ASSESING DROUGHT RISK IN TIMISOARA DURING THE LAST DECADE

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Abstract: *Drought can be operationally defined as a water deficit state in relation to plant, population, and economy needs, resulting in discomfort and unbalance of social and economic activitie and in negative impacts on some important environmental factors. The phenomenon is widely spread at present on Earth and in Europe, and it is due to greenhouse gas effect caused by pollution and by massive deforestation on Earth and in Romania. Atmospheric drought is seen through the significant increase of average daily temperatures during the summer as well as of average maximum temperatures in summer and winter months – an increase of the frequency of tropical days (daily maximum above 30^{0}C) and lack of precipitations. The paper presents the result of analysis of the following parameters in monitoring drought: sum of monthly and annual precipitations, average monthly and annual evapotranspiration in the studied years, monthly and annual hydric deficits and their graphic representation, average monthly temperatures and their evolution, as well as air relative moisture values; we also calculated and analysed aridity and climate indicators in Timisoara during the studied decade, From the point of view of the precipitations regime, an important indicator in identifying drought, the sum of monthly precipitations in the summer and even spring months (i.e. the annual sum of these precipitations) can help us draw a conclusion on the trend to drought and desertification during the studied decade. Moisture deficit was determined as the difference between the amount of precipitations and the values of monthly potential evapotranspiration and of plant water consumption, respectively, determined through the indirect Thornthwaite method, using average monthly and multi-annual in Timisoara. Identifying drought during the studied decade in Timisoara asks for drought management measures that could also be preventive measures, action measures during the phenomenon, and phenomenon control measures.*

Keywords: *atmospheric drought, soil drought, average monthly temperatures, average monthly temperatures, sum of monthly precipitations, potential evapotranspiration, aridity coefficient, climate coefficient*

INTRODUCTION

Drought is mainly a meteorology issue which depends on the level of precipitations, o the size of mean daily temperatures, on the increase of the frequency of tropical days, hence the different types of drought: meteorological, atmospheric, soil, hydrological, etc.

During the last decade, we have been confronted both in Europe and worldwide with an increase of mean temperatures, i.e. with a real warming up.

On areas with high risk of drought, the climate is warm and dry, with mean annual temperatures above 10^{0}C; the sum of mean annual precipitations is between 350 and 550 mm, and that of mean annual precipitations during vegetation (April-September) is between 200 and 350 mm.

The climate variability has an impact on all national economic branches; the most vulnerable of all are crops, i.e. agriculture, which means that precipitations during vegetation are much lower than evapotranspiration, which leads to hydric deficits as is the case of Timisoara.

MATERIAL AND METHODS

In this paper, we analyse the following parameters:

- annual precipitations and precipitations during vegetation between 2000 and 2009 recorded at the Meteorological Station in Timisoara, i.e. their evolution and abatements from the multi-annual means;
- mean monthly and annual temperatures, i.e. their evolution during the studied period;
- evapotranspiration, monthly, annual and vegetation values during the 10 years and the evolution of consumptions compared to multi-annual means;
- annual and vegetation hydro-climate balances;
- annual aridity indicators (de Martonne);
- annual hydro-climate indicators.

Potential evapotranspiration was calculated after the Thornthwaite method (1948) based on mean air temperature, with the following relation:

$$ETP = 16\left(\frac{10 \cdot tn}{I}\right)^{a} \cdot K$$

where:

ETP – monthly potential evapotranspiration (mm);

tn – mean monthly temperature for which ETP is calculated (°C);

I- area thermal indicator (sum of monthly thermal indicators);

$$I = \sum_{n=1}^{12} i_n$$

$$i_n = \left(\frac{t_n}{5}\right)^{1,514}$$

a = an exponent depending on I;

a = 0.0000006751 I^3 - 0.00007711 I^2 + 0.0179211 I + 0.49239;

I_n = monthly thermal indicator;

Hydro-climate indicator = (Precipitations/Potential evapotranspiration) x 100

Aridity indicator (de Martonne) = Precipitations/Temperature + 10;

Hydro-climate indicator = Precipitations – Potential evapotranspiration.

RESULTS AND DISCUSSION

Tables and diagrams below show an increase of mean annual temperatures compared to multi-annual mean – 0.1 and 2.2°C in 7 of the 10 years, while during vegetation they are much higher than the multi-annual mean of 9 of the 10 years.

As for precipitations, the years with the smallest amounts of rainfall were 2000 and 2009, when temperatures were the highest. On the whole, in 5 of the 10 years precipitations were lower than the mean of both annual and hot period means.

Potential evapotranspiration was higher, i.e. it was above multi-annual mean of 7 of the 10 years studied both in annual and in warm period values, with i.e. with values between 33.47 mm and 140 mm in 2009.

Table 1.

Mean monthly temperatures recorded at the Meteorological Station in Timisoara compared to multi-annual means (2000-2009)

Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual sum	1.04.-1.10
2000	-2.8	2.8	5.7	14.8	18.7	15.5	22.0	29.0	16.7	13.1	10.6	3.6	12.5	19.4
2001	2.3	3.3	9.4	10.7	17.8	18.7	22.2	22.9	15.1	13.3	3.5	-3.3	11.3	17.9
2002	-0.8	5.6	8.3	14.1	19.4	21.2	23.7	21.1	16.2	11.4	8.5	0.3	12.2	18.7
2003	-2.5	-4.7	4.7	10.4	20.2	23.8	22.4	24.2	16.2	9.0	7.5	1.3	11.0	19.5
2004	-2.2	1.5	6.0	12.2	15.2	20.0	20.5	21.2	15.8	12.7	6.0	2.4	10.9	17.5
2005	0.0	-3.3	3.4	11.4	16.8	19.7	22.1	20.3	17.3	11.1	5.0	1.3	10.4	17.9
2006	-2	0.0	5.0	12.4	16.2	19.5	23.6	20.1	17.5	12.0	6.0	2.0	11.0	18.2
2007	0.1	4.2	10.6	14.9	23.0	24.1	22.5	18.3	13.0	9.0	6.0	4.0	12.5	19.3
2008	1.7	4.8	8.6	13.1	23.0	22.5	20.7	21.0	15.2	11.1	7.0	3.7	12.7	19.3
2009	-0.3	2.0	7.3	16.0	19.0	21.3	24.0	23.7	20.0	12.3	8.3	4.3	13.1	20.6
Multi-annual mean	**-1.2**	**0.4**	**6.0**	**11.3**	**16.5**	**19.6**	**21.6**	**20.8**	**16.9**	**11.3**	**5.7**	**1.4**	**10.9**	**17.8**

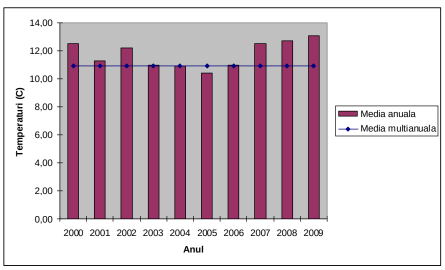

Fig.1. Evolution of mean annual temperatures (2000-2009)

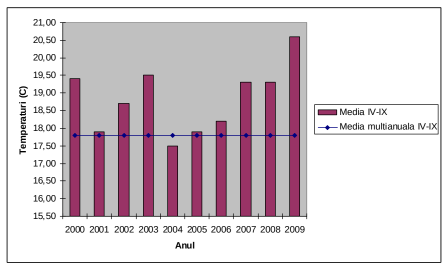

Fig.2. Evolution of mean temperatures during vegetation (2000-2009)

Table 2.

Monthly precipitations recorded at the Meteorological Station in Timisoara compared to multi-annual means (2000-2009)

Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual sum	1.04.-1.10
2000	22.5	11.2	45.0	34.0	31.1	41.8	25.3	8.6	23.7	1.8	20.6	34.5	300.1	164.5
2001	35.4	18.6	58.9	79.6	31.8	130.3	58.6	30.6	152.2	15.4	66.1	14.0	691.5	483.1
2002	8.7	10.5	7.6	47.1	53.1	74.8	62.2	98.6	48.2	52.6	42.7	66.7	572.8	384.0
2003	69.0	26.7	10.2	46.3	51.4	81	55.4	42	66.3	113	31.3	22.5	615.1	342.4
2004	60.0	40.3	18	59.1	66.2	34.8	45.2	76.9	55.6	62.8	127	60.8	706.7	278.7
2005	32.3	67.8	45.5	154	49.8	35.1	45.2	142	84.6	25.6	21.0	89.0	791.9	536.3
2006	30.0	42.0	49.0	78.8	50.2	87.8	50.4	98	21.2	17.0	31.0	21.0	576.4	386.4
2007	26.0	92.0	4.0	69.0	65.0	46.0	65.0	62.0	53.0	53.0	86.0	23.0	644.0	360.0
2008	45.7	22.6	119	61.4	62.2	230.8	61.1	29.6	67.1	25.9	53.0	55.0	833.4	512.2
2009	31.0	29.0	52.0	25.0	47.0	115.0	42.0	31.0	4.0	10.0	106.0	42.0	534.0	264.0
Multi-annual mean	**40.9**	**40.2**	**41.6**	**50.0**	**66.7**	**81.1**	**59.9**	**52.2**	**46.1**	**54.8**	**48.6**	**47.8**	**629.9**	**356.0**

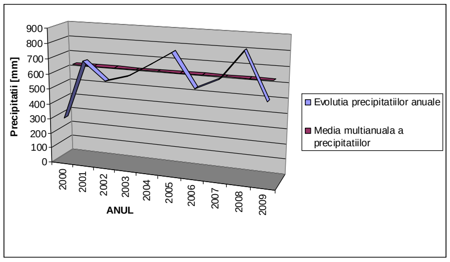

Fig.3. Evolution of annual precipitations (2000-2009)

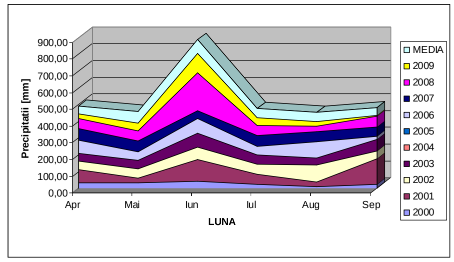

Fig.4. Evolution of precipitations during vegetation (2000-2009)

Table 3.

Mean monthly potential evapotranspiration recorded at the Meteorological Station in Timisoara compared to multi-annual means between 2000 and 2009

Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual sum	1.04.-1.10
2000	0.00	4.78	16.39	69.75	109.87	136.58	141.41	147.66	76.11	49.38	26.48	4.42	782.83	681.38
2001	0.00	7.66	37.25	48.77	106.52	115.19	144.96	139.36	69.99	53.71	8.06	0.0	731.47	624.79
2002	0.00	15.8	32.3	54.5	117.4	136.5	154.5	123.4	75.9	44.2	25.7	7.80	788.0	662.20
2003	0.00	0.0	16.02	47.52	122.6	151.4	142.6	144.9	75.77	33.04	22.15	2.39	758.4	684.80
2004	0.00	3.14	21.44	56.56	84.16	119.11	138.40	118.13	70.56	48.4	16.4	5.06	681.3	586.92
2005	0.00	0.0	15.9	52.11	94.99	116.95	135.42	112.09	78.74	41.6	11.89	3.10	662.8	590.30
2006	0.00	0.0	17.2	58.9	89.5	115.5	146.6	110.7	79.8	45.2	16.4	4.06	683.9	601.00
2007	0.10	10.9	42.7	72.0	136.8	149.3	138.4	98.9	55.7	31.9	16.4	9.40	762.5	651.10
2008	3.56	13.05	33.89	63.26	144.0	141.2	129.33	121.6	70.01	42.85	20.33	8.75	791.8	669.40
2009	0.00	4.41	27.65	81.06	113.6	131.9	155.37	141.29	98.39	48.67	25.11	10.55	838.0	721.60
Multi-annual mean	**0.0**	**1.0**	**23.0**	**53.0**	**97.0**	**123.0**	**135.0**	**123.0**	**81.0**	**44.0**	**16.0**	**2.0**	**698.0**	**612.00**

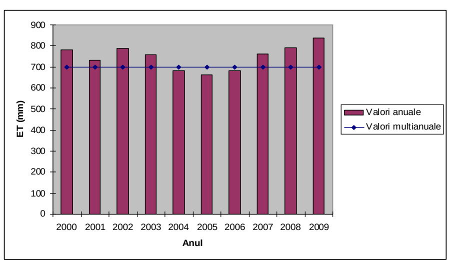

Fig.5. Evolution of annual evapotranspiration (2000-2009)

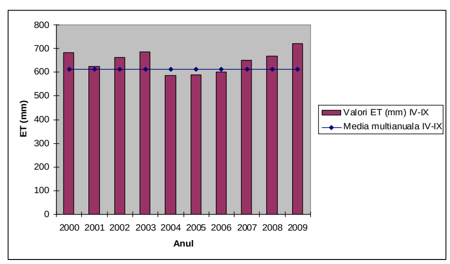

Fig.6. Evolution of evapotranspiration during vegetation (2000-2009)

Table 4 presents a synthesis of several parameters showing drought risk in the last decade, i.e. we calculated annual and vegetation period hydro-climate balance, hydro-climate indicators, aridity indicators, and ranking.

We can see that in 8 of the 10 years there were annual hydric deficits and that in 7 of the 10 years annual hydric deficits are higher than multi-annual mean, while during vegetation there were deficits in all 10 years, with deficits higher than normal ones during the warm period in 6 of the 10 years.

Table 4.

Mean annual hydro-climate balance in Timisoara (2000-2009)

Year	Precipitations (mm)	ETP (mm)	Annual P-ETP	P-ETP (IV-IX)	Hydro-climate indicator	Aridity indicator	Class*
2000	300.1	782.83	-482.83	-516.88	38.33	13.39	Very deficitary
2001	691.5	731.47	-39.97	-141.69	94.53	33.08	Little deficitary
2002	572.8	788.0	-215.2	-278.20	72.69	25.80	Little deficitary
2003	615.1	758.4	-143.3	-342.40	81.10	29.29	Little deficitary
2004	706.7	681.3	+25.4	-308.22	103.72	33.81	Little excedentary
2005	791.9	662.8	+129.1	-54.00	119.47	38.82	Moderately excedentary
2006	576.4	683.9	-107.5	-214.6	84.28	27.45	Little deficitary
2007	644.0	762.5	-118.5	-291.0	84.46	28.62	Little deficitary
2008	833.4	791.8	+41.6	-157.20	105.25	36.71	Moderately excedentary
2009	534.0	838.0	-304	-457.60	63.72	23.12	Little deficitary
Multi-annual 1896-1955	631.0	698.0	-67.0	-256.0	90.40	30.30	Little deficitary

*The ranking was done after the ICPA Methodology, 1987, III – Ecopedological indicators

Aridity indicator is a synthesis indicator showing the level of water deficit in an area, with low values indicating a high degree of aridity in the area.

As a result, 1 of the 10 years ranked in the very deficitary class, and 5 of the 10 years ranked in the little deficitary class. Two years were moderately excedentary, and two years were little excedentary.

Even in the moderately and little excedentary years, there were hydric deficits during vegetation and temperatures higher than means, as was the case for 2008 or 2004, with a hydric deficit during vegetation of 308.2 mm, higher than the average.

CONCLUSIONS

- Mean annual and warm period temperatures (April-September) were higher than normal ones in 7 of the 10 years studied, with 2000 the warmest year, when the annual mean was above 1.6^{0}C and 2009, when the annual mean was 2.2^{0}C than the multi-annual mean; 2007 also was very hot, with an annual mean 1.6^{0}C higher than the normal one, and 2008 with an annual mean 1.8^{0}C higher than the normal one. Temperatures are increasing during the period 2000-2009, with the hottest months May, June, and July, and with temperatures higher than the normal one ever since spring.
- Precipitations decreased compared to the mean in 5 of the 10 years studied, with lowest ones in 2000, when they recorded only 300 mm annually, which represents half of the multi-annual mean of the area; 2009 and 2006 also recorded 53.5 mm less than the mean.
- There were 4 of the 10 years in which the sum of precipitations was higher than the multi-annual mean, as in 2008, when the total amount of precipitations was 833.4 mm, much higher than the mean of 629.9 mm, i.e. 2005, 2004, and 2001, when it was 162 mm higher, and 76.6 mm respectively more than the multi-annual mean.
- The hydro-climate balance shows that in 7 of the 10 years studied they recorded annual hydric deficits between 39.97 mm and 482.83 mm; during vegetation in all 10 years they recorded hydric deficits, and in 6 of the 10 years they were much above the multi-annual mean of the area corresponding to the warm period.
- Of the 10 years, 6 were little deficitary and 1 was very deficitary (2000).

- Even in little deficitary years, there were cases of hydric deficits during the warm period, above the multi-annual mean with periods of drought followed by heavy rain.
- We can see in the last decade rather often periods of very high temperatures, lack of precipitations and hydric deficits during the warm period, followed by very heavy rains, which shows the aggressiveness of the meteorological phenomena lately as a result of global warming.

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