ASSESSING DROUGHT RISK IN THE ARAD AREA

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Abstract

A rather complete definition of drought is the one that mentions the fact that it is an extreme phenomenon with long setting period characterised by the decrease of precipitations below the mean level, by the decrease of the river flow and of underground waters, and that cause a high moisture deficit in air and soil, with direct effects on the environment and on agricultural crops.

World Meteorological Organisation suggested defining drought as the atmosphere sequence characterised by amounts of precipitations 60% smaller than the normal ones. The phenomenon is widely spread nowadays on the globe and in Europe, and it is caused by greenhouse effect gases, pollution, and massive deforestation.

The paper presents the following drought monitoring parameters in the Arad area: sum of monthly and annual precipitations, mean monthly and annual evapotranspiration, monthly and annual hydric deficits and their graphic representation, monthly mean temperatures and their evolution; we also calculated and analysed the characterisation climate indices (Thornthwaite, Lang, characterisation depending the precipitations deficit, etc.).

The moisture deficit was determined as the difference between the amount of precipitations fallen and the values of monthly potential evapotranspiration and of plant water consumption determined with the indirect Thornthwaite method, in whose calculus we used monthly mean temperatures and multiannual means of monthly temperatures.

The existence of drought in four of the nine years between 2003 and 2011 and the significant hydric deficits during the warm period April-September in the nine years ask for drought management measures – prevention, action during drought, control measures.

Key words: drought, sum of monthly precipitations, potential evapo-transpiration, aridity coefficient.

INTRODUCTION

Drought is mainly a meteorological issue depending on the level of precipitations, on the level of mean daily temperatures, on the increase in frequency of tropical days; there are, therefore, several types of drought: meteorological, atmospheric, pedological, hydrological, etc. (Sorocovschi, 2009).

Drought and desertification affect sustainable development because of their inert-relations with social issues that they generate and enhance reducing water reserves, reducing food production potential and, implicitly, reducing food safety (Moldovan, 2003).

Meteorological studies point, for Romania, to an increase of mean annual temperatures of 0.5^0C in the last century, with some differences between the different regions. There is, in Romania, a clear intensification of such phenomena as *drought* and *desertification* because of natural and artificial (deforestation, destruction of the irrigation system, etc.) causes. Of the 14.7 million ha of agricultural land, about 7 million ha (i.e. 48%) have been affected by drought over longer periods of time and in subsequent years (*Strategia Națională privind reducerea efectelor secetei, prevenirea şi combaterea degradării terenurilor şi deşertificării, pe termen scurt, mediu şi lung*, 2008).

In areas with high drought risk, the climate is hot and dry, with mean annual temperatures above 10^0C, with a sum of mean annual precipitations between 350 and 550 mm, and with a sum of vegetation precipitation (IV-IX) between 200 and 350 mm (Ienciu, 2009).

MATERIAL AND METHOD

To characterise drought, we need to take into account the amount of precipitations over a period and the deviations from normal levels (multiannual means), as well as other climate indices.

In this paper, we present an analysis of the following parameters:

- Annual precipitations and precipitations during vegetation in 2003-2011 recorded at the Meteorological Station in Arad, their evolution and deviations from multiannual means;
- Mean monthly and annual temperatures and their evolution during the period analysed;
- Evapo-transpiration – monthly, annual and during vegetation levels – during the period analysed and the evolution of consumptions compared to multi-annual means;
- Annual and during vegetation hydro-climate balances;
- Annual aridity indices (de Martonne);
- Annual hydroclimate indices.

- *Potential evapotranspiration* was calculated after the Thornthwaite method (1948) based on mean air temperature, using the formula:

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

where:

ETP – monthly potential evapo-transpiration (mm);

tn – monthly mean temperature for which ETP is calculated (^{0}C):

I – area thermal index, i.e. the sum of monthly thermal indices.

$$I = \sum_{n=1}^{12} i_n, \qquad i_n = \left(\frac{t_n}{5}\right)^{1,514}$$

a = exponent depending on I

$a = 0.0000006751\ I^3 - 0.00007711\ I^2 + 0.0179211\ I + 0.49239$.

I_n = monthly thermal index

The annual hydroclimate balance was calculated according to the current methodology using the formulas:

- *Hydroclimate balance* = Precipitations –Potential evapo-transpiration

- *Hydroclimate index* = (Precipitations/Potential evapo-transpiration) x 100

- *Aridity index (de Martonne)* = Precipitations/Temperature + 10; (FLOREA N et al, 1987).

- *Characterisation after Thornthwaite*

It relies on the differences between precipitations and evapo-transpiration. We compare on a monthly basis the water supply from precipitations (P) with losses caused by evapo-transpiration.

We note by d = ETP-P – the annual water deficit (the sum of monthly water deficits) – and by s = P-ETP – the annual exceeding water (the sum of monthly exceeding water) and we calculate the following:

- Moisture index *Iu = (s/ETP)*100*
- Aridity index *Ia = (d/ETP)*100* *where:*

ETP = annual value of potential evapo-transpiration

The global moisture index Im allows an annual characterisation from the point of view of precipitations:

*Im = Iu – 0.6*Ia or Im = [(s – 0,6*d)/ETP]*100*

Table 1

Climate characterisation after Thornthwaite

Global moisture index (Im)	Annual characterisation
Im>100	Supermoist
100>Im>80	Moist
80>Im>20	Supermoist
20>Im>0	Submoist
0>Im>-20	Subdry
-20>Im>-40	Semiarid
-40>Im	Arid

- *The Lang Index* allows a delimitation of climates in plane areas (agricultural areas). It is not applicable to monthly values.

$$L = \frac{P}{T}_{\text{annual}}$$

P = annual precipitations (mm)

T = annual mean temperatures (^{0}C)

Interpretation:

0 < L < 20 Arid climate; 20 < L < 40 Mediterranean climate;40 < L < 70 Semiarid climate; 70 < L < 1000 Moist climate

RESULTS AND DISCUSSION

The results of the analysis of the evolution of monthly mean temperatures in Arad and the deviations from multiannual mean levels (Figure 1) show that the hottest years during the period analysed (in an ascending order of temperature values) were 2007, 2008 and 2009, whose annual mean temperatures were above 12^0C.

In three years, there were annual mean temperatures close to the value of the multiannual mean (normal years from a thermal point of view). During the period analysed (2003-2011), there was an increase of the annual mean temperature of 0.3^0C compared to the multiannual mean, and during the hot period of the same years there was an increase of the temperature of about 1^0C.

Figure 2 shows that the lowest amount of precipitations was in 2008 (458.2 mm), with 469.4 mm in 2010, 425.1 mm in 2011, and 292.9 mm in 2003.

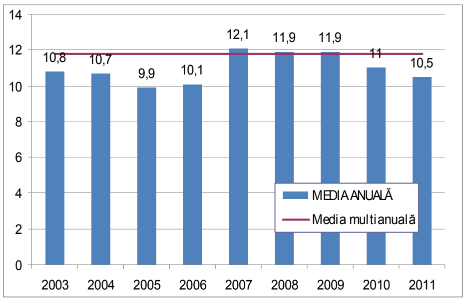

Fig. 1. Annual mean temperatures in 2003-2011 compared to the multiannual mean

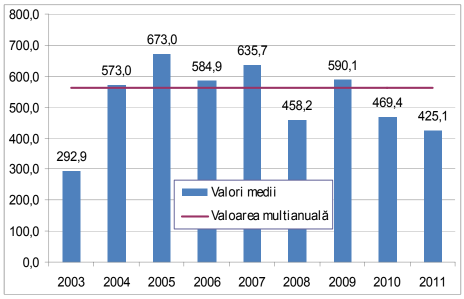

Fig. 2. Comparison between mean precipitation values and multiannual value for the period 2003-2011

Data concerning the hydroclimate balance show monthly hydric deficits (ETP-PP) and hydric excess (PP-ETP). The hydroclimate balance supplies a more eloquent image of the periods of hydric stress, allowing the monitoring of droughty periods and of droughty years. The graphs below (Figures 3-11) containing hydroclimate balance curves emphasise the periods of hydric deficit and their size (mm) over the studied years (2003-2011).

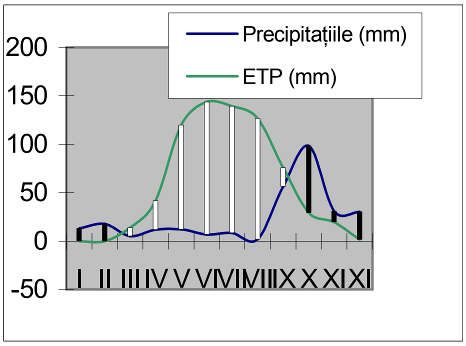

Fig. 3. Evolution of hydroclimate balance curve (2003)

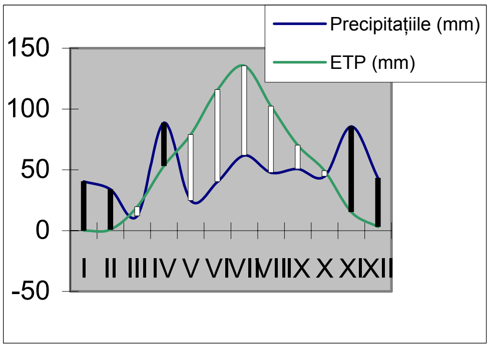

Fig. 4. Evolution of hydroclimate balance curve (2004)

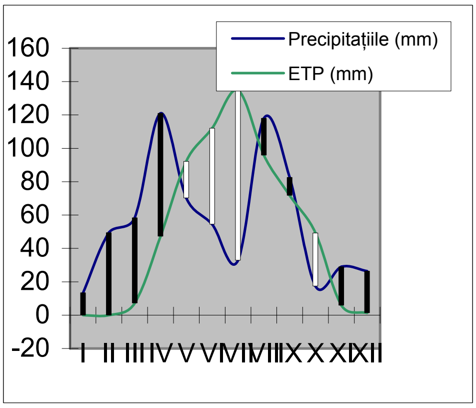

Fig. 5. Evolution of hydroclimate balance curve (2005)

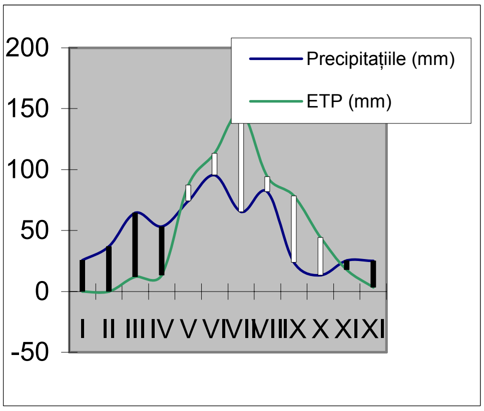

Fig. 6. Evolution of hydroclimate balance curve (2006)

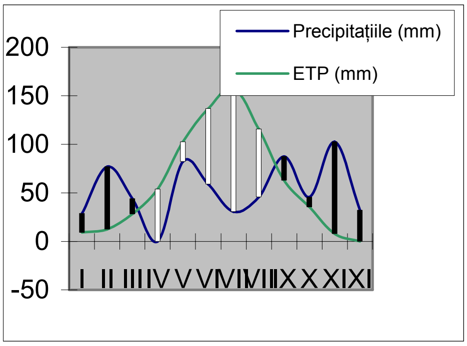

Fig. 7. Evolution of hydroclimate balance curve (2007)

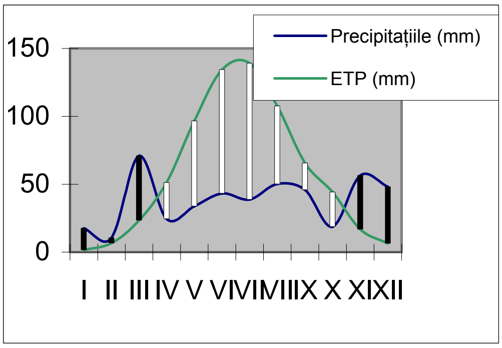

Fig. 8. Evolution of hydroclimate balance curve (2008)

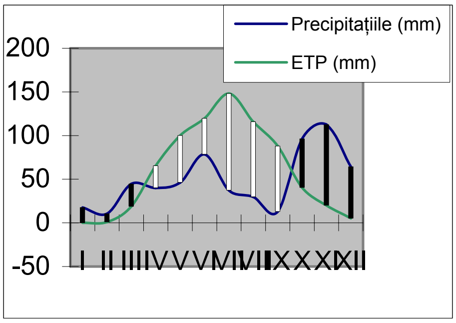

Fig. 9. Evolution of hydroclimate balance curve (2009)

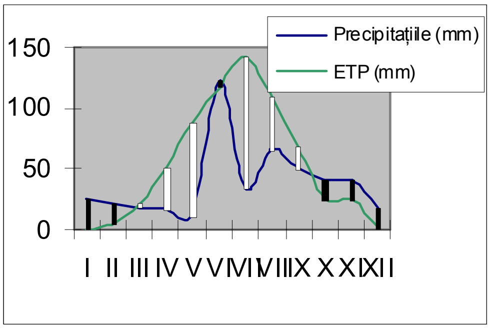

Fig. 10. Evolution of hydroclimate balance curve (2010)

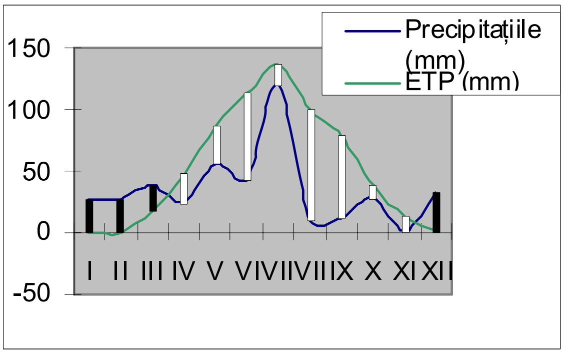

Fig. 11. Evolution of hydroclimate balance curve (2011)

Table 3 shows the years depending on the annual hydroclimate balance, on the annual hydroclimate index, and on the aridity index.

It is clear that most analysed years had low deficits (2004, 2005, 2006, 2007, and 2009) and high deficits (2003, 2008, 2010, and 2011). These analyses depend on the annual values of the studied years.

Table 3

Annual mean hydroclimate balance in Arad during the period 2003-2011

Year	Precipitations (mm)	ETP (mm)	Annual P-ETP	Hydroclimate index	Aridity index	Class
2003	292.9	710.8	-418.0	41.2	14.1	High deficit
2004	573.0	644.6	-71.6	88.9	27.7	Low deficit
2005	673.0	617.4	+55.6	109.0	33.8	Low deficit
2006	584.9	610.7	-25.8	95.8	29.1	Low deficit
2007	635.7	723.5	-87.8	87.9	28.8	Low deficit
2008	458.2	693.8	-235.6	66.0	20.9	High deficit
2009	590.1	722.4	-132.3	81.7	26.9	Low deficit
2010	469.4	655.8	-186.4	71.6	22.3	High deficit
2011	425.1	635.2	-210.1	66.9	20.7	High deficit
Multiannual mean 1896-1955	631.0	698.0	-67.0	90.4	30.3	Low deficit

The classification has been made according to current methodology (*Metodologia ICPA, 1987, III – indicatori ecopedologici*)

Characterisation after Thornthwaite is illustrated in Table 4 with global moisture indices (Im): we can see that 2003 was a semiarid year and other four years were subdry (2004, 2008, 2010, and 2011)

Table 4

Characterisation after Thornthwaite for the period 2003-2011

Year	Moisture index Iu	Aridity index Ia	Global moisture index Im	Characterisation of the year
2003	15.4	78.4	-31.64	Semiarid year
2004	22.6	56.4	-11.24	Subdry year
2005	43.6	34.6	22.84	Semimoist year
2006	30.2	34.4	9.56	Submoist year
2007	36.1	48.3	7.12	Submoist year
2008	21.5	55.4	-11.74	Subdry year
2009	36.1	54.4	3.46	Submoist year
2010	14.8	43.2	-11.1	Subdry year
2011	16.9	49.9	-13.04	Subdry year

Characterisation after Lang is shown in Table 5: we can see that of the nine years, seven are semiarid according to this index.

Table 5

Characterisation after Lang during the period 2003-2011

Year	**Lang L Index**	**Characterisation of the year**
2003	27,1	Mediterranean climate
2004	53,5	Semiarid climate
2005	68,0	Semiarid climate
2006	57,9	Semiarid climate
2007	52,5	Semiarid climate
2008	38,5	Mediterranean climate
2009	49,6	Semiarid climate
2010	42,7	Semiarid climate
2011	40,5	Semiarid climate

CONCLUSIONS

- Mean annual temperatures and mean temperatures during the hot period of the year (IV-IX) were higher than normal temperatures in three of the nine studied years, with the hottest years 2007, 2008 and 2009.
- The precipitations decreased compared to the mean in four of the nine studied years, reaching 292.9 mm/year in 2003 (i.e. half of the multiannual mean of the area) and values below the multiannual mean in 2008, 2010 and 2011.
- Hydroclimate balance shows that there were, in eight of the nine

studied years, hydric deficits between 25.8 and 418.0 mm; during the vegetation period, all nine studied years had significant hydric deficits between 181.7 and 549.2 mm (2003).

- According to Thornthwaite, one year was semiarid and four years were subdry, while according to Land, seven of the nine studied years were semiarid.
- The last decade had frequent periods with very hot temperatures, with no precipitations and with hydric deficits during the hot period, followed by rather considerable rainfalls, which points to the aggressiveness of the meteorological phenomena because of global warming.

REFERENCES

1. Florea N., V. Bălăceanu, C. Răuță, A. Canarache, 1987, *Metodologia Elaborării Studiilor Pedologice, Partea a III a, Indicatorii ecopedologici*, Bucureşti;
2. Ienciu Anişoara, 2009, *Monitorizarea factorilor de risc*, note de curs, Timişoara;
3. Ienciu Anisoara, Oncia Silvica, Peptan Carmen, Fazakas Pal**,** 2010, *Assesing drought risk in Timisoara during the last decade*, Research Journal of Agricultural Science
4. Moldovan F., 2003, *Fenomene climatice de risc*, Editura Echinox, Cluj - Napoca,;
5. Oncia Silvica, C. Teodoreanu, Laura Vulcănescu, I. Nemeş, 2003, *The humidity deficit in 2000-2002 period on natural condition of Banat Field,* Lucrări Ştiinţifice, vol. XXV Timişoara;
6. Sorocovschi V., 2009, Seceta, concept, geneza, attribute si clasificare, Riscuri si catastrofe, vol. VIII, nr.7;
7. * * *, *Strategia Naţională privind reducerea efectelor secetei, prevenirea şi combaterea degradării terenurilor şi deşertificării, pe termen scurt, mediu şi lung*, Ministerul Agriculturii şi Dezvoltării Rurale;
8. http://www.maap.ro/pages/strategie_antiseceta_update_09.05.2008.pdf, 2008
9. http://www.revistacalitateavietii.ro/2005/CV-3-4-05/8.pdf.
10. www.meteo.ro