THE STUDY OF HYDRO-CLIMATIC DEFICITS IN THE ARAD AREA

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Abstract. *Climatic changes in Arad area, Romania, made possible for droughty periods to appear in areas where the sums of annual or seasonal precipitations is closer to multiannual means, that is, the water which came with a high intensity (mm/min) rainfall was prevented from being collected in the soil. This shows that the main hydro-climate risks are the hydric deficits and some humidity excess periods. This study is focused at presenting the hydric deficits (i.e. the existence of large droughty periods an d some hydric excess) in the Arad area in a time span of over two years (2015-2016). These years have been analyzed from the multiple points of view of several hydro climatic indicators from the specialized literature. The following parameters for monitoring hydro climate deficits in the Arad area have been used: sum of annual and monthly precipitations, monthly and annual hydric deficit and their own graphic representation, average monthly temperatures, monthly and annual mean evapotranspiration, mean monthly temperature and their evolution. Climate and hydro-thermal indexes of drought (Hellman, Topor, Lang and the hydro-thermal indicator Seleaninov) have also been calculated and analyzed. Moreover, the Thornthwaite index of precipitation efficiency has been characterized according to the precipitation deficit. When taking into consideration the rainfall regime, which is an important indicator of acknowledging drought and humidity excess, this of course depending only on the sum of monthly precipitations in the summer as well as in the spring (annual sum of the precipitations), a conclusion can be drawn is that during the lenghty period studied (2015-2016) the second year, 2016, was humid and rainy. Regarding the precipitation deficit, when compared to monthly, seasonal, annual and multiannual figures, it can be said that June, August and September were mainly droughty periods in both analyzed years. The year 2015 was a semi-arid one according to most indicators analyzed, having significant hydric deficits during most of the hot season as well as higher monthly and annual temperatures than multi-annual ones. Finally, results regarding the year 2015 show that there have been periods with hydric deficits, even droughty months from April till August, being defined as a semi-arid year in most indicators analyzed.*

Keywords: *potential evapotranspiration, annual hydric deficits, precipitation deficit, hydro-thermal indicators*

INTRODUCTION

In the past fifty years mankind started confronting itself with various forms of drought, hydric deficits and desertification, these phenomena leading the way to other problems in different sectors.[6]

Drought is the phenomenon which has as main characteristics the reduction of rainfall from a certain area with figures under the multiannual average for a certain period of time as well as a trend of high temperatures all these having different lengths from one area to another.[8] The global apparition of drought shown by climatic data reveal a clear reduction of rainfall quantities doubled by a progressive atmospheric warmth. [3],[4]

The climatic change hypothesis is supported by observations and measurements thoroughly made worldwide and in Romania concerning certain climatic parameters and regarding some climate effects on certain water resources.[11], [12]

MATERIAL AND METHODS

This paper analyzes the following factors:

The evolution of monthly and annual mean temperatures during the period analyzed comparing the differences to multi-annual means. Precipitation during vegetation and annual precipitation was recorded at the Meteorological Station in Arad their evolution and deviation being compared to multi-annual averages.[5],[7]

Monthly and annual evapotranspiration as well as vegetation values have been calculated with the chosen Thornthwaite formula whereas annual hydric indexes have been calculated with N. Topor and Hellman indexes. The Thornthwaite formula (1948) which is based on the mean air temperature was used for calculating the potential evapotranspiration [9],[10].

To characterise synthetically the climate, we used the following climate indices:
Hydro climate balance, annual indices of aridity (de Martonne), Thorthwaite indice.
The global index of wetness lm supplies an annual pluviometric characterisation [3]:
Im = Iu – 0.6*Ia or Im = [(s – 0,6*d)/ETP]*100

- The de Martonne aridity index allows the delimitation of arid, semi-humid climates, while the monthly one differentiates the areas affected by drought. [2],[3]

$$A = \frac{P}{T+10} \text{ annual}$$

$$A_1 = \frac{12Pi}{T_i} \text{ monthly}$$

P = annual or monthly precipitations (mm)
T = mean annual or monthly temperatures (^{0}C)

- The Donciu humidity index is calculated with the formula:

$$I_D = \frac{100 \cdot P}{ETP}\%$$

where:

P – sum of annual precipitations (mm);
ETP – potential evapotranspiration (mm).

- precipitation efficacy (P - ETP), where P is the sum of annual precipitations (mm) and ETP is potential evapotranspiration (mm); [1]

- **The Lang index** allows delimiting climate in plane areas (agricultural areas). [3]
- **The Hellman Index**

Pluviometric characterisation of a month is done by comparing the amounts of precipitations of the month with the multiannual mean. It is grouped into 9 categories. [2], [3]

RESULTS AND DISCUSSIONS

After monthly average temperatures evolution at Arad and their deviations from the multi-annual average was analyzed, certain aspects can be observed in figure 1, which indicate that the year 2015 clearly was the warmest year, followed by 2016.

Comparing the two analyzed years, their annual average temperatures, it has been revealed that they were fairly superior to normal, with values situated between 1,2-2,1 °C and the highest value of temperature in the warm season was measured in the year 2015 with a normal overcoming with 2,1 °C, followed by 2016 in which the average in the warm period was up to 1,41 °C higher than normal. July and August, 2015 and 2016`s warm season months have also been warmest months of the period studied.

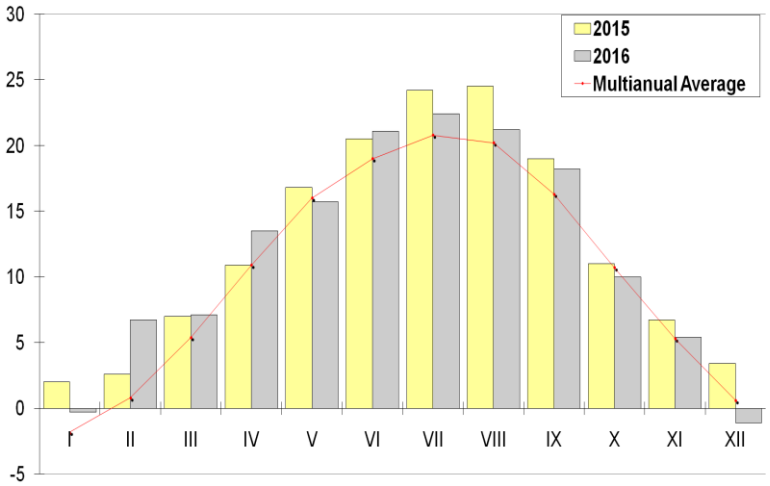

Figure 1. Monthly mean temperatures in the years 2015-2016

In Arad, considering the year of 2015 in the warm period the quantity of fallen rainfall was much more reduced than normal of the season. On another term, it can be said that just from the single point of view of fallen rainfall quantities it was a special year because the annual average rainfall sum was with 496.1 mm more lower than the multiannual average 593,5 mm.

The study reveals that in the year of 2015 the total hydric deficit was high, but short in

the manifestation period i.e. from April-September inclusively, as shown in figure 3.

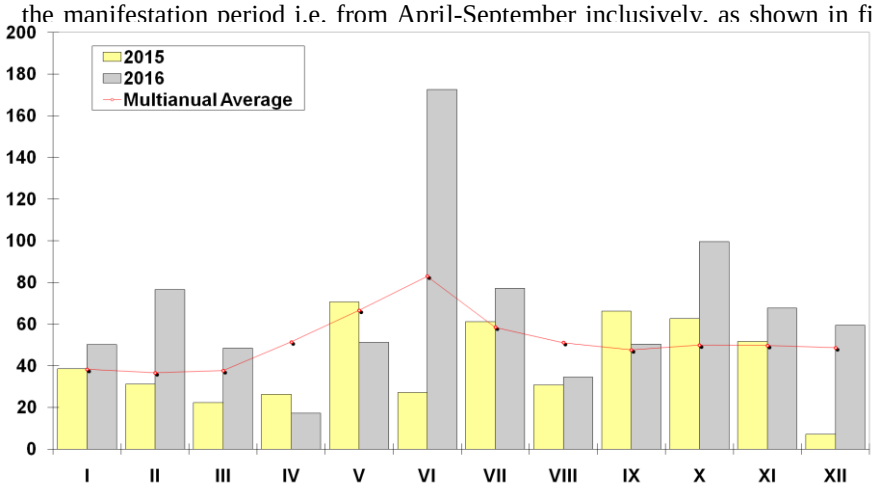

Figure 2. Monthly mean precipitations in the years 2015-2016

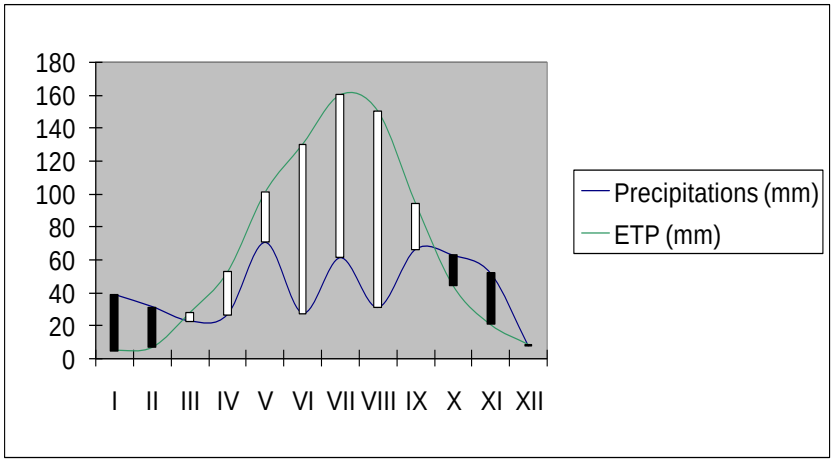

Figure 3. Hidroclimatic result in the conditions from Arad 2015

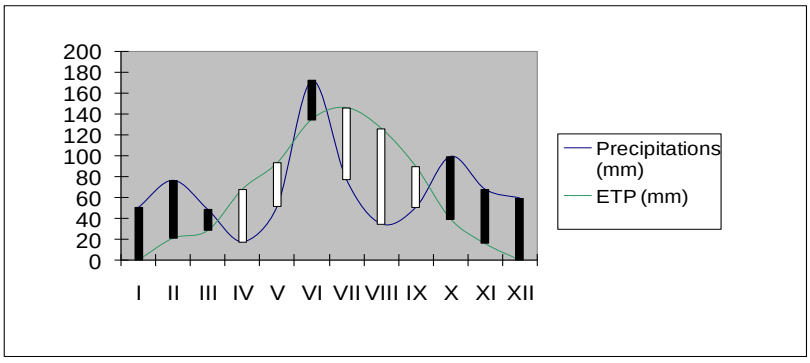

Figure 4. Hidroclimatic result in the conditions from Arad 2016

Table 4

Characterisation of the years 2015, 2016 in Arad depending on the main climate indices

Climatic type depending on indices	P – ETP (mm)	Donciu Index	Thornthwaite Index	De Martonne Index	Thornthwaite global index of Wetness	Lang Index
2015	-304.49	61.97	-38.03	22.05	22.05	36.69
Interpretation	*Semiarid climate*	*Semiarid climate*	*Moderately Wet climate II*	*Semiarid climate*	*Semiarid climate*	*Semiarid climate*
2016	46.48	106.12	6.12	37.29	37.29	*69.44*
Interpretation	*Moderately Wet climate I*	*Moderately Wet climate I*	*Moderately Wet climate I*	*Moderately Wet climate II*	*Moderately Wet climate I*	*Semiarid climate*

From Table 4 it can be seen that the two years studied in Arad were semiarid to indicators such as the Donciu, Thornthwaite, Martonne index, or the Lang index. And moderately wet I, moderately wet II at the Thornthwaite index.

Table 5

Characterisation after Hellman criterion of the period 2015-2016 at Arad

YEAR	MONTH	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2015		LN	LN	LFS	LFS	LEP	LES	LN	LFS	LEP	LFP	LN	LES
2016		LFP	LEP	LFP	LES	LS	LEP	LP	LFS	LPP	LEP	LFP	LFP

Depending on the Hellman criterion, it can be seen from Table 5 that in 2015 there were five months of drought, and in 2016 the majority of the months were rainy except for the months of April and August that were droughty.

Table 6

Pluviometric Characterisation after N. Topor Index in the period 2015 – 2016
In Arad

Studied year	Normal months	Rainy months	Droughty months	Pluviometric index value Ia	Year characterisation
2015	4	3	5	0.71	Drought year
2016	1	8	3	2.43	Rainy year

CONCLUSIONS

- Discussing the analysis of 2015-2016 at Arad, the results point that the year 2015 still was the warmest because the annual average temperature being 12,5 ° C, followed of course by the year 2016 with an annual average temperature of 11,6 °C compared to the normal of the area 10,4 °C.
- Taking into consideration the rainfall, the annual rainfall average for 2016 was considerable higher than normal, this year being granted as an excessive one.
- Next, in the year 2015 the highest hydric deficits have been recorded from March until September (411,33 mm) whereas in the year 2016 the measured hidric deficit was 291,7 mm.

- N. Topor index shows that 2015 was droughty and 2016 was a rainy year. Just by looking into the main referred climatic indexes, Donciu, Thorthwhite, de Martonne, Thorntwhite global humidity index, Lang index, the years 2015 and subsequently 2016 were discovered to be semi-arid, moderately dry I, moderately dry II.

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