DROUGHT ANALYSIS IN OZANA DRAINAGE BASIN

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ABSTRACT. – Drought analysis in Ozana drainage basin. Ozana drainage basin is located at the contact between large landscape units (the Carpathian mountains, the Subcarpathian area, and the plateau region). This placement determines the existence of a complex climate in the region. Despite being small in size, and its extension on an W-E direction, differences can be observed, especially of the way extreme phenomena take place. In the case of droughts, it had different intensities in the mountains, compared to the plateau region. In order to emphasize the different distribution on the territory, several climatic indexes have been calculated, regarding dryness (De Martonne Index, Hellman criterion). The analysis of these indexes at the same monitoring stations (Pluton, Leghin and Dumbrava) emphasizes the growth of the drought periods in the plateau region and the fact that they shorten in the mountain area. In the mountainous area, where the land is very well forested, the values of the De Martonne index can reach 45.4, and in the plateau regions, where the forest associations are sparse, the values dropped to 30.6. According to the Hellman criterion, several differences can be emphasized, at basin level. In the mountainous region, there is only one month that, at a multi-annual level, has stood up among the rest, as being excessively droughty, while in the median /central region of the basin, three months have been identified, that have such potential, as well as five months, at Dumbrava.

Keywords: Ozana, drought, De Martonne, Hellman, index

1. INTRODUCTION

The meteorological drought is a stochastic phenomenon, for which it is difficult to accurately delineate the spatial and temporal extent, and it cannot normally be foreseen a long time before it occurs (Bayat et. al, 2015). This phenomenon is generated by a series of both natural and anthropogenic factors, and it gradually occurs in the field. At first, the atmospheric drought sets in, and it is usually a stage characterized by a long time period, and it is correlated with the rise in the evapotranspiration processes, which dictates the diminution in pedological water reserves, after which the pedological drought sets in. The drought can be defined based on the degree of dryness, compared to a normal average value, and the time period on which it extends (Minea et. al, 2004).

In the last 5 years, a severe drought has been registered at macroregional level. Within the Ozana drainage basin, this phenomenon has been recorded in the period 2011-2015, with a different intensity year after year, depending on the three gauges (Iosub, et al., 2010). There is a time of reappearance of the extreme

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meteorological events periods which are quite clear-cut: 9-14 years, 3-4 years and 2 years (Iosub, et al 2015).

The drought manifestation differences, considering the territory and the monthly multiannual level, were identified by using De Martonne Index and Hellman criterion. In this context, one can analyze the periods in which the drought phenomena appeared, their temporal and spatial enlargement, and the most frequently affected periods of the year. The analysis is performed on a dataset that spans 38 years (1977-2015). It is important to follow closely the differences that may arise from the major relief units, even though the distance analysed in a straight line is reduced to 50 km. Such differences are specific to the transition areas between the major landforms (Chendes, 2011).

The aim of this study is to examine the intensity and the frequency of droughts in the Ozana drainage basin, at monthly and multiannual level, and the manifestation differences of the phenomenon in the territory.

2. STUDY AREA AND DATA SOURCES

The Ozana drainage basin is located in the north-eastern part of Neamt county and it crosses three relief units from West to East: Stanisoara Mountains, Moldavian Subcarpathins and Moldavian Plateau (Fig. 1). The orientation of the valley on the W - E direction and the relief's gradual loss in altitude towards East, make a consistent distribution of the climatic elements in this direction.

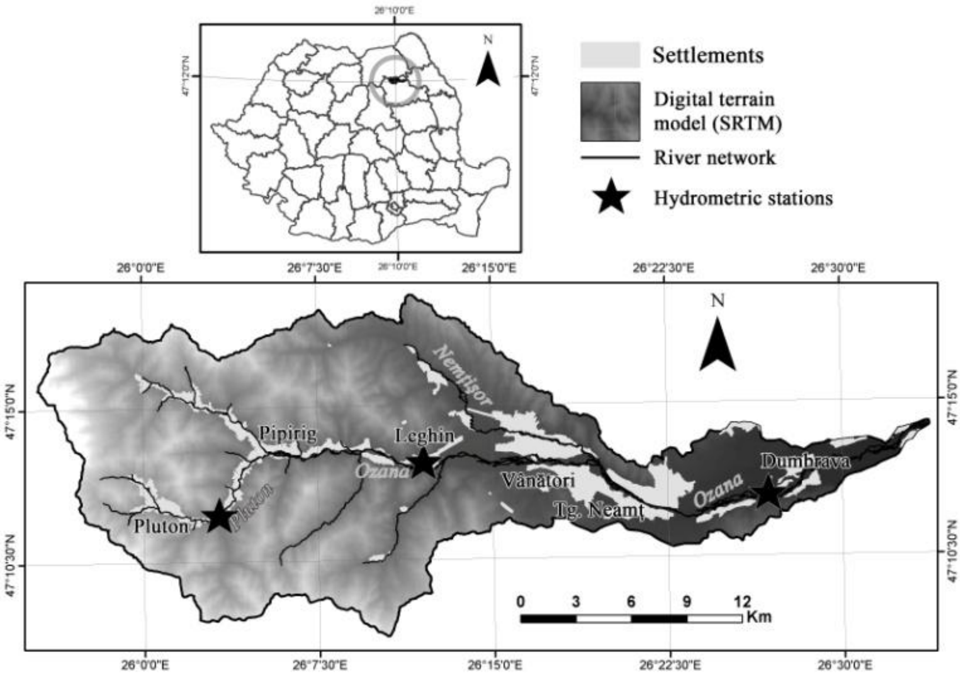


Fig. 1. ***Geographical location of the study area***

Considering the amount of rainfall distribution in the drainage basin, it can be noticed a division into zones depending on altitude and longitude. In terms of the rainfall, regional differences occur between the Stânişoara Mountains and the Subcarpathian area. Generally speaking, it can be observed that rainfall decrease in quantity as you move toward the plateau; this fact can be inferred from the multiannual average amount of rainfall recorded in the mountainous area of 820 mm/ m²/year and 640 mm/m²/year at Dumbrava (Iosub et. al, 2014).

The data, based on which the analysis was performed, have been extracted from ROCADA (Bârsan, 2014) and from those offered by the Siret Water Basin Administration. Their processing and analysis have been carried out in the open source R-programme. The study was extended over a larger area around the Ozana drainage basin in order to validate the data and integrate the study area into a larger zone.

3. MATERIALS AND METHODS

De Martonne index allows for the determining of the aridity degree of a certain region, for specific periods of time (a month or a year), being an expression of the restrictive characteristic that the climate conditions impose to certain plant associations (Baltas, 2007).

De Martonne index was calculated according to the equation:

$IDM = P/T+10$

where P means the precipitation and is expressed in millimetres, T is the temperature and is measured in degrees Celsius.

The Hellman criterion for drought assessment consists in calculating the monthly and annual rainfall deviations based on the average and it is calculated according to the formula:

$100(Pi-Pmed)/Pmed$

where Pi is the deviation of the monthly precipitation amounts, and Pmed is the multiannual average.

The results are expressed in percentage and their values vary between 0% and 100%, expressing the intensity of pluviometric deviations compared to the average (Table 1).

Table 1. ***Hellman criterion classification and corresponding event***

Hellman values	Category
0 – 10%	Extremely dry
10 – 20%	Severely dry
20 – 30%	Dry
30 – 40%	Moderately dry
40 – 60%	Normal
60 – 70%	Moderately wet
70 – 80%	Wet
80 – 90%	Severly wet
90 – 100%	Extremely wet

4. RESULTS AND DISCUSSIONS

The map of De Martonne index for the Ozana catchment (fig. 2) shows that there is a gradual decrease of the index depending on the characteristic relief unit. The differences of values are not very significant between the mountain and the plateau area, only 10 points, but they mark a distinction between two major classes, humid and slightly humid. The rainfall differences are specific to the transition zones between the major relief units, and the Ozana catchment area is characterized by three landforms: mountain, plateau and Subcarpathians.

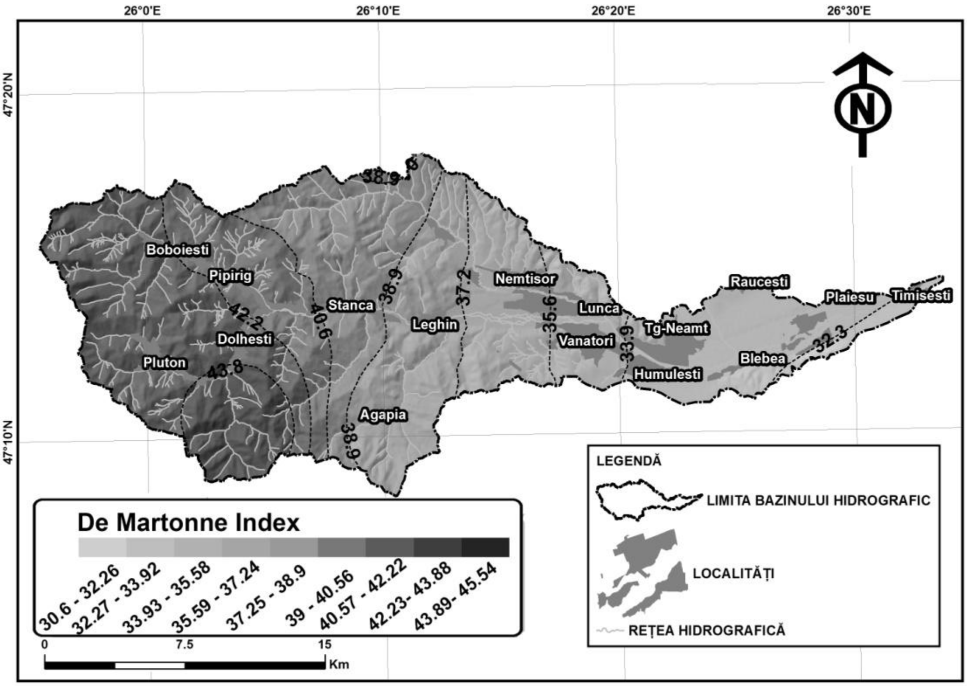
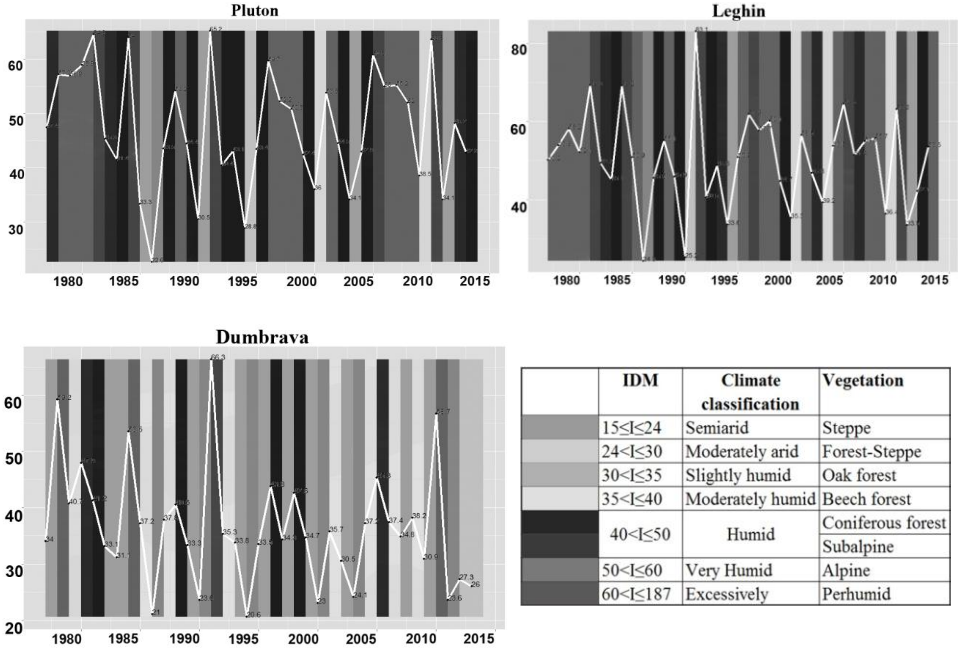


Fig. 2. ***De Martonne index map for the Ozana catchment (1961-2015)***

The multiannual values of the index vary between 30 and 50, which may incorporate the zone into a humid temperate one, covered with forests and rivers that have a permanent runoff. Also, the values obtained correspond with other studies performed at the regional or macroregional level in Romania (Chendes, 2011; Paltineanu, 2007).

The values resulted, that exceed 40, indicate the areas that are covered with forest vegetation, in a very high percentage. The values that range between 30 and 40 are characteristic to the areas covered in forest, with a medium percentage. The values under 30 indicate the existence of the conditions that are specific to the silvo-steppe. In the case of Ozana drainage basin, the fact that the territorial distribution of the values resulted from the De Martonne index coincides with the degree of coverage with forest vegetation.

In the mountainous area, where the land is very well forested, the values of the index can reach 45.4, and in the plateau regions, where the forest associations are sparse, the values dropped to 30.6 (fig. 2). By following these limits, one can observe in the graphs, the deviations from the "normal" humidity, and the years characterised by strong drought events can be identified: 1986, 1987 (the value of the index drops by 20 units, compared to the value that is specific for the area), 1990, 1994 at Pluton, and these periods can be observed at all the 3 hydrometrical stations (fig.3). The closer to area is to the outlet, the more arid the conditions are.



	IDM	Climate classification	Vegetation
	15≤I≤24	Semiarid	Steppe
	24<I≤30	Moderately arid	Forest-Steppe
	30<I≤35	Slightly humid	Oak forest
	35<I≤40	Moderately humid	Beech forest
	40<I≤50	Humid	Coniferous forest
			Subalpine
	50<I≤60	Very Humid	Alpine
	60<I≤187	Excessively	Perhumid

Fig. 3. ***Annual evolution of De Martonne Index, at Pluton, Leghin and Dumbrava hydrometrical stations (1977-2015)***

By applying the Hellman criterion, the months (at a multi-annual level) in which the drought or dryness phenomena were prone to appear, had to be identified. According to the graphs, several differences can be emphasized, at the basin level (fig.4). In the mountainous region, there is only one month that, at a multi-annual level, has stood up among the rest, as being excessively droughty, while in the median / central region of the basin, three months have been identified, that have such potential, as well as five months, at Dumbrava.

In the mountain region (Pluton), the minimum values during droughts have been most frequently recorded in September, being noted in 2.6% of cases. At the multiannual level, the drought frequency occurrence per months varies from 43% in December to 18.4% in June (Table 2). In the transition area between the

Carpathians and the Subcarpathian region (Leghin), the frequency of occurrence per months increases.

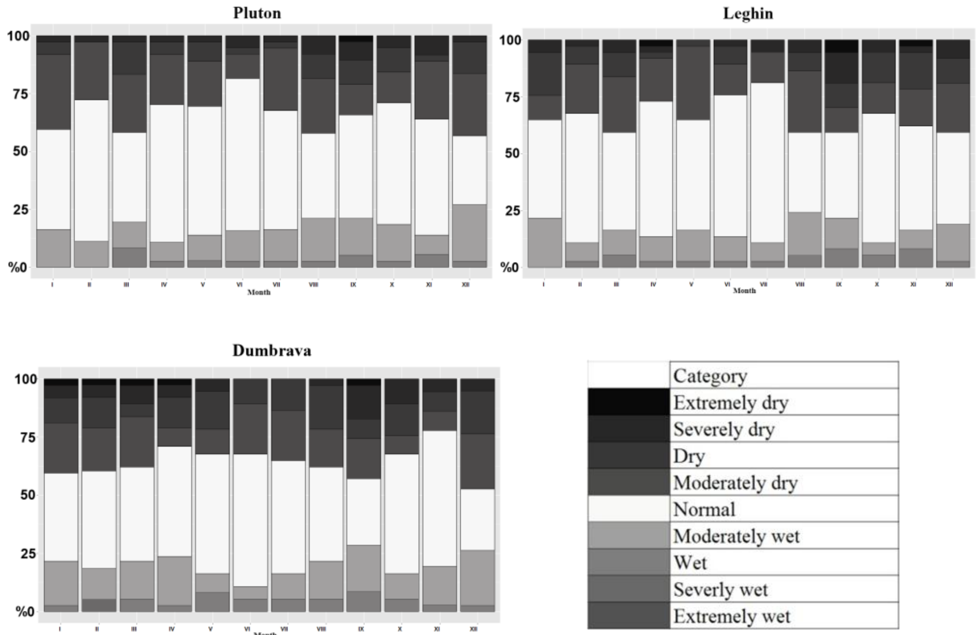


Fig. 4. ***Frequency of months with different pluviometrical characteristics, according to Hellman criterion at Pluton, Leghin and Dumbrava stations (1977 – 2015)***

The lowest value, of 24%, is characteristic to August and the highest, of 41%, appear in March and December. The months that recorded severe droughts were April (2.7%), September (5.4%) and November (2.7%). In the plateau area (Dumbrava), the greatest possibility of drought occurrence is in December with a frequency of 47.4%, and the lowest risk is in November, with 22% chance of occurrence. Such severe droughts were recorded in the following months: January, February, March, April and September, all with a frequency of less than 3%.

Table 2. ***The monthly frequency of drought occurrence (%)***

	J	F	M	A	M	J	J	A	S	O	N	D
Pluton	41	28	42	30	31	18	32	42	34	29	36	43
Leghin	35	32	41	27	35	24	19	41	41	32	38	41
Dumbrava	41	39	38	29	32	32	35	38	43	32	22	47

At the multiannual level, the frequency of droughts is 33% in the mountainous area, it increases one percent in the transition area and it reaches 37% in the plateau where the Ozana river drains into the Moldavian river. Depending on the intensity of the drought, the most common category is that of less dry months with a multiannual frequency varying between 16% and 22% (table 3).

Table 3. ***Frequency of drought cathegories for each station (%)***

	Pluton	Leghin	Dumbrava
Moderately dry	21.8	18.7	16.4
Dry	5.9	9.2	12.6
Very dry	4.7	5.0	5.6
Extremely dry	0.2	0.9	2.0

The frequency of months that have a higher incidence of droughty periods is greater during the cold season and in the autumn. Also, the fact that the periods characterized by droughts are more frequent and last for a longer time span, than the time periods associated with excessive precipitation events can be observed.

5. CONCLUSIONS

In the present study, several indicators were calculated and applied on the Ozana drainage basin region, in order to quantify the degree of aridity, but also the degree of air humidity. Based on them, specific months have been identified, that are prone to the occurrence of the drought phenomena (January, February, March, April, September and November), and have a greater frequency during the transition seasons (spring and autumn). The drought manifests differently in the field, being more pronounced in the plateau regions. A rise in frequency and intensity for this phenomenon can be observed from the West, to the East. The reason for which these differences appear, can be explained through the accentuation of the Eastern continental influences

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