POTENTIAL EVAPOTRANSPIRATION AND DRYNESS / DROUGHT PHENOMENA IN COVURLUI FIELD AND BRATEŞ FLOODPLAIN

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Abstract. The values of potential evapotranspiration in both Covurlui Field and Brateş Floodplain are some of the greatest in Romania. The water deficit is high in the hot season. The dryness coefficient shows subunit values, categorizing the studied area as a droughty one. The drought periods (according to the Hellman criterion) are frequent and intense. The parameters of the climatic processes presented show the need for irrigations in agriculture.

1. Evapotranspiration

The annual regimen of evapotranspiration is directly influenced by the air temperature, wind conditions and the active surface characteristics. Evapotranspiration is a specific process especially for the hot season, the values recorded in the cold season months being insignificant.

According to literature, when computing the potential evapotranspiration many methods are used, including in various proportions the climatic agents conditioning the evapotranspiration. Penman formula (based on the energetic chain) and Thornthwaite formula (based on temperature) are ones of the most used.

Penman formula:

$$Ep = Q\frac{s}{s+\gamma} + \frac{\gamma}{s+\gamma}Ea$$

where:

Q = net radiation

E_a = 0,35 (es-ea) (0,5 + 0,01 v), agent expressing the atmospheric conditions according to the wind speed;

es = water vapor pressure at *t* temperature;

ea = the actual water vapor pressure;

es-ea = saturation deficit;

v = wind speed;

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$\frac{s}{s+\gamma}, \frac{s}{\gamma+s}$ = weighted agents

s = the slope of water vapor pressure curve at *t* temperature;

γ = dew-point constant.

The annual average potential evapotranspiration (computed based on Penman formula) reaches values between 850 and 950 mm in the south-east of the country, a region with higher thermal and calorific potential and lesser precipitations, where the studied area subsumes (*Climate of Romania*, 2008). The results obtained by this method are close to those measured with the evapotranspiration meter.

More often, Thornthwaite method is used, having the formula:

$$ETP = 16\left(\frac{10t}{I}\right)^{a} F(\lambda)$$, where:

t = monthly average temperature (°C);

I = annual calorific index;

$$I = \sum_{n=1}^{12} in, \qquad in = \left(\frac{t}{5}\right)^{1,514} = \text{indice termic lunar;}$$

$$A = 6{,}75 \cdot 10^{-7} \cdot I^{3} - 7{,}71 \cdot 10^{-5} \cdot I^{2} + 1{,}79 \cdot 10^{-2} \cdot I + 0{,}49;$$

$F(\lambda)$ = expression for correction according to latitude and month of the year (Thornthwaite, 1948).

Tab. 1 - Average potential evapotranspiration in Covurlui Field and Brateş Floodplain and the neighborhood area

Stations	**Month**												**Annual**
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Galați (1961-2008)	2,4	4,9	15,7	49,2	96,5	126,0	143,7	127,7	79,9	42,6	14,6	3,4	706,6
Tecuci (1961-2008)	2,4	4,6	15,1	49,4	96,1	123,7	138,7	122,3	76,1	39,8	13,1	2,5	683,7
Balinteşti (1961-1983)	2,0	5,2	12,1	48,0	95,5	123,3	133,9	118,1	75,2	38,5	13,9	3,9	669,7
Maicăneşti (1961-1999)	1,8	4,9	14,4	48,4	95,2	124,6	139,1	123,5	78,4	40,2	13,4	2,8	686,6

Using this method, we noticed that the ***average potential evapotranspiration*** scores down values over 600 mm (except Balinteşti, where it is a little less), during *the hot* season (April-October), in the vegetation period. It reaches values between 594.1 mm in Balinteşti and 623 mm in Galați. This value is one of the greatest in the country, being only 75 to 85 mm lower than the annual total value. Such values are explained by the temperature increase and intensification of the biological processes, including the plant transpiration ones (table 1). During May-July period, the period of maximum vegetation, the average potential evapotranspiration scores down almost half of the total annual value (between 352,7 mm in Balinteşti and 366,2 mm in Galați). The highest values arise in July (143,7 mm in Galați), when the highest monthly average temperatures are recorded, that month being the second one, after that of June, in what concerns the average quantity of precipitations.

Tab. 2 - Maximum potential evapotranspiration in Covurlui Field and Brateş Floodplain and the neighborhood area

Stations, period	**Month**												**Annual**
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Galați (1961-2008)	5,6	15,6	32,9	67,1	124,6	152,0	177,8	149,5	104,1	60,9	26,1	9,6	928,8
Tecuci (1961-2008)	6,6	12,7	32,4	64,3	124,7	143,8	167,1	148,3	101,1	56,7	25,2	7,6	890,6
Balinteşti (1961-1983)	3,1	9,9	24,1	63,3	115,1	140,8	147,5	135,4	88,3	56,8	24,6	8,0	816,8
Maicăneşti (1961-1999)	5,8	11,1	30,8	64,4	113,9	139,9	161,9	146,5	99,1	57,7	24,2	8,2	863,4

Tab. 3 - The minimum potential evapotranspiration in Covurlui Field, Brateş Floodplain and the neighborhood area

Stations, period	**Month**										**Annual**
	I - III	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	
Galați (1961-2008)		30,8	79,2	108,4	122,5	104,0	62,7	31,7			539,2
Tecuci (1961-2008)		31,3	80,0	103,7	118,3	97,2	61,2	26,0			517,8
Balinteşti (1961-1983)		29,5	79,4	106,2	121,0	98,2	64,2	27,4	0,8		526,7
Maicăneşti (1961-999)		32,8	78,6	106,2	120,2	103,1	63,0	28,2			532,2

The maximum values of the monthly potential evapotranspiration in the *cold season* are over 100 mm (between 126 mm in Balinteşti, in the north, and 154 mm, in the south, in Galați). *The minimum potential evapotranspiration* scored down in *the hot season*, the vegetation one, shows values of ca. 500 mm, only 20 to 30 mm less than the annual minimum total (table 3). During May-July period, the minimum potential evapotranspiration totalizes approximately 300 mm in the northern part and 304 to 310 mm in the south of the territory. In July, in the region, the minimum potential evapotranspiration scores values over 120 mm, also being in this situation the month with the highest values.

The water deficit reaches annual average values between 162 mm (in Balinteşti) and 255 mm (in Galați). The deficit in June and July reaches averages varying from 30 mm in the north to 60 mm in the south (in June), between 76 mm in the north and 96 mm in the south, respectively, (in July), being one of the highest in the country,

The United Nations Program for the Environment approves, for computing the dryness coefficient, a formula based on the relationship between precipitations and potential evapotranspiration:

$$I = \frac{P}{ETP},$$

where: I = the dryness coefficient;
P = the annual quantity of precipitations (mm);
ETP = the annual potential evapotranspiration (mm).

In the studied area, this coefficient scores values increasing from south to north: 0,65 in Măicăneşti, 0,69 in Galați, 0,72 in Tecuci and 0,75 in Balinteşti. The values are, in fact, characteristic to the whole southern and south-eastern part of Romania (*Climate of Romania*, 2008) and show a climate with dryness tendencies.

2. Dryness and drought phenomena

The drought is considered as a spring or summer prolonged period with precipitations much under the normal value, in conditions of increased air temperature. Due to such, the water provisions in the soil are decreased a lot, creating adverse background for the normal growth of plants. There can be distinguished an atmospheric drought, with very poor precipitations, high temperatures and low air humidity and pedological drought, when the water provisions in the ground are depleted,

According to Hellman, the *drought* period is that period when not even 0,1 mm of precipitations fall on the ground for 14 consecutive days during October-March period or 10 days during April-September period. The *dryness* period is a 5 consecutive days period when not even 0,1 mm of precipitations fall to the earth. Such phenomena, with high impact on the human society, are frequent in the Covurlui Field and the Brateş Floodplain all around the year and their happening was recorded in time in a lot of documents.

The dryness and drought phenomena are climatic complex phenomena caused by climate characteristic features (the quantity and regimen of atmospheric precipitations, the relative humidity, the air temperature, the evapotranspiration, the wind frequency and speed, the anti-cyclonic predominant regime caused by the Siberian or Azoric anti-cyclones or wedge of the two), and also by the active surface characteristics: relief features (altitude, slope, exposure, morphology), characteristics of the soil (type, structure, soil surface temperature and the water provisions within the same), characteristics of vegetation (vegetation phase, plants strength degree to water shortage), underground water depth, anthropic factors considering the type of agricultural technological works performed, etc. Out of them, the most important for the drought phenomenon occurrence are the precipitation level and the air temperature.

Regular months are considered (according to Hellman's criterion) those months when the precipitation quantity is no more or less than 10% of the respective month average quantity.

Regular months but more rainy ones are those months when the precipitation quantity is more than 10 to 20% over the average; the rainy months have precipitation quantities with 21 to 30% over the average; quite rainy months have precipitation quantities with 31 to 50% over the average, and the extremely rainy months have 50% precipitations over the average.

Regular months but less droughty ones are considered those months when the precipitation quantity is less than 10 to 20% under the average; the droughty months have quantities with 21 to 30% below the average; very droughty months have quantities with 31 to 50% below the average; the extremely droughty months have the precipitation quantities with more than 50% below the average (N, Topor, 1964).

Out of the total of 644 agricultural months analyzed for Galați (with blank periods, between 1922 and 2008), 946 agricultural months for Tecuci, respectively, (between 1921 and 2008), 140 month were normal ones (22%) in Galați and 121 months (19%) in Tecuci; 304 months (47%) were droughty ones in Galați (out of which 194 months, representing 30%, were extremely droughty), and for Tecuci, out of the 308 droughty months (49%), 199 months (32%) were extremely droughty. The rainy months were 200 (31%), out of which 131 (20.5%) were extremely rainy months in Galați, and 201 months (32%) were rainy ones in Tecuci, out of which 131 months (21%) were extremely rainy. Compared to what was shown above, it can be noticed that the number of droughty months is greater in percentage, confirming a tendency of territory drying. Considering the pluviometric features of the months, the years have been analyzed as per the formula:

$$I\ an = \frac{N + 2P}{N + 2S}$$

where: - N – is the number of regular months;
- P - is the number of rainy months;

- S - is the number of droughty months;
- I an – the pluviometric coefficient of the respective year.

For *I an* less than 0,33, the years are considered as extremely droughty; the pluviometric coefficient ranging from 0,33 to 0,41 is for extremely droughty years; 0,50 to 0,60 for droughty years and over 0,71 for droughty years. For *I an* of 0,85, the years are regular but a little droughty, for a coefficient of 1, the years are regular, for 1,18 the years are regular but a bit rainy, for 1,40 – rainy ones, and for 1,66 – very rainy years. The 2,0 coefficient shows extremely rainy years and over 2,43 – exceptionally rainy years.

On the whole country area, since 1881 up to 1961, 17 years were droughty, five years extremely droughty (1896, 1903, 1930, 1934, 1953) and four years exceptionally droughty (1894, 1904, 1948, 1959). In Moldova, years 1910, 1921 and 1945 are distinguished as years with very severe droughts (Topor, 1970).

At the meteorological stations Galați and Tecuci, where the observation periods were longer (from 1922, 1921 respectively, up to 2008, with some intermittences), we could find out that 7 years were regular ones in Galați and 8 years were regular in Tecuci, 4 years were less rainy in Galați and 6 years for Tecuci; 4 rainy years, 3 years respectively, in Galați and Tecuci; 2 very rainy years, one year respectively for Galați and Tecuci; 2 extremely rainy years in Galați (1933 and 1966) and one extremely rainy year in Tecuci (1966); exceptionally rainy years were in Galați - 1997 (with an annual pluviometric coefficient of 3) and 2005 (with a coefficient of 3,8) while in Tecuci years 1941 (a coefficient of 3), 2005 and 2007 (both with a coefficient of 2,43) belonged to this category.

By the other hand, the number of droughty years is much greater, as follows: 9, respectively 8 less droughty years in Galați and Tecuci; 6, respectively 8 droughty years in Galați and Tecuci; very droughty years in Galați were 19 and 12 in Tecuci; extremely droughty years were 14 for both Galați and Tecuci; while exceptionally droughty years (with pluviometric coefficients of 0,26; 0,14; 0,1 and 0,09) were 12 years in total (1927, 1928, 1934, 1938, 1942, 1945, 1948, 1950, 1951, 1983, 1990, 2008) in Galați, and 11 years in Tecuci (1927, 1928, 1931, 1932, 1935, 1936, 1938, 1983, 1985, 1986 and 1994).

In order to analyze the frequency of years with specific pluviometric features in the last 86 year period, based on the pluviometric features of the months, we used data from the meteorological stations in Galați and Tecuci as representative ones considering their locations in the southern, respectively the northern parts of the analyzed area. This analysis outlined some short rainy periods and more (and longer) droughty periods, for 1922 to 2008 period (1921 to 2008 in Tecuci). The first rainy period in Galați is 1957 to 1958, the second one is 1966 to 1969, interrupted by one droughty year alone - 1967, the third period is 1979 to 1981 followed by 1996 to 1997 and 2004 to 2005. In Tecuci, the rainy periods are 1969 to 1970 and 1996 to 1999. The rainy periods have between 2 and 4 years.

The droughty periods in Galați are 1922 to 1932, with short interruptions given by regular years (1923 and 1929), 1934 to 1939, 1942 to 1956, 1959 to 1965, 1970 to 1978 (with the insertion of only one regular year: 1976), 1982 to 1995 (also during this period we have two regular years: 1984 and 1988) and 1998 to 2003, (1960 to 1968) and the second one of 10 years (1981 to 1990). The periods are of 6 up to 14 years, with small interruptions, most of them containing extremely and excessively droughty years.

The droughty periods in Tecuci are 1928 to 1939, 1944 to 1946, 1963 to 1965, 1967 to 1968, 1971 to 1975, 1985 to 1987, 1989 to 1995 (with the insertion of just one regular year: 1991) and 2000 to 2003. The periods are shorter than those for Galați, with 2 to 7 years, with small interruptions, only the first period having 12 uninterrupted years. Most of the periods contain both extremely and exceptionally droughty years.

This kind of analysis prioritized the droughty years, the percentages and features being not quite accordant for the rainy years compared with the droughty ones, also because the used computation model exhibits a real predomination of droughty years. So, if for *I an* of 1.66 the very rainy feature was applied, that of very droughty is applied for two values of the annual coefficient, 0.60 and 0.50, the logics being identically applied for the extremely rainy feature, *I an* = 2, while for extremely droughty we have two situations, with *I an* of 0.41 and 0.33, etc. This way of analyzing is not fully suggestive as the droughty year features can be given by 4 or 5 months, all belonging to the cold season, when the low temperature and evapotranspiration together with the lack of plants biological intense activity make undetectable the effects of such droughty years.

The effects of intensive droughts in the last two decades were not that strongly recorded in the memory of the human society as far as the social impact nowadays for strong droughts (some of them with only local spreading) cannot be compared to the one in other times (as were the impacts of droughts in 1906 to 1907 or 1945 to 1946). The effects of droughts, materialized in crop ravaging, drying of grazing fields, drying or critical diminishing of river levels, decreasing of underground water levels, dust storms, rise of animal morbidity and mortality are decreasingly reflected on the human morbidity and mortality as the civilization progressed.

The drought phenomena are very frequent in this part of the country with an increased degree of continental features. There can be noticed a non-periodical occurrence of the phenomenon in what regards the frequency, duration and intensity.

Conclusions

The practical importance of analyzing the evapotranspiration, dryness and drought phenomena is increased for domains like agriculture, but also for the whole economy (for the investment field in general), and also for the life of people. The annual precipitation average quantities in the analyzed area are insufficient related to the annual average temperatures.

The average values of evapotranspiration decrease from Bârlad river valley to south, towards the Siret river valley and that of Danube too, but especially towards the Brateş floodplain where the degree of sheltering increases (Apostol, Apăvăloae, 1985). Even though the decrease per the total of area analyzed is small, the temperature rise, streaming formation probability increase and evotranspiration intensification may lead to an aridity evolution if the tendencies persist. The territory of Covurlui field and Brateş floodplain, entirely located in the humidity deficit area (annual average quantity of precipitations lower than the annual average value for evotranspiration - Bogdan, Niculescu, 1999), has all conditions together for acclimating frequent and long droughts. Therefore, for the agriculture in this area, irrigations are stringently needed, chiefly for the three abundant water sources located on three out of four sides of the region.

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