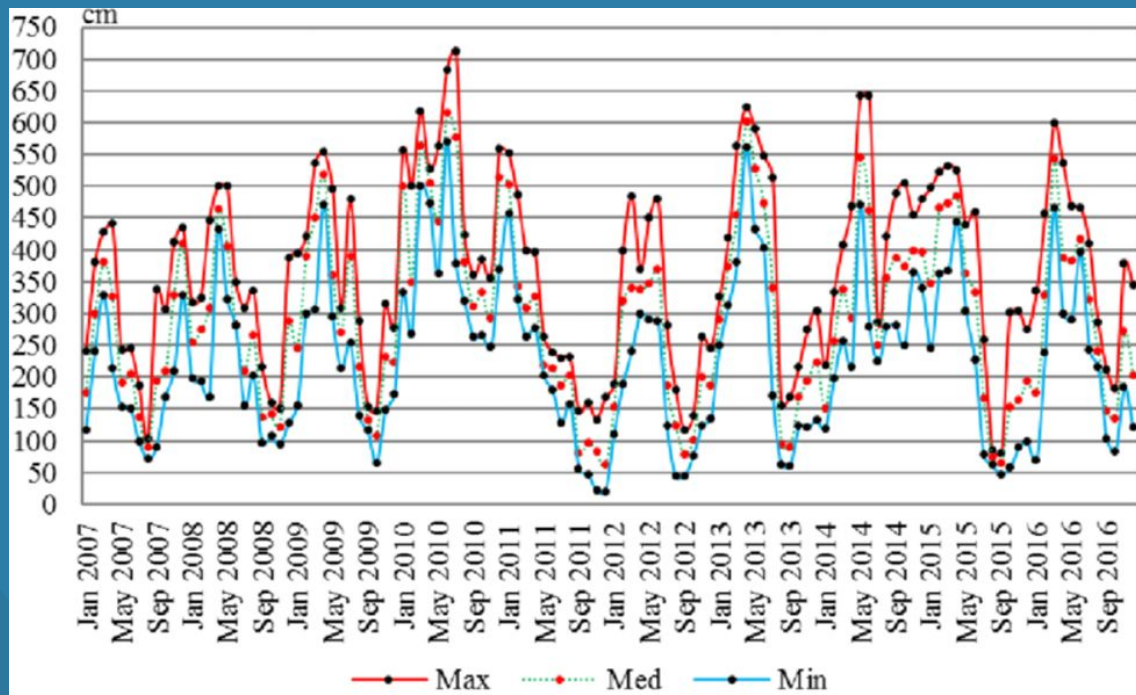


RIVERS

Furthermore, we analyzed rivers in our country. The Danube River, which is the second-longest river in Europe, flows through several countries, including Romania. In recent years, the Danube has experienced severe droughts, which have had a significant impact on the surrounding ecosystem and human activities.

These droughts are caused by changes in precipitation patterns and temperatures, which are both influenced by climate change. In Romania, the Danube River is a vital source of freshwater for irrigation, hydroelectric power, and transportation. However, the river has experienced several droughts in the past 20 years, with the most severe occurring in 2012. During this drought, the water levels of the Danube dropped to their lowest in 50 years, which had a significant impact on the economy and the environment. The low water levels made it difficult for ships to navigate, disrupting the transportation of goods and impacting local businesses. Additionally, the drought had a significant impact on the local ecosystem, leading to the death of fish and other aquatic species.

The following graph shows the fluctuation in water levels of the Danube river between January 2007 to September 2016.



In addition to the Danube River, other rivers in Romania have also experienced droughts in recent years. For example, the Jiu River, which is a tributary of the Danube, experienced a severe drought in 2020, which impacted the surrounding agricultural areas. The drought led to a decrease in crop yields and increased the risk of wildfires in the region. Similarly, the Arges River, which is another tributary of the Danube, experienced a severe drought in 2019, which had a significant impact on the local ecosystem.

DECADE	XX-TH CENTURY	
	EXTREMELY DROUGHTY YEARS	EXTREMELY RAINY YEARS
1901-1910	1907-1908	1910
1911-1920	1917-1918	1911, 1912, 1915, 1919
1921-1930	1923-1924, 1927-1928	1929
1931-1940	1934-1935	1937, 1939, 1940
1941-1950	1945-1946, 1947-1948, 1949-1950	1941, 1944, 1947
1951-1960	1952-1953	1954, 1955, 1957, 1960
1961-1970	1962-1963, 1964-1965	1969, 1970
1971-1980	1973-1974, 1975-1976	1972, 1974, 1975, 1976
1981-1990	1982-1983, 1985-1986, 1987-1988	1981, 1990
1991-2000	1992-1993, 1997-1998, 1999-2000	1991, 1997
	XXI-ST CENTURY	
2001-2010	2000-2001, 2001-2002, 2002-2003, 2006-2007, 2008-2009	2005, 2006, 2010
2011-2020	2011-2012	

Table 1. Droughty/rainy years in Romania, 1901-2010

These river droughts in Romania are closely linked to climate change. As temperatures continue to rise and precipitation patterns become more erratic, we are likely to see more frequent and severe droughts in the region. These droughts not only impact the surrounding ecosystem and human activities but also contribute to climate change.

During a drought, the lack of water can lead to an increase in forest fires, which release carbon dioxide into the atmosphere. Additionally, the dry soil and vegetation can lead to a decrease in carbon sequestration, which contributes to climate change.

To mitigate the impacts of droughts on rivers in Romania and around the world, it is crucial that we take action to address climate change. This includes reducing our carbon emissions, transitioning to renewable energy sources, and promoting sustainable land use practices.

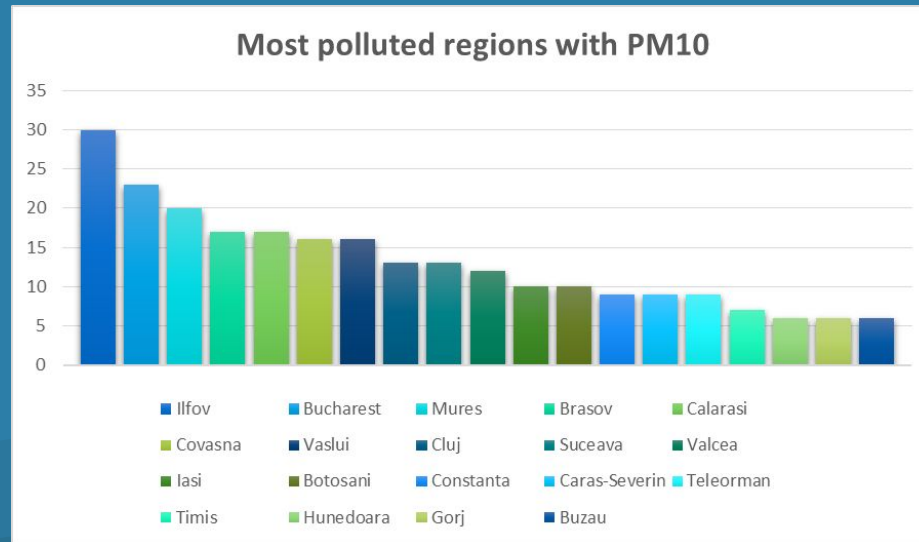
Additionally, we can work to improve water management strategies, such as increasing water storage capacity and implementing more efficient irrigation systems. By taking these actions, we can help to ensure the health and sustainability of our planet's freshwater resources and reduce the impact of climate change on river droughts.



POLLUTION

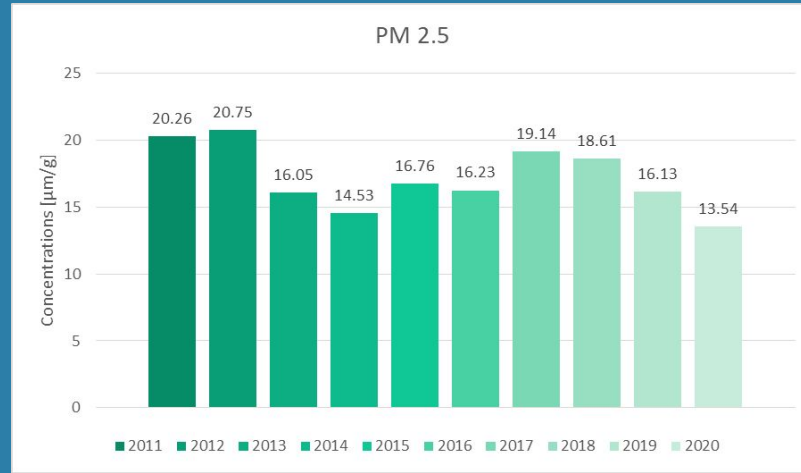
Now moving on to the causes of droughts, our first area of investigation was pollution. The escalation of industrial activities has resulted in a rise in emissions of harmful gases and wastes, along with various other contributing factors, causing a significant increase in pollution levels that pose a threat to both public health and the environment. The primary air pollutants that Romania is currently facing are PM2.5, PM10, Ozone, and NO2. Furthermore, the concentration of PM2.5 in the country has exceeded the recommended limit by 1.5 times, which is a significant concern since their size allows them to enter the lungs and bloodstream, leading to health issues. Solid fuel combustion and conducive air conditions contribute to particulate matter pollution, which is at its peak during the colder months.

Research conducted in 2020 identified the most heavily polluted regions in Romania with regards to PM10 emissions, with the top 5 comprising Ilfov, Bucharest, Mures, Brasov and Calarasi. Consequently, the air quality in these regions is also poor. On the other hand, Galati, Harghita and Valcea were found to be the least polluted areas, with a relatively better overall air quality.



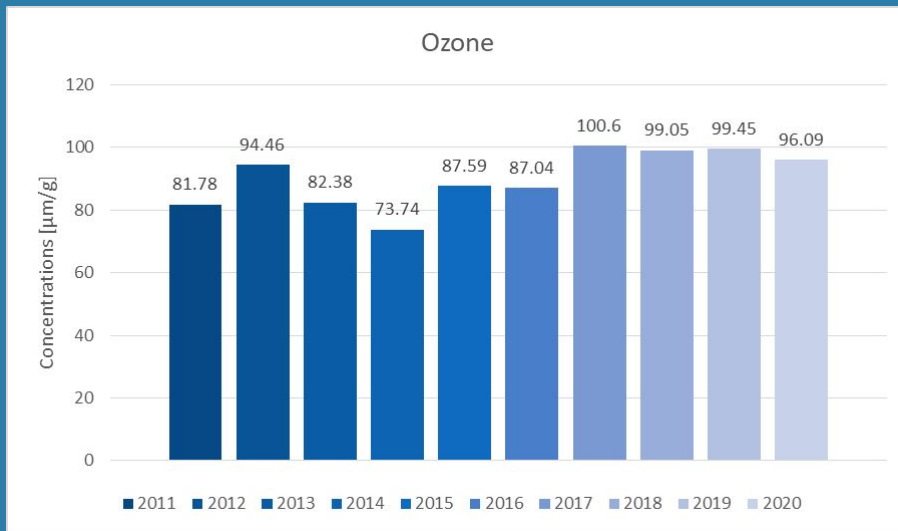
Source: [Romania Air Quality Index \(AQI\) : Real-Time Air Pollution Level](#)

Source: [Romania – air pollution country fact sheet](#)



The graph presented above indicates that the years with the highest concentration of PM 2.5 are 2011-2012 and 2017-2018, whereas the lowest concentrations were recorded in 2014 and 2020.

Source: [The ranking of the most polluted cities in Romania.](#)



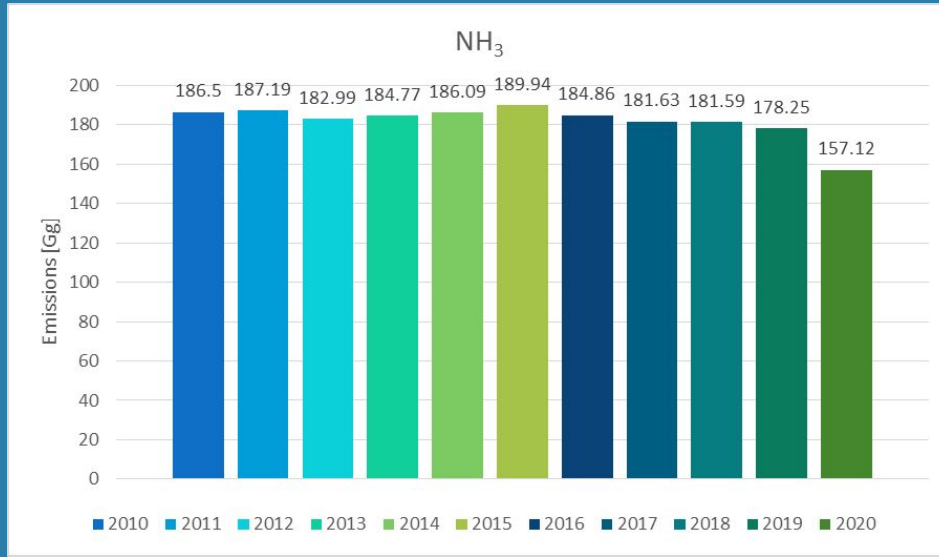
For ozone, the average concentration over the last 10 years is 90.218. Above it are the concentrations from 2017-2020 and 2013, and below, the years 2011 and 2014.

Source: [Romania – air pollution country fact sheet](#).



Since 2010, there has been a decreasing trend in SO₂ emissions, with the highest emissions occurring during the period from 2010 to 2013 and the lowest emissions occurring from 2017 to 2020.

Source: [An overview of air quality in Romania. Top 5 most polluted regions in the country.](#)

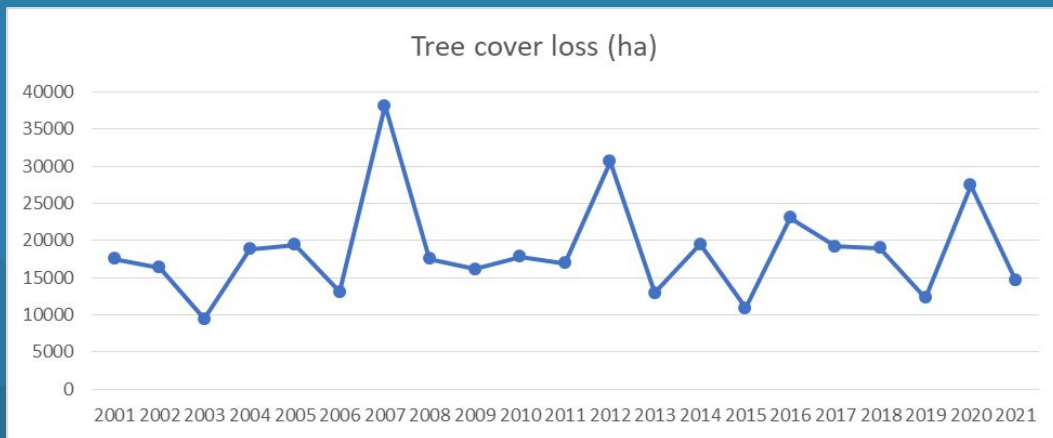


As we can observe in the chart above, the NH₃ emissions have been quite constant through the last 11 years, the exception being 2020, where it's shown the decrease influenced by the pandemic.



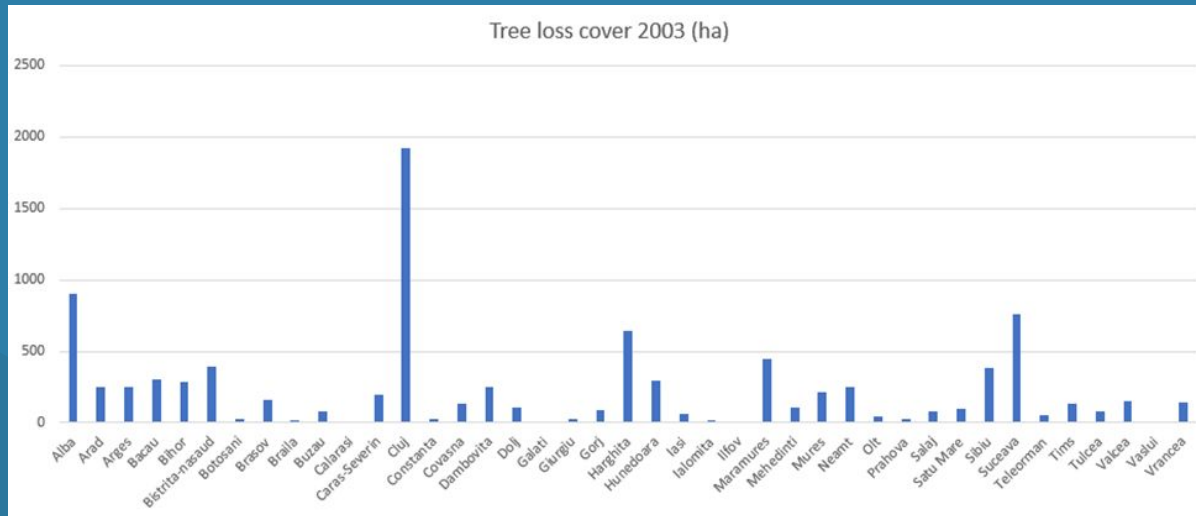
DEFORESTATION

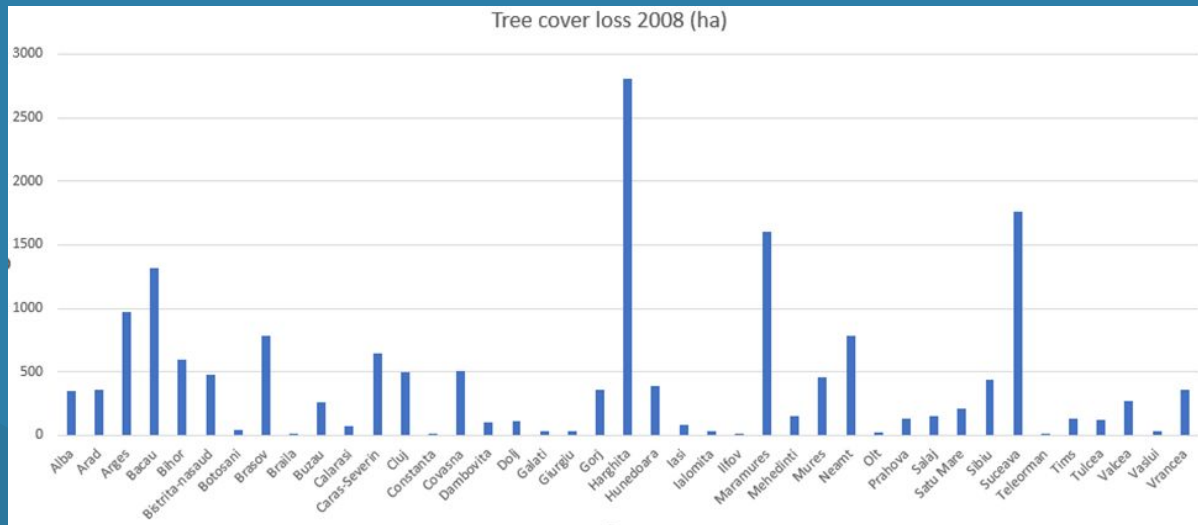
We have now reached the final chapter of our investigation, which focuses on deforestation. Deforestation is a significant problem currently faced by the world, and one of its many consequences is aridity, which has a considerable impact on droughts (the topic we are analyzing). In Romania, deforestation rates are high, and reforestation rates are insufficient. As a result, most experts agree that Romania is grappling with a deforestation issue. According to Global Forest Watch (n.d.), "From 2001 to 2021, Romania lost 391kha of tree cover, equivalent to a 4.9% decrease in tree cover since 2000".



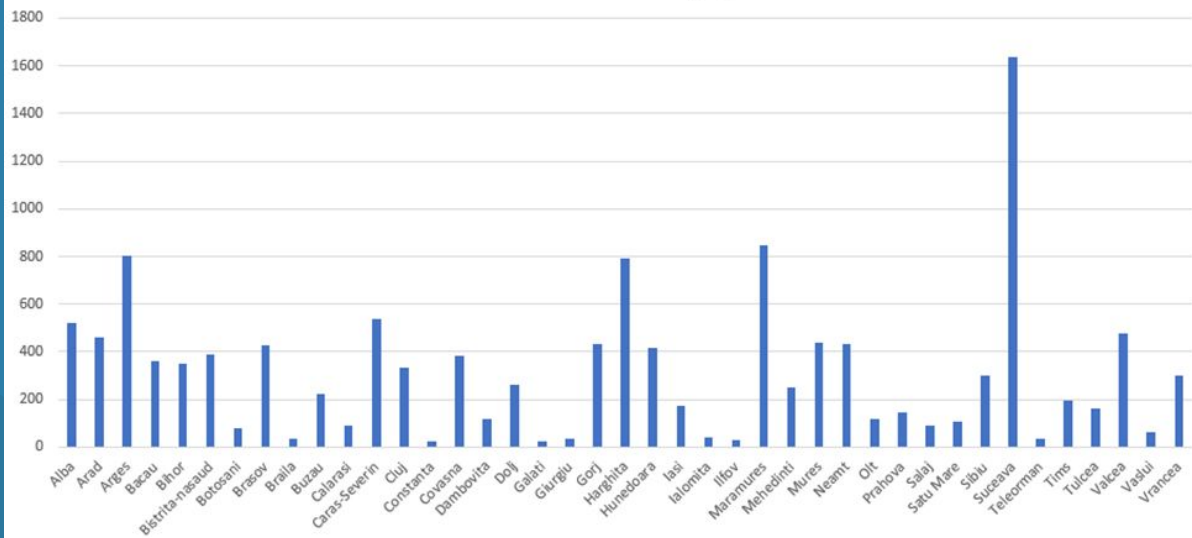
Source: [Global Forest Watch](#)

We analysed and compared deforestation data from all 41 counties of Romania (excluding the capital Bucharest) from 2003 to 2022, using 5 year increments.

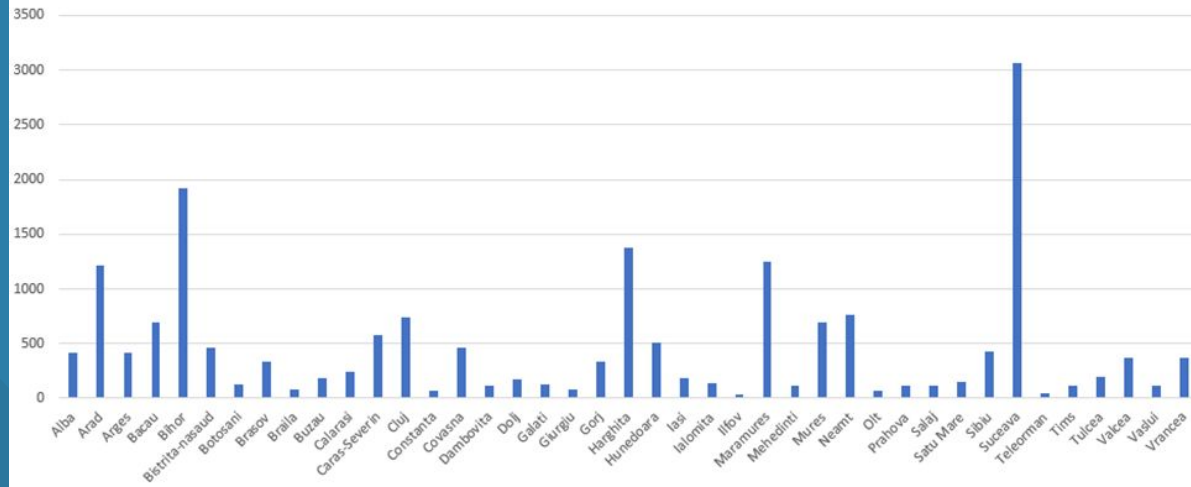




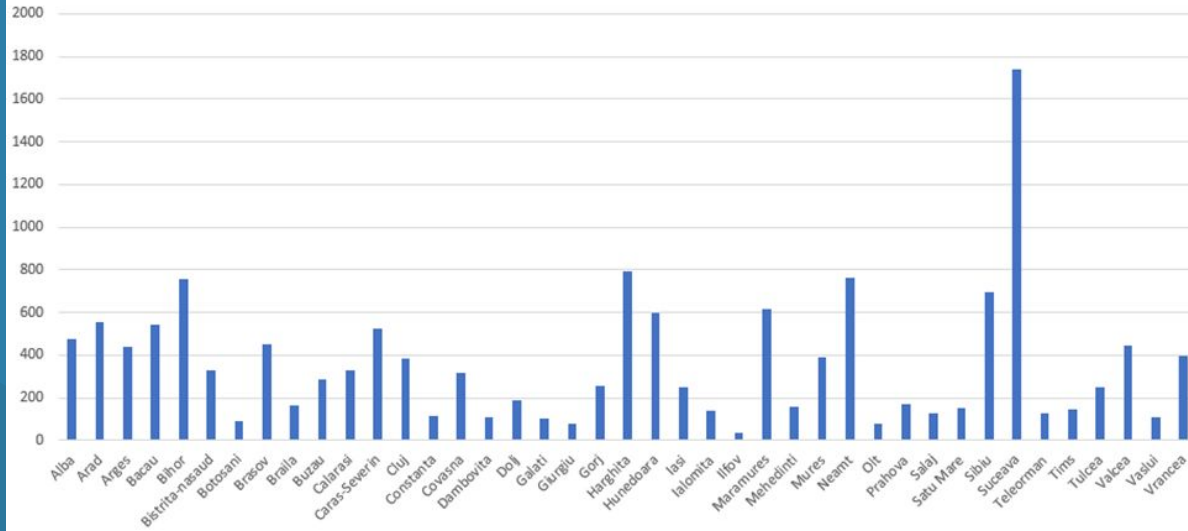
Tree cover loss 2013 (ha)



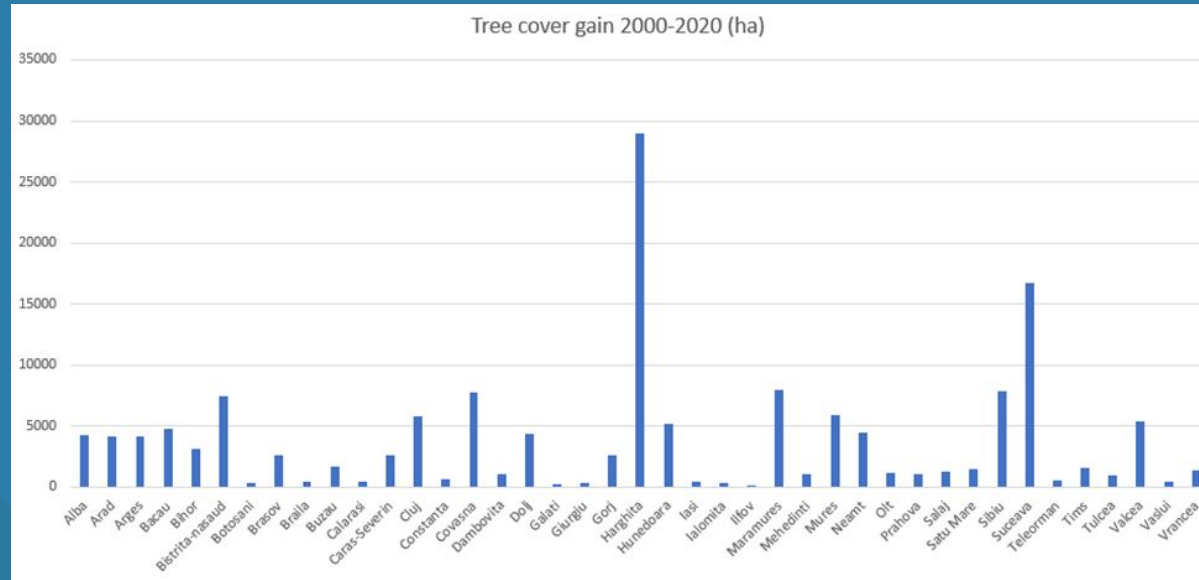
Tree cover loss 2018 (ha)



Tree cover loss 2021



We also analysed total tree cover gain between the years 2000 and 2020.



We observed that some counties with loss in tree cover have compensated with gains due to reforestation efforts, but there are still a lot of counties in which reforestation rates are low compared to the threat of climate change and so face climatic consequences.



CONCLUSION

By observing the time periods that showcase climate changes and linking them with the time periods of our droughts, we obtained the following conclusion:

In the drought of 2022, we observe an average annual temperature lower than that of 2020 and 2019 by almost 2 degrees, the amount of precipitations is only slightly more than half that of 2018, the air quality and deforestation have average characteristics, actually lower than in most of the other years.

The drought of 2020, which only affected the eastern part of the country, had a much lower intensity than that of 2022. It is notable for the increased deforestation that took place that year and for the increased average annual temperature. Regarding deforestation, 2020 ranks as the third highest year in the past 20 years in terms of the number of hectares of trees that were cut down. In terms of average annual temperature, the year 2020 is the second warmest year in the history of Romania.

The drought of 2019, which was also the longest, has a relatively low level of precipitations and has the distinction of having the highest annual average temperature, which, when combined with the factor mentioned earlier, provides a possible explanation for its prolonged duration.

The drought of 2015 is notable for setting a new average annual temperature record at that time, (it was subsequently broken in 2018, 2019 and 2020). The precipitation levels of that year are slightly below average and 2019 also oversees an increase in air pollution when compared to 2016, 2017 and 2018.

We find the drought of 2012 the most interesting because it was heavily affected by pollution deforestation and river levels. Firstly we can see it has a drop of 1 degrees Celsius in average temperature compared to 2011, also we can observe that from 2009 to 2015 all years had around the same average annual temperature except for 2012 which had a very low average. Secondly we can observe that it recorded the lowest precipitations in the last 15 years, which also leads to draughts, that combined with the highest emissions in gases in the last 15 years, a incredible drop in the water level of rivers and the second highest area affected by deforestation in the last 20 years, lead to one of the most notable draughts in the history of our country.

The draught in 2009 stands out from the rest due to its low level in the water level of rivers and due to its above average precipitations. Its annual average temperature is also a very high one at the time it was the second highest in the history of Romania, the first being 2007 at the time of recording.

The draught of 2007 set the record for the highest annual average temperature, and an increase of over 2 degrees celsius from the year 2006, which is also the highest recorded difference between two consecutive years, another aspect that stands out in this particular year is the low level of the river Danube and that of the river Jiu. All of these factors makes the 2007 draught the one with the second longest duration after the 2012 one, that making it also a record for that time.

The draught of 2003 oversaw a very dry year with very low precipitations and a small average annual temperature, the water level and the air quality in that time is also recorded as below average.

During the drought of 2022, there was a decrease in the average annual temperature by almost 2 degrees compared to 2020 and 2019. Precipitation levels were only slightly over half of what was observed in 2018, while air quality and deforestation remained average, if not lower than most other years.

In 2020, the drought only affected the eastern part of the country with lower intensity than in 2022. However, there was an increased deforestation rate that year, and the average annual temperature was higher, making it the second warmest year in Romania's history. The drought of 2019 was the longest of the ones studied, with relatively low precipitation levels and the highest average annual temperature of all the years. This, combined with other factors, could explain its prolonged duration.

In 2015, the drought set a new record for the highest average annual temperature, which was broken in subsequent years. Precipitation levels were slightly below average, and there was an increase in air pollution compared to the previous three years.

The drought of 2012 was heavily influenced by pollution, deforestation, and low river levels. The average annual temperature dropped by 1 degree Celsius compared to the previous year, and it recorded the lowest precipitation levels in the past 15 years. Additionally, emissions were at their highest, and deforestation was the second highest in the past 20 years, making it one of the most significant droughts in Romania's history.

The drought of 2009 had below-average river levels, above-average precipitation, and the second-highest annual average temperature in Romania's history at the time. In 2007, the drought set the record for the highest annual average temperature, with an increase of over 2 degrees Celsius from the previous year, and the lowest levels in the Danube and Jiu rivers. This drought also had the second-longest duration after the one in 2012. Finally, the drought of 2003 was very dry, with low precipitation levels and a small average annual temperature. Water levels and air quality were also below average that year.

