DROUGHT CHARACTERIZATION ELEMENTS IN CALAFAT-BĂILEŞTI-DĂBULENI AREA (1971-2010)

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ABSTRACT: - Drought characterization elements in Calafat-Băileşti-Dăbuleni area (1971-2010). The extreme weather events caused by scarce rainfalls and high air-temperatures have increased throughout the last decade, seriously damaging agriculture. In order to characterize droughts which negatively affect agriculture in the area of reference, a 40 years'time series meteorological data (1971-2010) were used from the Calafat, Bechet and Băileşti weather stations. The average annual rainfall amounts total about 540 l/m^2 and air-temperatures means oscillate around 11.5°C. According to the Walther-Lieth climograms, the dry period lasts for more than three months at all three weather stations, while the drought period lasts for little more than one month (August). The same droughty month (August) is also reflected by the Péguy climograms. The Standardized Precipitation Anomaly shows a cyclic occurrence of heavy and scarce rainfall periods, in which the 1983, 1985, 1992, 1993 and 2000 years could be considered as droughty years and the 1979, 1999 and 2005 years, as rainy and very rainy years. The so-called normal years represent more than 60% of the total time-series years, the droughty years totaling a second-order share. Both the Hellman criterion and the deciles method which have been applied in the analysis, clearly highlights that the 1994, 2000, 2002 and 2007 years went to extremes. The high air-temperatures greatly increase the evapotranspiration rates, which combined with a large moisture deficit in the soil, can cause the most severe pedological drought.

Keywords: Drought, Walther-Lieth and Péguy climograms, Standardized Precipitation Anomaly, Hellman Criterion, Deciles.

1. INTRODUCTION

The purpose of this study is to create an overview of the intensity and frequency of the atmospheric drought, on monthly and annual level, in Calafat-Băileşti-Dăbuleni area. The focus on droughts mainly results from its negative impact on three different plans: economic, social and environmental. To analyze this phenomenon may be useful in mitigating and reducing the negative effects.

The drought is a complex meteorological phenomenon, characterized by rainfall shortage or scarcity, high temperatures and high values of saturation deficit, extended over longer periods of time (weeks or even months). These conditions determine the depletion of soil water reserves and cause difficulties to plant growth and development. There are several types of droughts: atmospheric drought (extended moisture deficit only in air), pedological drought (extended

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moisture deficit in the ground) and complex droughts (large moisture deficit both on air and in the ground), (Ciulache and Ionac, 1995).

Global climate change manifesting through increasing average temperature and changing rainfall regime, has mainly caused the extent of the drought-affected areas, both globally and in our country, all through the last decades (Sandu, Mateescu and Vătămanu, 2010).

The Calafat-Baileşti-Dăbuleni area is located in the southern parts of the Dolj county (Fig.1). It is part of the Oltenia Plain, whose main economic sector is agriculture. The impact of drought on agriculture is even greater as soil texture is sandy in most of this area.

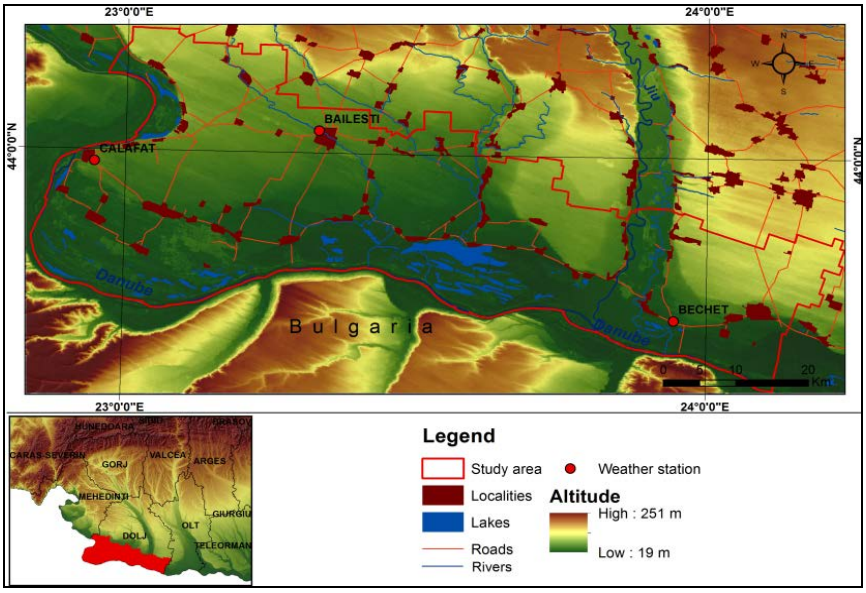


Fig.1. ***Location of the study area***

2. DATA AND METHODS USED

The meteorological elements used in this paper are represented by the rainfall and air-temperature recorded at the three weather stations: Calafat, Bechet Băileşti over a 40 years's time period (1971-2010).

I have tried to make an overview of the drought phenomenon in the area of Calafat-Băileşti-Dăbuleni by using some graphical and statistical methods such as the Walther-Lieth and Péguy Climograms, the Standardized Precipitation Anomaly, the Hellman criterion and the deciles method.

Both *Walther-Lieth and Péguy* climograms use mean monthly rainfall amounts and average monthly air-temperatures, revealing the periods of drought, normal and wet periods of the year.

The *Standard Precipitation Anomaly (SPA)* was computed by the formula of Gaceu (2002), Vlăduț (2006-2008): $SPA=(m_i - m)/\alpha$; where: m_i – amount of rainfall in a given period, m – multiannual average amount, α – standard deviation.

The value of the SPA gives a measure of the severity of a wet or dry event, as summarized in Table 1. Based on this classification, it was calculate drought frequency.

Table 1. ***SPA Classification according to Gaceu (2002)***

SPA Value	Class
SPA ≥ 2.00	Extremely wet
1.50 < SPA≤ 2.00	Severely wet
1.00 < SPA ≤ 1.50	Moderately wet
-1.00 < SPA ≤ 1.00	Almost normal
-1.50 < SPA ≤ -1.00	Moderately dry
-2.00 < SPA ≤ -1.50	Severely dry
SPA < -2.00	Extremely dry

The *Hellman* criterion is basically expressed by the deviation from the temperature average. Therefore, it may be expressed as the value of positive or negative deviations from the mean, and the actual values of these deviations can establish the thermal character of the months and years throughout a multiannual period of time, according to the Hellman criterion Table 2 (Gaceu, 2002). One can estimate the probability of drought occurrence from the years with different thermal characteristics, by simply using the frequency analysis.

Table 2. The thermal character of the months and years according to the Hellman criterion

Monthly mean deviation (°C)	Annual mean deviation (°C)	Class
> 10.0	> 5.0	excessively hot
5.1 ... 10.0	2.1 ... 5.0	very hot
2.1 ... 5.0	1.1 ... 2.0	warm
1.1 ... 2.0	0.6 ... 1.0	slightly warm
-1.0 ... 1.0	-0.5 ... 0.5	normal
-2.0 ... -1.1	-1.0 ... -0.6	cool
-5.0 ... -2.1	-2.0 ... -1.1	cold
-10.0 ... -5.1	-3.0 ... -2.1	very cold
< -10.0	< -3.0	excessively cold

The extreme deciles (D1 and D9) are used to highlight the potentiality for risk of any climatic element. D1 (10% of the temperature and precipitation data from the entire range are smaller than this value) is a good indicator of a high precipitation deficit or, in case of air-temperatures, of cold-spells. D9 (10% of the temperature and precipitation data from the entire range are greater than this value)

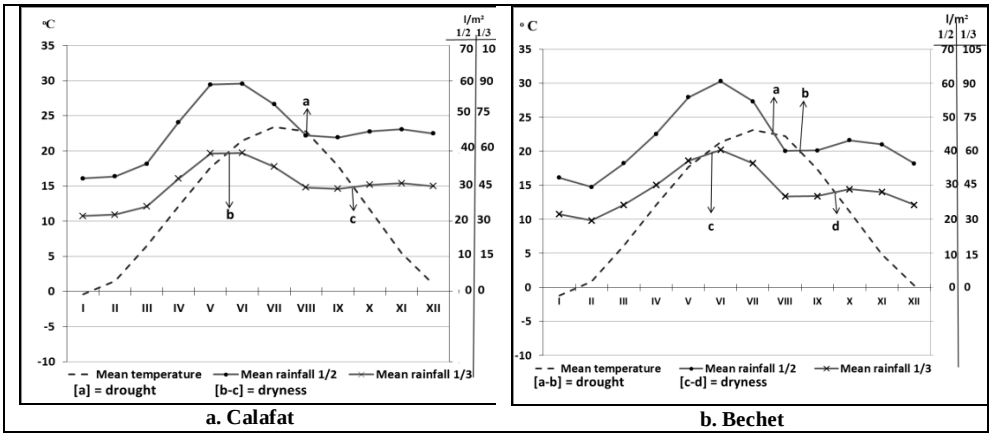
highlights, in terms of temperature, the rainy or hot periods. The calculation of the deciles is based on the classical methodology proposed by Gibbs and Maher (1967), (Dumitrașcu, 2006).

3. RESULTS AND DISCUSIONS

In Calafat-Băileşti Dăbuleni area, the average annual rainfall is 540 l/m² and the average annual temperature is 11.5 ^{0}C. Monthly, the smallest amount of rainfall is recorded on February, at Bechet (29.5 l/m$^{2)}$ and Băileşti (34.5 l/m^2) and in Ianuary, at Calafat – 32.2 l/m^2; while the highest rainfall amounts are recorded in June, at Bechet (60.6 l/m^2) and Calafat (59.2 l/m^2) and in May, at Băileşti (58.8 l/m^2).

Thermally, the highest air-temperature values have been recorded in July at all the three weather stations (23.4^{0}C at Calafat, 23.1^{0}C at Bechet and 23^{0}C at Băileşti) and the lowest values, in January (-1.2^{0}C at Băileşti and Bechet and -0.4^{0}C at Calafat).

The ***Walter-Lieth Climograms*** (Fig. 2) show a dry period during August, when the curve of the average air-temperature exceeds that of the rainfall, both in terms of 1/2 and 1/3 report . The dry period lasts from June to September, when the average temperature curve exceeds that of the average rainfall amounts in terms of 1/3.



a. Calafat **b. Bechet**

Fig.2. ***The dryness and drought periods in Calafat (a) and Bechet (b) (Walter-Lieth Climograms), calculated for the period 1971-2010***

If analyzing the ***Péguy Climograms*** drawn for Calafat (Fig. 3 a) and Bechet meteorological stations (Fig. 3 b), one may easily notice that August is an arid month, July - hot and humid, March, April, May, June, September, October and November - moderate, and December, Ianuary and February – cold months.

As in the case of the Walter-Lieth climograms, the rainfall scarcity due to high air-temperatures in August, is the main cause of drought in the area of reference.

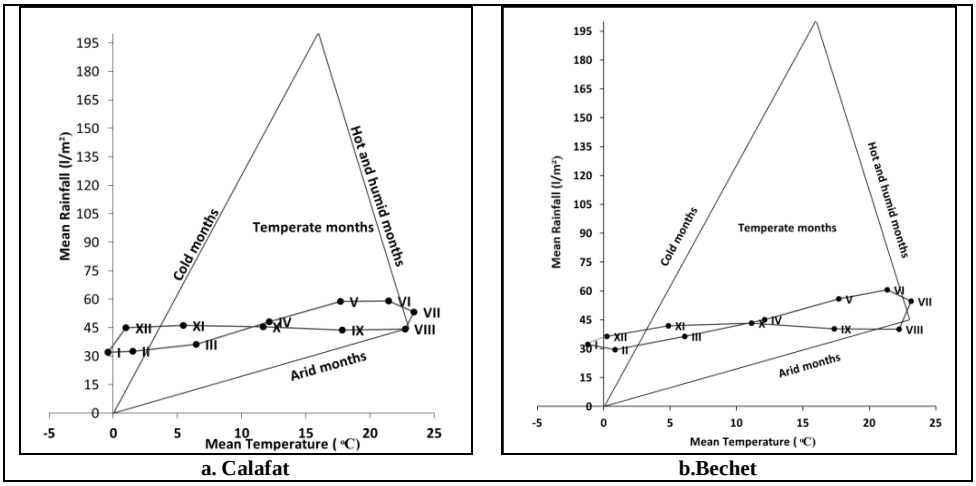


Fig.3. ***Climatic characteristics of the months in Calafat (a) and Bechet (b) (Péguy Climograms), calculated for the period 1971-2010***

According to the 12 months-averaged ***Standardized Precipitation Anomaly***, in the1971-2010 period, there were predominantly normal years in 67.5% cases in Calafat, 70% cases in Bechet and Băileşti. The occurrence probability of *moderate drought* was 7.5% in Calafat and Băileşti and 10% at Bechet. The *severe drought* has occurred in 2.5% of cases in Calafat and 5% at Bechet, while the extreme drought has occurred in 5% of cases in Calafat and 5% at Băileşti.

Although it is highly unlikely for severe droughts to occur, one may however notice that, all through the second and the third decade of the analyzed period, the frequency of the years with scarce rainfall has seriously diminished (Fig. 4). The smallest SPA values (-12) were recorded in 1992 and 2000, these two being characterized as extremely dry years on conditions that the SPA values were constantly lower than -2.

Because a one month-averaged SPA reflects only short-term climatic conditions, its applicability may be closely related to short-term soil moisture and crop stress, especially during the growing season.

Thus, according to SPA values calculated on a monthly basis, the highest probability to occur a moderate drought is in September (20% at Băileşti meteorological station), January (17.5% at all three stations), March (17.5% Băileşti and Calafat), June (17.5% at Calafat) and July (17.5% at Băileşti and Bechet). The severe drought records the greatest values of occurrence probability in March (7.5% in Calafat) January (5% in Calafat) and December (5% in Bechet) and the extreme drought, in August (5% at Calafat).

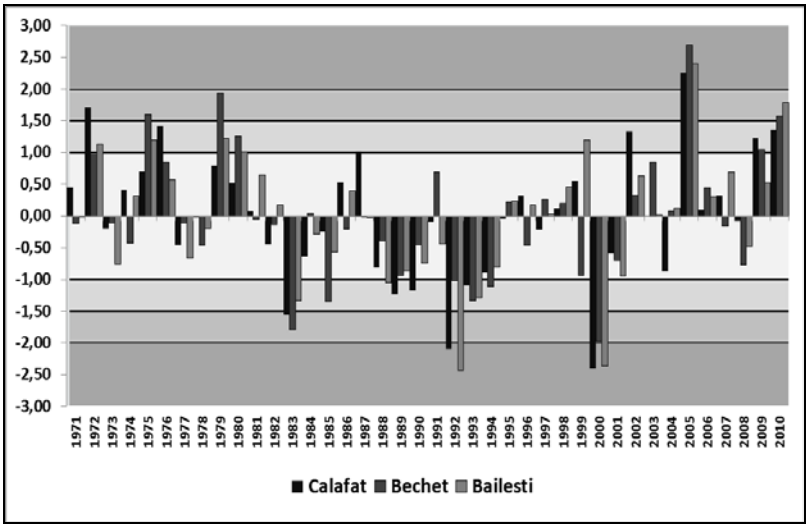


Fig. 4. ***The 12-months averaged Standardized Precipitation Anomaly (Ianuary – December), at Calafat, Bechet and Băilești weather stations (1971-2010)***

However, rainfall scarcity is not the only factor that causes droughts. Along with this element, air-temperatures also play an important role.

According to ***the Hellman criterion***, more than 50% of the years wich were analyzed, could be considered as normal in terms of heat budget, while 12.5% were warm in Bechet and Calafat, and 10% at Băileşti meteorological station (Fig.5). If during the first two decades of the overall analyzed period (1971-1990) the years with negative deviations were dominant, in the last two decades (1990-2010), the years with positive deviations prevailed instead, increasing trends becoming evident at all the three meteorological stations.

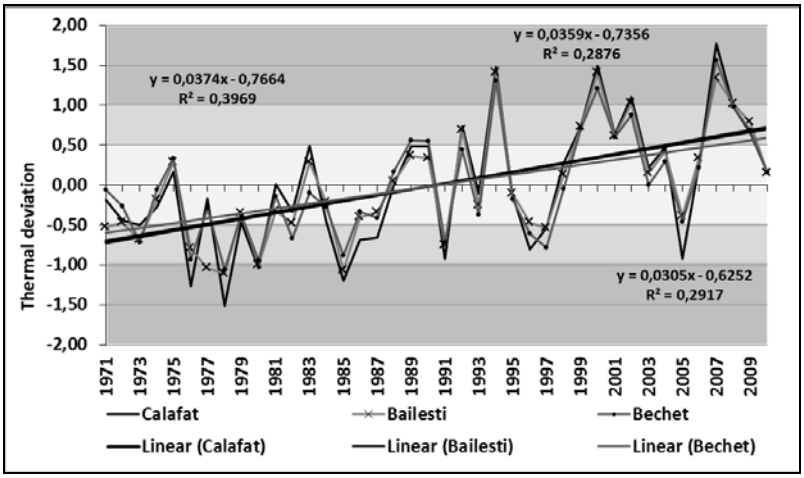


Fig. 5. ***Annual air-temperature deviations from the multiannual average at Calafat, Băilești, Bechet weather stations (1971-2010)***

The highest positive values of thermal deviations could be indicative of the warm years class, such years being specific in 1994 (1.47 °C at Calafat, 1.41 °C at Băileşti and 1.21 °C at Bechet), 2000 (1.50 °C in Calafat, 1.41 °C in Băileşti and 1.21 °C in Bechet). 1983, 1989, 1990, 1992, 2001, 2008, 2009 were warm years, with different deviation values, depending on the location of the weather station.

Monthly, there is a marked difference concerning the deviation share on different value classes between the months from the cold and the warm seasons. Thus, the most common positive deviations are recorded in January and February and the percentage of normal values is the lowest, according to Hellman criterion. The occurrence probability of values higher than normal, for the cold season months, is less significant for the drought analysis.

In summer, the air-temperature rise above the normal favours the intensification of evapotranspiration processes, which in conditions of low humidity, can lead to droughts in warm season. The highest thermal deviations values which are really relevant for the warm season months, range between 2.1 and 5^{o}C and group into the warm months category. The highest occurrence probability of such values is to be noticed in April (15% at Calafat) and August (15% at Bechet and 12% at Băileşti). Even though the share of this category in the total time-period that was analyzed is pretty low, the increasing frequency during the last two decades leads to a positive trend.

The arrangement of monthly precipitation amounts and temperatures in deciles is another technique used for drought monitoring.

In case of rainfall amounts, 10% of the values are smaller than Decile 1, still with various values from one month to another (Table 2). The smallest value of D1 has been recorded in October at Calafat (4.4 l/m^2) and Bechet (4.2 l/m^2) weather stations, and in August at Băileşti station (3.5 l/m^2), indicating that in 10% of the cases, there were very small amounts of precipitation fallen these months. If analyzing the Decile 1 values, one may notice that the 1983, 1990, 1992, 2000, 2007 and 2008 years recorded scarce rainfall amounts for more months on end.

Table 2. ***The distribution of D1 monthly values (pluviometric) at Calafat, Băileşti and Bechet weather stations.***

D1	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Calafat	7.9	6.5	9.15	20	25.7	14.95	8.35	6.3	7	4.4	10.75	11.85
Băileşti	5.75	9.6	7.9	20.2	19.35	16.25	7.6	3.5	6.7	3.9	11.55	8.05
Bechet	8.55	7.5	11.2	21.5	20.85	19.25	14.9	8.8	7.95	4.2	12.2	11.25

As regards air-temperature values, the analysis of the highest decile (D9) is useful as 10% of the values are above it. The highest D9 value was recorded in June and August (24-25^{o}C) at all the three meteorological station (Table 3). In the same time, the D9 decile highlighted high air-temperature values for more successive months in 2000, 2002, 2003 and 2007 years.

Table 3. ***The distribution of D9 monthly values (thermal), at Calafat, Băileşti and Bechet weather stations***

D9	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Calafat	2.4	5.2	9.6	14.35	19.5	23.35	25.1	25.15	19.55	13.3	7.9	3.75
Băileşti	36.5	1.8	4.6	9.1	14.2	19.6	23	24.85	24.6	19.25	13	7.25
Bechet	1.95	4.6	9.05	14.25	19.65	23.05	24.75	24.45	19.1	12.85	7.3	2.9

4. CONCLUSIONS

The present paper highlights the features of atmospheric drought in the southern parts of the Dolj County, by means of the main meteorological elements such as rainfall amounts and air-temperatures. By using various data processing methods, we could identify the dry periods and their occurrence frequency on various time scales.

All through the 1971-2010 periods, the dry years, with scarce rainfall amounts, were 1983, 1985, 1992, 1993, 2000, with varying degrees of water deficit. Thermally, the 1992, 1994, 2000, 2002, 2003 and 2007 were also identified as hot-dry years.

On a monthly basis, August can be considered as the driest month, due to its high air-temperature and low rainfall values, but the drought phenomenon has a high occurrence probability in other months of the year as well, such as September, December, January, March, April.

Even though the highest share of the period is given by the climatically normal years, both from rainfall and thermal view-points, the drought episodes have had pretty large negative impacts on crops in the area of reference.

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