



DROUGHT ASSESSMENT IN THE MOLDAVIAN PLAIN

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Abstract: The Moldavian Plain, located in the North-Eastern part of Romania, has a temperate-continental climate with a nuance of excessivity in the precipitation regime. This paper aims to analyse droughts in the Moldavian Plain for the period 1961-2010, by using a classical method - the *de Martonne Aridity Index*, and two other less known indices developed in Romania and the Republic of Moldova. Among these indices, the Dry Spells Index demonstrates a increasing frequency of dry years in recent decades.

Introduction

The aim of this study is to evaluate the frequency and tendency of drought in the Moldavian Plain, a low hilly region located in the North-Eastern part of Romania, with a temperate-continental climate. Considering the fact that there is no universally accepted definition of drought, several indices have been used to estimate this phenomenon, among which the de Martonne Aridity Index has been one of the most applied for the study area, since 1929.

1 Materials and Methods

The temperature and *rainfall data* for the Botoşani and Iaşi weather stations was obtained from ROCADA: Romanian daily gridded climatic dataset (1961-2013).

Emmanuel de Martonne created an aridity index using the following formula:

$$Ia = \frac{P}{T+10}, \text{ where:}$$

P represents the annual rainfall and T represents the annual average temperature. In order not to have negative values, the value 10 is added to T .

For the calculation of the monthly values, another formula is used:

$$Ia = \frac{P*12}{T+10}, \text{ where:}$$

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P and T represent the monthly precipitations, respectively the average monthly temperature. P was multiplied by 12 so that the results can be compared to the annual values.

The steppe corresponds to the regions where the aridity index has a value lower than 25, the forest steppe regions have an index between 25 and 30, and values above 30 are characteristic to the forrest regions (*Buletinul meteorologic lunar*, 1929).

The Emmanuel de Martonne Aridity Index was calculated for two weather stations and six gauge stations in the Moldavian Plain for the period 1961-2010. The dataset was extended for the stations Darabani, Dorohoi, Avrămeni, Răuseni, Cotnari and Podul Iloaiei, through the arithmetic mean method and normal ratio method, based on the average temperature and rainfall data published by Mihăilă (2006)(Fig. 1).

Table 1. Weather stations and gauge stations in the Moldavian Plain

Station number	Station name	Latitude (N)	Longitude (E)	Elevation (m)
1	Darabani	48°11'	26°36'	200
2	Avrămeni	48°05'	26°57'	240
3	Dorohoi	47°58'	26°23'	197
4	Botoșani	47°51'	26°41'	180
5	Răuseni	47°34'	27°11'	62
6	Cotnari	47°22'	26°57'	289
7	Podu Iloaiei	47°13'	27°15'	90
8	Iași	47°10'	27°36'	100

In Hârjoabă's opinion (1979), the indices that don't take into account the number of days with precipitations are relative (such as Hellmann Criterion, de Martonne, Gaussen and *Péguy*), because the monthly quantity of rain, which might classify a month as being humid, could fall in a single day, while the index, created by Topor, has two drawbacks: it doesn't use air temperature, nor does it lay weight on the importance of the previous month. Therefore Hârjoabă proposes an aridity index which combines elements of the index developed by the students of de Martonne for the determination of the monthly aridity and those of Topor and *Péguy* (the first to determine the dry nature of a month according to the pluviosity of the previous month), using the following formula:

$$I = Pmm/T^{\circ}C+10,$$

in which:

I = the monthly aridity index;
 Pmm = rain in mm for the correspondent month;
 T°C = temperature for the correspondent month;
 10 = correction coefficient.

According to this formula, a month is dry when:

$I \leq 1$, regardless of the number of days with precipitation;
 $1 < I \leq 1.5$, under the condition that the number of rainy days does not exceed 2, but the number of rainy days can be 4, if the previous month was dry.

$$I_{ZU} = \frac{\sum_{ZU}(V-VIII)}{X_{ZU}(V-VIII)}, \text{ unde:}$$

The Index of Dry Spells proposed by Maria Nedea (2012) represents the ratio between the number of dry days registered in specific years by their multiannual average, expressed by:

$\sum_{ZU}(V-VIII)$ – the sum of dry days registered in May-August, when the intensive growth and development of crops takes place;

$X_{ZU}(V-VIII)$ – multiannual average of dry days (May-August).

A day is considered dry if the air temperature exceeds 25°C, and the air humidity is below 30%.

If $I_{ZU} = 2.1$ the number of dry days exceeds the double of their multiannual average, resulting in a significant dry period.

2 Results and Discussions

According to *Buletinul meteorologic lunar* (The Monthly Weather Bulletin) for April 1929, the first publication to determine aridity in Romania using the de Martonne index, most of the Moldavian Plain's values ranged between 25 and 30 in 1896-1915, while in *Geografia României* (The Geography of Romania), I, 1983, the values of the index increase from East to West (Fig. 2). The map using the values from the eight weather and gauge stations indicates a higher grade of aridity in the central area of the plain (Fig. 3).

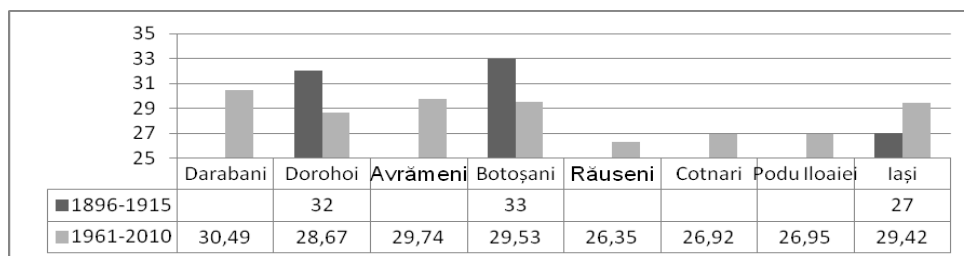
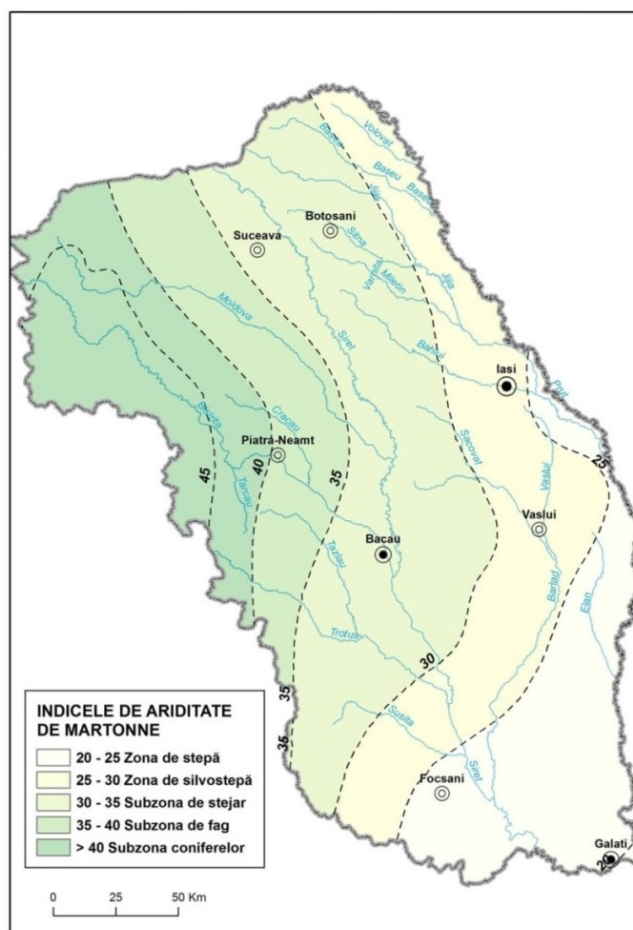


Fig. 1. The values of de Martonne Index for the Moldavian Plain.

Fig. 2. The values of the de Martonn aridity in the region of Moldavia (according to *Geografia României*, vol. I, 1983).

The monthly values have been calculated for Botoșani (1961-2010) and Iași (1894-1960 și 1961-2010) weather stations. Over the year, the highest values are not caused by high amounts of precipitation but by the low temperatures that cause a very low evapotranspiration potential (Daniela Larion, Mihaela Pălimariu, 2007). The lowest monthly values are characteristic for the month of September at Botoșani (and at Iași between 1894-1960) and for the month of October at Iași (Fig. 4-5). Throughout the period of time common to the two weather stations, the

values have varied between 17 and 45. The most arid years were: 1967, 1986 in Botoșani, and 1990, 1994, 2000 in Iași (Fig. 6).

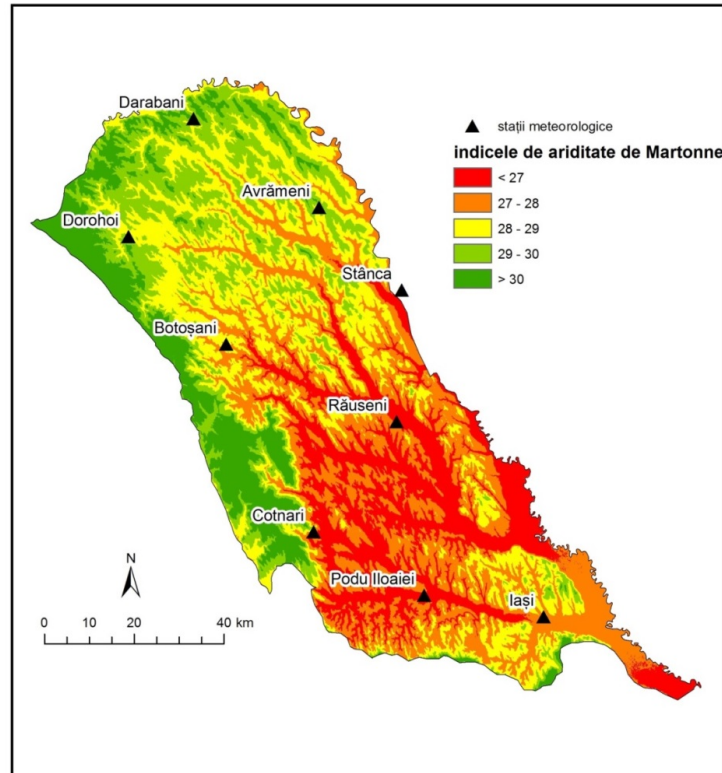


Fig. 3. The de Martonne index on the Moldavian Plain, calculated for the period 1961-2010.

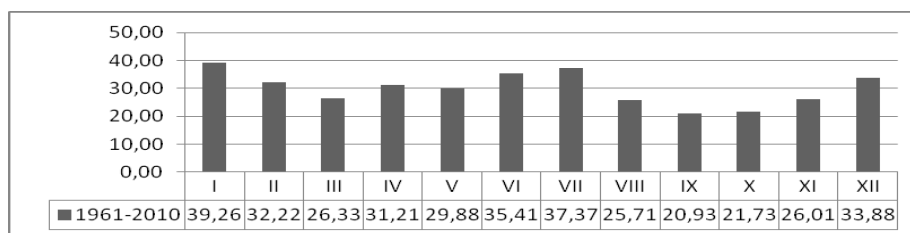


Fig. 4. Monthly values of de Martonne Index at Botoșani station (1961-2010).

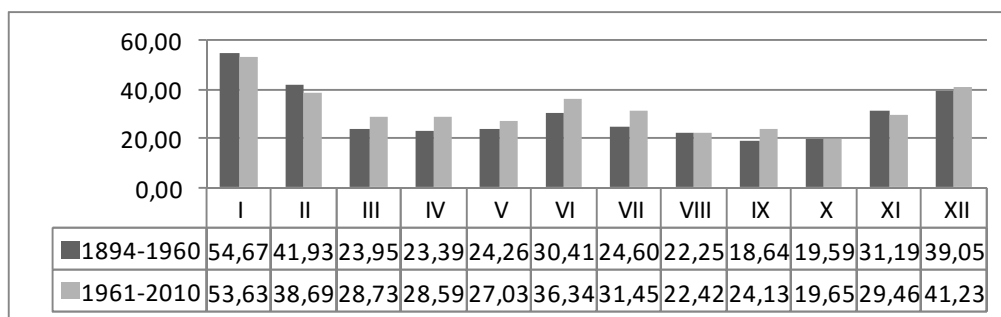


Fig. 5. Monthly values of de Martonne Index at Iași station (1961-2010).

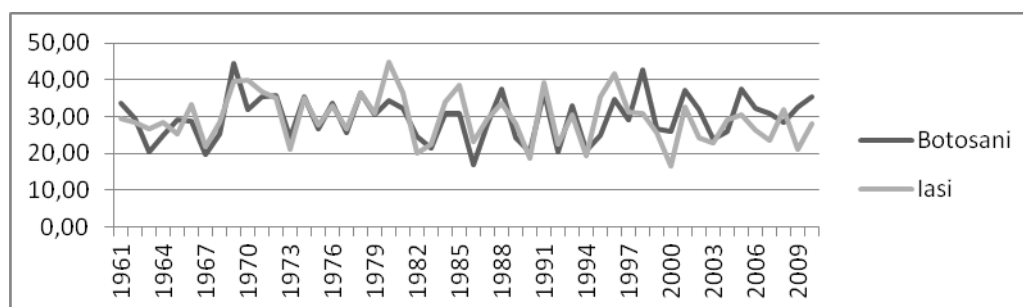


Fig. 6. The variation of de Martonne Aridity Index values between 1961-2010.

According to Hârjoabă's Aridity Index, at Botoșani and Iași, the percentage of dry months was almost identical in the period 1961-2010 (21-21.5%), the most affected by drought being October (42%) and September (38%), while June being the less affected (6-8%)(Fig. 7). The most dry decade was 1981-1990 (Fig. 8).

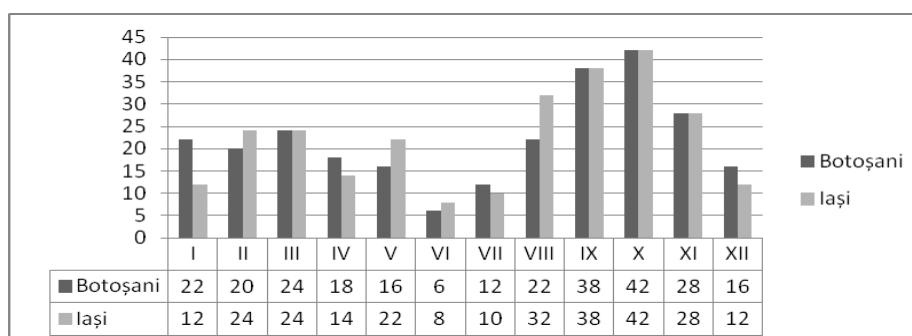


Fig. 7. The monthly proportion of dry months in Botoșani and Iași (1961-2010).

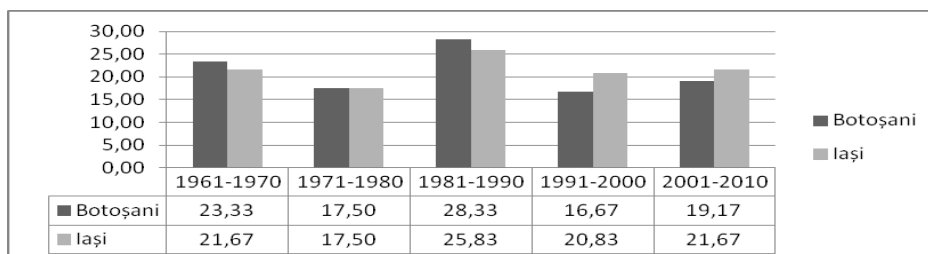


Fig. 8. The proportion of dry months in Botoșani and Iași (1961-2010).

The results obtained by using Nedealcov's Index of Dry Spells show an intensification of the aridization process in Botoșani and Iași, as the dry years are becoming more and more frequent in the last two decades. In Botoșani, the years 1963, 1987, 1999, 2000, 2002, 2007 and 2010, have registered the highest values (6.53 in 2010). In Iași, 1996 was the first dry year, followed by 2000, 2007 and 2010. In the latter two years the highest values have been registered (4.53 and 4.68)(Fig. 9-10).

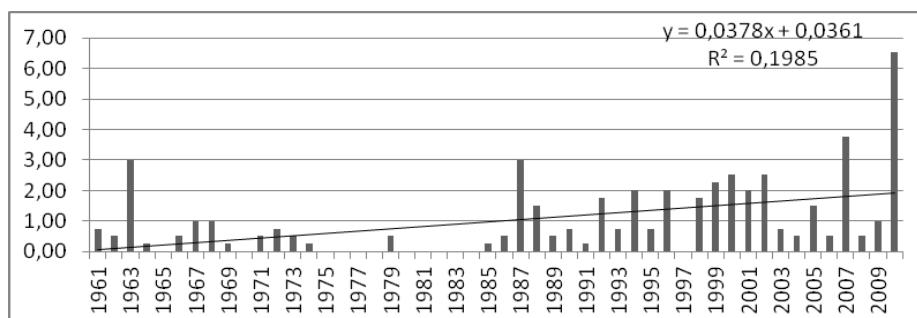


Fig. 9. The evolution of the Dry Spells Index at Botoșani (1961-2010).

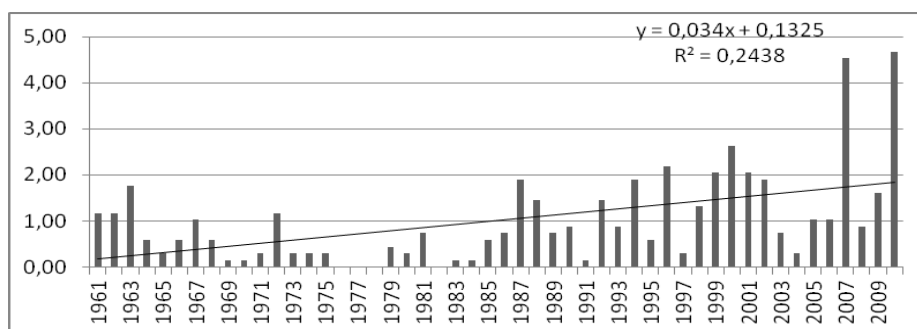


Fig. 10. The evolution of the Dry Spells Index at Iași (1961-2010).

Conclusions

By use of de Martonne Aridity Index, the most vulnerable area has been pointed out, and a clear tendency of the aridization process has been revealed by Nedelcov's Index of Dry Spells, but the suitability of these estimation methods needs to be determined and validated by further studies.

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