MONITORING HYDRIC DEFICITS IN THE AREA OF SÂNNICOLAU MARE, ROMANIA

Ienciu Anisoara*, Smuleac Laura*, Manea Dan*, Peţ Ioan*, Bertici Radu*

* University of Agricultural Sciences and Veterinary Medicine of Banat „Regele Mihai I al României",Timisoara, e-mail: ienciuani@yahoo.com

Abstract

One of the most important hydro-climate risks is that of hydric deficits, i.e. of drought risk or flood risk. Droughts can occur in any area of the Earth, but the strongest effects are in arid, semi-arid, and sub-humid areas, where ecosystems are characterised by high frailty. This type of drought is increasingly frequent in southern and eastern Romania and it tends to extend to central and western Romania. The goal of this paper is to study hydric deficits, i.e. drought risk in Sânnicolau Mare, Romania, in 2012-2014. The three years have been analysed through the prism of several indicators of drought characterisation mentioned in literature, that we compared with multi-annual averages. The following hydro-climate risk monitoring parameters are analysed in the paper: the sum of monthly and annual precipitations, monthly average evapotranspiration, monthly and yearly hydric deficits and their graphic representation; we calculate and analyse characterisation climate indicators such as Thornthwaite, Lang, characterisation depending on precipitation deficit, etc. rom the point of view of the precipitation regime – an important indicator in declaring drought and moisture excess, respectively – the sum of monthly precipitations in summer or even spring, i.e. their yearly sum, helps draw conclusions on the existence of hydro-climate risks during the studied period. The years 2012 and 2013 were semi-arid depending on most analysed indicators: they were years with monthly and annual temperature averages higher than multi-annual ones, with significant hydric deficits during the hot period, followed by the year 2014, a moister year. Results show that there have been periods with hydric deficits, droughty periods in two (2012 and 2013) of the analysed years in Sânnicolau Mare, particularly during the hot season (April-September), years considered semi-arid in most analysed indicators. It is also clear that the year 2014 was a rainy, moist year and the warmest year of all.

Key words: average monthly temperatures, sum of monthly precipitations, aridity coefficient, climate coefficient

INTRODUCTION

Precipitation deficit has, because of its duration, distribution and intensity, direct effects on existing water resources, on water demands and on water use. These effects can lead to dysfunctionalities such as lack of water in the functioning of natural and/or human ecosystems (http://www.rowater.ro/daolt/Plan%20Management/.pdf).

The last decade has been characterised, both in Romania and worldwide, by a raise of average temperatures, i.e. a real warming. For Romania, meteorological studies point to an increase of average annual temperatures of 0.5°C in the last century, with a few differences between the regions.

Even when both the annual evapotranspiration values and the values recorded in the vegetation period were at a minimum, those years still had humidity deficits;

In Banat, the climate is undergoing a process of transformation. The transformation is both thermal, as a result of the increased values recorded in the past years, and pluviometric, caused by decreased rainfalls that no longer cover the plant water use (Şmuleac et all., 2010, Mircov et all., 2013).

Drought can also occur in areas where annual or periodical precipitations are "normal" or close to the multi-annual average, but water comes from rare precipitations with high intensities (mm/min) that do not allow soil accumulation. This type of drought is increasingly frequent in southern and eastern Romania and it tends to extend to central and western Romania (Mircov et all., 2009).

Drought has been defined as the period of hydric deficit characterised by the negative difference between inputs and outputs of water in the system that cause reversible or irreversible unbalance and dysfunctions (Stângă, 2007).

In areas with high drought risk, climate is warm and dry, with annual average temperatures above 10°C, with average annual precipitations between 350 and 550 mm and with 200-350 mm precipitations during vegetation (IV-IX).

At global scale, land undergoing drought and desertification cover ¼ of the total land on the Earth affecting about 1,000,000,000 inhabitants in over 110 countries among which Romania (*Strategia Naţională privind reducerea efectelor secetei, prevenirea şi combaterea degradării terenurilor şi deşertificării, pe termen scurt, mediu şi lung*).

MATERIAL AND METHOD

To characterise hydric deficit, we take into account size of precipitations during a certain period and deviations from normal values (multi-annual means) as well as other climate indicators.

In this paper, we analyse the following parameters:

- Annual and vegetation period precipitations during 2011-2013 recorded at the Meteorological Station in Oravita, their evolution and deviations from multi-annual means;
- Monthly and annual mean temperatures and their evolution during the period analysed;
- Monthly, annual and vegetation evapotranspiration during the period analysed and the evolution of consumptions compared to multi-annual means;
- Annual and vegetation hydro-climatic balance;
- Annual aridity indicators (de Martonne);
- Annual hydro-climatic indicators.

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

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

where:

ETP – monthly potential evapotranspiration (mm);

tn – monthly mean temperature for which we calculated ETP in ^{0}C;

I – thermal indicator of the area (sum of monthly thermal indicators);

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

a = exponent depending on I;

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

I_n = monthly thermal indicator.

Annual hydro-climatic balance was established after the "Methodology of soil studies – Part III – Ecopedologic indicators" using the following relations:

Hydroclimatic balance=Precipitations–Potential evapotranspiration.

Hydroclimaticindicator=(Precipitations/Potentialevapotranspiration)x100

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

Interpretation of de Martonne aridity indicator:

0 < A < 5 Arid climate

5 < A < 20 Semi-arid climate

20 < A < 30 Semi-humid climate

30 < A < 55 Humid climate

Results were interpreted after the table suggested by Donciu (1986) where he presents limit values of the main humid climate types in Romania (Table 1).

Table 1

Limit values of the main humid climate types in Romania (after Donciu, 1986)

Climate type	P – ETP (mm)	Donciu indicator	Thornthwaite indicator	De Martonne indicator
Excessively humid	600 to 1200	200 to 570	100 to 470	60 to 187
Very humid	300 to 600	160 to 200	60 to 100	50 to 60
Humid	100 to 300	120 to 160	20 to 60	40 to 50
Moderately humid I	0 to 100	100 to 120	10 to 20	35 to 40
Moderately humid II	-100 to 0	90 to 100	0 to 10	30 to 35
Moderately dry	-200 to -100	70 to 90	-20 to 0	24 to 30
Semi-arid	-350 to -200	50 to 70	-30 to -20	15 to 24

Characterising climate conditions depending on the deficit of precipitations was done calculating the percentage of precipitations of mean values as shown in Table 2.

Hydrothermal and climatic indicators

Characterisation after Thornthwaite

It is based on the differences between precipitations and evapotranspiration. We compare on a monthly basis the water supply from precipitations with losses through evapotranspiration.

By noting with d = ETP-P – annual water deficit (sum of monthly water deficits) and with s = P-ETP – annual water excess (sum of monthly excesses over a year) we calculate:

- Humidity indicator **Iu = (s/ETP)*100**
- Aridity indicator **Ia = (d/ETP)*100**

where ETP is the annual value of potential evapotranspiration.

The global indicator of humidity Im confers an annual precipitation characterisation:

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

Table 2

Characterisation of weather conditions depending on the deficit of precipitations (after Barbu I. and Popa I., 2001)

% of monthly mean precipitations	% of seasonal and annual mean precipitations	Characterisation
91-110	96-105	Normal
81-90	90-95	Little droughty
71-80	85-90	Droughty
51-70	75-85	Very droughty
< 50	< 75	Excessively droughty

Table 3

Climate characterisation after Thornthwaite (after Neacşa and Berbecel)

Global humidity indicator (Im)	Annual characterisation
Im > 100	Super-humid
100 > Im > 80	Humid
80 > Im > 20	Semi-humid
20 > Im > 0	Sub-humid
0 > Im > -20	Sub-dry
-20 > Im > -40	Semi-arid
-40 > Im	Arid

Lang indicator allows a delimitation of the climates per plane areas (agricultural ones). 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 Semi-arid climate

70 < L < 1000 Humid climate

RESULTS AND DISSCUSIONS

After analysing the evolution of monthly average temperatures in Sânnicolau Mare and the deviations compared to multiannual average values we see in Figure 1 and the year 2014 was the hottest, followed by the years 2013 and 2012. In all three studied years, annual average temperatures were superior to the normal average, and the average of the hot period was much above the multiannual average with values between 0.4-1.5°C in the years 2013 and 2012; in the year 2014, in the hot season, the average was sensibly lower (-0.3°C).

Figure 2 shows that the year 2013 had a precipitation deficit including in the hot period. In the year 2013, the total amount of precipitations was 361.6 mm, compared to the multi-annual average of 530.8 mm. The year 2012 had a deficit of 92.7 mm compared to the multi-annual average, reaching 63.6 mm during the hot period.

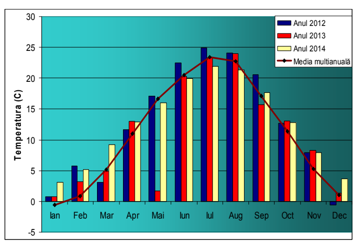

Fig. 1 Monthly average temperatures in the years 2012-2014

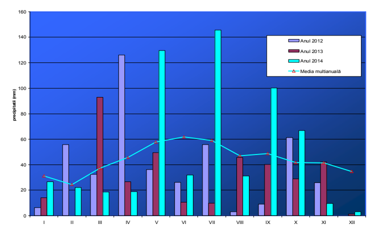

Fig. 2 Monthly average precipitations in the years 2012-2014

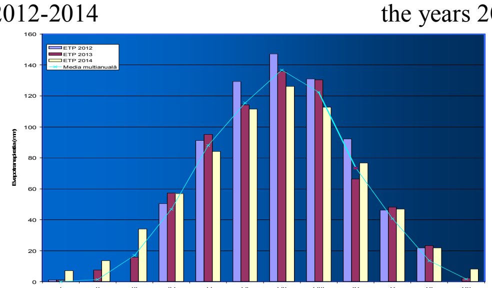

Fig. 3 Monthly averages of potential evapotranspiration

Figure 3 shows the evolution of evapotranspiration values in the three studied years in Sânnicolau Mare. In the year 2012, annual evapotranspiration was the highest, i.e. 720.04 mm (62.92 mm more than the multiannual average), and in the year 2013, it reached 697.2 mm (40.1 mm more than the multiannual average). In the year 2014, the value of annual evapotranspiration was 42.04 mm higher than the multiannual average, and in the hot season, the average was 15.11 mm lower than the normal average of the area.

The hydro climate balance provides a clear image of hydric stress periods allowing the monitoring of hydric deficit periods, i.e. droughty periods.

The graphic representation of hydro climate balance (Figures 4-6) shows the time distribution of hydric deficit periods and their size (intensity) during the three years in Sânnicolau Mare. Graphs show that the highest hydric deficit was in the year 2013, followed by the year 2012. In the year 2014, a rainy year, hydric deficit periods were fewer and lower quantitatively.

Table 4 shows a characterisation of the hot period (IV-IX) in the years 2012-2014 depending on the deficit of precipitations compared to monthly, seasonal and annual multi-annual averages. We can see in the table that in the year 2012, June, August and September were excessively droughty, May – very droughty; the hot period of the year was very droughty and the year 2012 was very droughty.

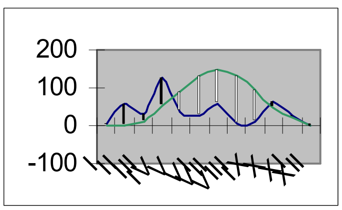

Fig. 4 Evolution of hydro-climate balance curves in the year 2012

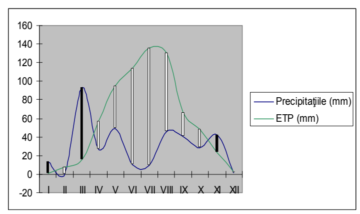

Fig. 5 Evolution of hydro-climate balance curves in the year 2013

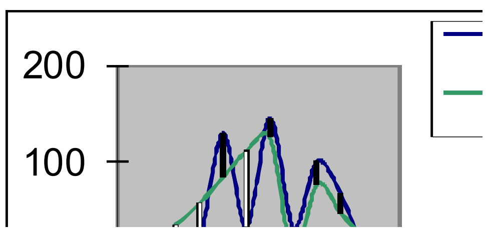

Fig. 6 Evolution of hydro-climate balance curves in the year 2014

Table 4

Characterisation of the weather in Sânnicolau Mare depending on precipitation deficit during the hot period in the years 2012-2014 (% of monthly, seasonal and annual averages)

An	IV	V	VI	VII	VIII	IX	IV-IX	Annual
2012	276	62.62	42.39	94.56	6.36	18.48	82.53	80.12
Interpretation	Rainy	Very droughty	Excessively droughty	Normal	Excessively droughty	Excessively droughty	Very droughty	Very droughty
2013	58.3	85.46	17.15	16.61	96.81	82.54	68.12	56.93
Interpretation	Very droughty	Little droughty	Excessively droughty	Excessively droughty	Normal	Little droughty	Excessively droughty	Excessively droughty
2014	41.2	224.2	51.77	246.7	66.24	205.7	113.8	142.9
Interpretation	Excessively droughty	Rainy	Very droughty	Rainy	Very droughty	Rainy	Rainy	Rainy

In the year 2013, June and July were excessively droughty, and April was very droughty; the hot period of the year was excessively droughty, and the year 2013 in Sânnicolau Mare was excessively droughty. The year 2014 was a rainy year from the point of view of precipitation deficit, as was the hot season (April-September). June and August 2014 were very droughty, and April was excessively droughty.

Table 5

Characterisation of the years 2012- 2014 in Sânnicolau Mare depending on the main climate indicators

Climate type	P – ETP (mm)	Donciu indicator	Thornthwaite indicator	De Martonne indicator	Thornthwaite global moisture indicator	Lang indicator
2012	-281.9	60.84	-39.15	20.28	-13.58	37.76
Interpretation	semiarid	semiarid	semiarid	semiarid	sub-dry climate	Mediterranean climate
2013	-335.6	51.86	-48.13	16.28	-22.63	29.63
Interpretation	semiarid	semiarid	semiarid	semiarid	semiarid climate	Mediterranean climate
2014	-94.9	86.41	-13.58	25.71	-0.33	44.75
Interpretation	moderately moist II	moderately dry	moderately dry	moderatel y dry	sub-dry climate	semiarid climate

Table 5 presents the main climate indicators calculated for the three studied years (2012-2014) in Sânnicolau Mare.

The table shows that most climate indicators range, in the years 2012 and 2013, in the semi-arid category, while in the year 2014 they range in the moderately moist II and moderately dry one, respectively.

CONCLUSIONS

- Analysing the years 2012-2014 in Sânnicolau Mare, we could see that the year 2014 was the hottest year, with an annual average temperature of 13.5°C, followed by the year 2013 with an annual average temperature of 12.2°C and by the year 2012 with an annual average temperature of 11.6°C;
- The year with the highest precipitation deficit was the year 2013, when the sum of annual precipitations was only 361.6 mm (compared to the multi-annual average of 530.8 mm), while the year 2014 had an excess of precipitations;
- The highest values of potential evapotranspiration were in the year 2012 (720.04 mm), while in the year 2013 and the year 2014 they were sensibly equal;
- The highest hydric deficits were in the year 2012 (461.00 mm) from April to September; in the year 2013, the hydric deficit period was higher, with a total deficit of 444.00 mm; in the year 2014, the total hydric deficit was much lower (231.6 mm);
- Depending on the percentage of precipitations from seasonal and

annual average precipitations, the year 2012 was very droughty, and the year 2013 was excessively droughty, while the year 2014 was rainy both during the period and the duration of vegetation;

➢ According to the annual hydric deficit, to the Donciu indicator, to the Thornthwaite indicator and to the de Martonne indicators, the years 2012 and 2013 were semi-arid and the year 2014 was moderately moist II and moderately dry, respectively;

➢ The Thornthwaite global moisture indicator shows that the years 2012 and 2014 were sub-dry and the year 2013 was arid; according to the Lang indicator, the years 2012 and 2013 had a Mediterranean climate, while the year 2014 had a semi-arid climate.

REFERENCES

1. Barbu I., Popa I., 2001, Monitorizarea riscului de apariţie a secetei în pădurile din România, rev. Bucovina Forestieră IX, 1-2;
2. Busuioc Aristita, Traşcă V., 2005 – Romania's Third National Communication on Climate Change under the United Nations Framework Convention on Climate Change, Ministerul Mediului şi Gospodăririi Apelor, Bucureşti;
3. Florea N, V, Bălăceanu, C. Răuţă, A. Canarache, 1987, Metodologia Elaborării Studiilor Pedologice, Partea a III a, Indicatorii ecopedologici, Bucureşti,;
4. Grumeza N., Tuşa C., 2000 - Consumul de apă şi evoluţia teritoriului amenajat pentru irigaţii în România, Buletinul AGIR, P. 20-24
5. Ienciu Anisoara, Oncia Silvica, Peptan Carmen, Fazakas Pal**,** 2010, Assesing drought risk in Timisoara during the last decade, Research Journal of Agricultural Science
6. Ienciu Anişoara, 2012, Monitorizarea factorilor de risc, note de curs, Timişoara;
7. Moldovan F., 2003, Fenomene climatice de risc, Editura Echinox, Cluj - Napoca;
8. Mircov D.V., Fekete Z., Cozma Antoanela, 2009, The analysis of the rain gange system at the main meteorological stations from Timis and Caras Severin Countries, Lucrari Stiintifice, Fac. de Agricultura, Timisoara;
9. Mircov V., Pop Georgeta, Moisa C., Cosma Antoanelea, 2013, Climatic risk determined by the pluviometric regime registered in the Banat area during 1961-2010, Proceeding of the 41 International Simposium – Actual task on agricultural engineering, ISSN 1884-4425, Opatija, Croatia;
10. Pleşa I., Cîmpeanu S., 2001 – Îmbunătăţiri funciare, Ed. Cris Book Universal, Bucureşti;
11. Stângă I.C.,2007, Riscurile naturale.Noţiuni şi concepte. Ed. Univ.Al Ioan Cuza, Iaşi;
12. Șmuleac Laura, oncia Silvica, Ienciu Anisoara, 2010, The study of potential evapotranspiration in the Banat plain in 1897-2011, Research Journal of Agricultural Science ISSN 2066-1843, vol.42 (3)1-908, Timisoara;
13. *** http://www.rowater.ro/daolt/Plan%20Management/.pdf
14. ***Strategia Naţională privind reducerea efectelor secetei, prevenirea şi combaterea degradării terenurilor şi deşertificării, pe termen scurt, mediu şi lung, Ministerul Agriculturii şi Dezvoltării Rurale;
15. http//www.maap.ro/pages/strategie_antiseceta_update_09.05.2008.pdf, 2008
16. ***www.meteo.ro