The study of drought phenomena in the Transylvania Plain using the analysis of the non-periodical variations of precipitations

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Abstract: The Transylvanian Plain is one of the regions with variable humidity, being pluviometrically characterized by an alternance between excedentary and deficitary periods. The dryness and drought phenomena manifest differently in period and intensity when pluviometric deficit is registered. Between 1891-1997 and 1953-1997 dryness and drought parameters, monitored in five meteorological stations and four pluviometrical points, were analyzed. This study was based on the analysis of the non-periodical variations of precipitations (annual, semestrial and seasonal).

Key-Words: - drought, precipitations, aridity, deficitary periods

1 Introduction
The Transylvania Plain represents the smallest (3908 sq. km) of the three divisions of the Transylvania Plateau.

The Transylvania Plain is a territory with a variable humidity, having both excessively dry or wet spells thus causing dryness and drought phenomena and excessively wet spells.

The present study analyses the dryness and drought phenomena by using three periods analyzed. Therefore, the meteorological stations in the limitrophe areas of the Transylvania Plain analyzed over a century old data (1880-1998). Four stations and four pluviometrical points analyzed around half a century old data (1953-1997). In order to emphasize certain territorial particularities regarding the origins and evolution of the phenomenon analyzed a shorter period of time was observed (1968-1997) using the data from six meteorological stations and ten pluviometrical points all over the Transylvania Plain.

2 Dryness, drought and aridity phenomena
Drought is mainly caused by the lack of precipitation which causes dryness in the air. The drought is a complex phenomenon triggered by multiple factors such as climatic, edaphic physiological and human. The notion of drought is relative, yet its main characteristic is the decrease in water reserves for a certain period of time or for a certain region. A certain period of time without precipitation can lead to drought according to several parameters (length, intensity, time of year, etc.) and human factors. From a meteorological point of view, drought appears when the quantity of precipitation in a certain period of time is considerably lower than the average quantity of precipitation or a critical value that marks the beginning of a drought. The human factor can influence the parameters of the hydric drought by the way water resources are used.

According to the different stages of the water cycle, Lambert [7] have distinguished several stages of drought: atmospheric, pedologic, phreatic and reservoir.

The atmospheric drought starts when the precipitations cannot compensate for physical evaporation and plant transpiration.

The pedologic drought settles when the atmospheric drought lasts for a longer time and the water reserves in the soil approaches 0. When the water reserves become null, plants start to wither and than we talk about biological drought or the hydric stress of plants [4].

The phreatic drought is the result of river water deficit, which leads to the use of underground water, namely it depletes the underground water reserves. In such situations, the underground flow decreases towards 0 causing drought, which affects the underground water table and springs.

The potamologic drought appears when the underground waters sustaining river courses are finished, which leads to the drying of streams and rivers, whose flow approaches 0. In such situations, irrigations and fresh water supplies from rivers without reservoirs is impossible. The start of hydrologic drought is considered to be the moment when the period without precipitations leads to insufficient water in rivers to meet the needs.
The reservoir drought is the last and most serious stage of a drought and implies the decrease towards 0 of the usable water reserve in the reservoirs.

Among the most important characteristics of drought are the temporal (the beginning or end, length, persistence), space (the area of development) and energetic (the intensity) [6]. Each type of drought can be localised, dated and quantified and it can therefore be analysed quantitatively and qualitatively (table 1).

<table>
<thead>
<tr>
<th>Type of drought</th>
<th>Quantitative parameters</th>
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<tbody>
<tr>
<td>Meteorologic</td>
<td>$P &lt; ETP &lt; ETR$, $P \rightarrow 0$</td>
</tr>
<tr>
<td>Pedologic</td>
<td>$RU + P - ETR = 0$, $RU \rightarrow 0$</td>
</tr>
<tr>
<td>Potamologic</td>
<td>$Q \rightarrow 0$</td>
</tr>
<tr>
<td>Phreatic</td>
<td>$Qs \rightarrow 0$</td>
</tr>
<tr>
<td>Reservoirs</td>
<td>$LU \rightarrow 0$</td>
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Table 1. Types of drought and quantitative parameters (according to Lambert) [7]. Where: $P$ - quantity of precipitations; $ETP$ – potential evapotranspiration; $ETR$ – real evapotranspiration; $RU$ – usable water reserve in soil; $Qs$ – underground flow; $Q$ – watercourse flow; $LU$ – usable water resource in reservoirs.

The notions of dryness and drought are related but they differ in length as they represent two distinct stages where the plants need for wetness is differentiated. It is very important to distinguish between aridity and drought [8]. Although both are characterized by the lack of water, aridity and drought are two distinct notions. Aridity is a permanent climatic form while drought is an extreme phenomenon that settles in a certain area for a certain period of time.

Droughts are not local phenomena and are often associated to the persistence of anticyclones [9]. The meteorological interpretation of drought relies on thorough knowledge of the physical processes that determine less precipitation or even lack of precipitation as well as knowledge of accompanying synoptic patterns associated to anomalies of general circulation. Drought should not be mistaken for aridity, which applies to dry regions permanently lacking water.

3 Methods used in the study

The methods and procedures used in evaluating the dryness and drought phenomena took into consideration different criteria that rely on simple climatic parameters (precipitation, humidity) or complex climatic parameters (indexes for aridity, climogrames), hydric, bioclimatic, complex and edaphic parameters (the balance of water in the soil) [2].

This paper studies the dryness and drought phenomena relying on the analysis of the non-periodical variations of precipitations (annual, semestrial and seasonal).

4 The non-periodical variations of the quantities of precipitations and their negative deviation

The dryness and drought phenomena registered non-periodical variations whose amplitude was emphasised by the negative deviation of the annual and monthly quantities of precipitations as compared to the multi annual average.

The smallest annual quantities of precipitations between 1891 and 1997 were registered in different years and varied between 300 and 400 mm. These values are almost twice as high as those registered in the south of the country (the Romanian Plain and Dobrogea), where the period between 1885 and 1995, the smallest annual quantities of precipitations varied between 200 and 300 mm [1].

The highest value was registered at Dej (409.1mm) and Bistrița (389.9 mm), area better exposed to the humid masses of air from the west, while the lowest was registered at Turda, as a result of foehn masses of air [5].

The negative deviation of the average annual quantities of precipitations were between 225 mm and 270 mm. The territorial distribution of these values emphasizes their gradual reduction from the east to the west of the Transylvania Plain.

One should notice that in the areas in the west and north of the Transylvania Plain, where the smallest annual quantities of precipitation had the highest values, the negative deviations registered the highest values. Yet it does not mean that in the areas mentioned the intensity of droughts was higher.

For instance, although the negative deviations at Dej (227.6 mm) and Beclean (254.2 mm) registered high values, still the annual quantities corresponding to the least droughty year in the period between 1953 and 1997 were 60-70 mm higher than in Turda, where the smallest annual quantity of precipitations was registered in 1961.

The same situation appears when we compare the quantities of precipitations registered at Ogra and Tg.Mures in the year 1986.

A close analysis of the variation in the annual quantities of precipitation in the period between 1891 and 1997 shows that it is quite uncommon for the same year to be the driest on the whole territory observed. (fig.1)
As the density of the stations under analysis is quite low, the droughty years differ in the area. Thus, the year 1924 was the driest for Turda, 1986 for Tg. Mures, 1923 for Cluj-Napoca and 1961 for Dej. However, it is noticeable that in certain years the drought affected large areas in the north of the Transylvania Depression.

The following years are worth mentioning: 1961, 1986, 1990, 1992, 1917, 1948, 1982, 1994 etc. In certain situations, the drought affected only certain areas within the Transylvania Plain [12]. Thus, in 1907 the drought affected only the northern part of the area studied while in 1948 it affected only the western part. During the driest years, the negative deviations of the quantities of precipitations represented between 35% and 47% of the multi annual quantity (fig. 2).

Fig. 2: Relative deviations (%) of the annual quantities of precipitations as compared to the multi annual average (1891-1997)

Relative deviations of the annual quantities of precipitations as compared to the multi annual average between 1950 and 1999 emphasize the same distributions (Fig. 3)

Fig. 3: Relative deviations (%) of the annual quantities of precipitations as compared to the multi annual average (1950-1999)

Between 1968 and 1997, the driest year was 1968 in the southern part of the ‘plain’, 1983 in the north and 1971 in the east. By observing the frequency of the periods lacking rain during consecutive years, one can notice that the droughty years have grouped, which makes their effects even more serious. All stations
registered short periods as the most frequent, comprising two consecutive years lacking rain.

The most numerous periods lacking rain during two consecutive years were registered at Dej station (7 periods). Next there are the stations at Cluj-Napoca and Turda (with 5 periods), Tg.Mures (4 periods) and Bistrita (0 periods). At each station the number of periods lacking rain reduces as they become longer. Thus, the number of periods lacking rain longer than 5 consecutive years was of 3 at Bistrita and of one at Tg.Mures. The longest periods of more than five consecutive years was of 13 years registered at Dej and of one at Tg.Mures. The longest periods of more than five consecutive warm semesters was of 15 years registered at Cluj-Napoca and Tg.Mures and of 11 years at Cluj station (1943-1953) and Tg.Mureş (1986-1996).

At the stations in the northern part of the Transylvania Plain 15 droughty periods were registered while there were only 12 in the south. This does not mean, however, that the intensity of the drought was higher in the north of the ‘plain’ because the precipitations were more abundant.

Between 1891 and 1997 there were isolated years lacking rain, when the deviations from the multi annual value exceeded 100 mm. Their number was of five at the stations in the south of the Transylvania Plain and of two-three in the north. The year 1958 had the highest deviation of -190.8 mm (Turda), and then the years 1921 with -166.8 mm (Cluj-Napoca) and 1961 with -162.7 mm (Tg.Mureş). In 1921, although isolated in the range of statistic data, the drought affected the entire Transylvania Plain, which showed that there can be serious droughts on extended areas, even in case of isolated years [11].

The negative deviation of the average quantities of precipitation in the warm semester of the year, due to its length, can reflect the frequency and intensity of the drought. The smallest quantities of precipitation in the warm semester of the year varied between 220 mm (Bistriţa) and 166.8 mm (Tg.Mureş).

The largest quantities of precipitation in the warm semester of the year varied between 200 mm and 250 mm, having the same tendency to increase from the west to the east of the region. The phenomenon is better emphasized if the period between 1953 and 1997 is analysed, when the data from for pluviometric points were also observed. At each station the number of the periods lacking rain regarded as consecutive warm semesters reduces as they become longer. The maximum number of periods longer than five consecutive warm semesters lacking rain was of one at Dej, two at Turda, Tg.Mures and Bistriţa and three at Cluj-Napoca.

The longest period with consecutive warm semesters lacking rain was registered in the south of the Transylvania Plain, at Tg.Mures, where there were 14 consecutive warm semesters (1941-1954). Turda follows with 12 consecutive warm semesters (1942-1953). A close analysis of the total consecutive warm semesters lacking rain shows that the most numerous were at Turda (15) and the smallest number at Tg.Mures (11). Consequently, it seems that there are also other types of differences between the west and east of the Low Hills Plain.

On seasons, the largest negative deviations as compared to the multi annual average (1950-1999) was registered at most stations in autumn, representing 71% and 80%. In spring, the values in percentage of the maximum negative deviations are the most reduced, holding between 52% and 61%. The analysis of the variations in the seasonal quantities of precipitations between 1950 and 1999 shows that quite rarely it happens that the same season is the driest on the entire area observed [3]. Therefore, in the spring of 1992 all meteorological stations registered the highest pluviometric deficit, representing 52% and 61%. Similar situations were signalled in the winter of 1989, when the negative deviations were of maximum value at the stations in Turda, Dej and Cluj-Napoca, being between 52% and 71%.

In autumn, the highest negative deviations were registered in 1953 at the stations in Tg.Mures, Turda and Cluj, respectively in 1986 at Dej station, with values between 71% and 80%. In the autumn of 1986, the negative deviations were more significant (64%- 71%) and the pluviometric deficit was felt throughout the entire Transylvania Plain [10].

In summer, the maximum negative deviations occurred in different years and no pattern was noticed in their space distribution. The maximum values of the negative deviations in this season were between 44.6% (Dej) and 64.7 % (Turda).

Analysing the frequency of the deficit years according to Hellman criterion we find that most stations registered the excessively droughty years as being the most frequent (11%-18%). The predominant years are those whose frequency exceeds 40% at all stations. In the southern part of the Transylvania Plain the frequency of the excessively droughty years decreases from west to east. During a year, there was a succession of dryness periods. Between 1953 and 1998, the most numerous periods of dryness were registered in 1973 at Turda station (25 periods) and in 1964 at Tg.Mures station (19 periods). A reduction of the periods of dryness is noticed from the west to the east of the region. The smallest number of dryness periods was registered in 1968 and 1976 at Tg.Mures station (9 periods), in 1975 at Turda station (5 periods) and at Sarmas station in 1977 and 1898 (8 periods).

The most numerous days of dryness were registered in 1973 reaching a number of 141 at Tg.Mures station and 161 at Turda station. There is a decrease of the days of dryness from the west to the east of the
Transylvania Plain, while at Sarmas station, in the center of the Plain, a maximum number of days of dryness was registered in 1986 (135 days). The smallest number of days of dryness was registered in 1977 and 1998 at Tg.Mures station (64 days) and in 1975 at Turda station (34 days), while at Sarmas station it was in 1977 (51 days).

The analysis of the annual days of dryness between 1953 and 1997 shows a clear growth tendency at Turda station while not so obvious at Tg.Mures station. There is a similar evolution in a different period (1967-1997), more obvious at Sarmas and Turda stations, which shows a higher degree of “continental” characteristics in the south-western and central parts than in the west of the Transylvania Plain. This situation is determined by the effect of “little precipitation” caused by the higher sector of the Apuseni Mountains. The number of droughty periods is lower than those of dryness, ranging from 0 to 8 at Turda station, 0 to 6 at Tg.Mures station and 0 to 5 at Sarmas station. The most numerous days of dryness were registered in 1957 at Turda station (160 days), in 1961 at Tg.Mures station (105 days) and in 1972 at Sarmas Station (82 days). Numerous days of dryness were also registered in 1956 at Turda station and in 1953 and 1983 at Tg.Mures station. Between 1953 and 1997 the average annual length of dry days varied between 0 and 43. An analysis of the dry days in the period mentioned shows a tendency to decrease at both stations. The evolution of the dry days in the period between 1967 and 1997 shows a slight tendency to increase at Tg.Mures station, constant values at Turda station and a clear decrease at Sarmas station.

5 Conclusion

The Transylvania Plain is accidentally affected by drought in any season, the drought having different length and intensity. The phenomenon is more intense in the south-western part of the Plain, decreasing in intensity generally from the south-west to the east and north of the area studied. The same decreasing process is applied to the number of the droughty periods.

The main factor causing drought is the general weather circuit. Drought occurs in stable anti-cyclonic fields. The place where this phenomenon occurs is determined by a series of local factors among which especially the local weather circuit, the position and orientation as to the mountain area. During the periods analyzed, unique in their length and intensity were the droughts in the last two decades of the last century when there were several drought years (1982, 1985, 1986, 1990, 1992 and 1994). Other droughts were registered in isolated years: 1907, 1917, 1924, 1948 etc. The risk degree increases when the droughts occur in several sequencing years or seasons.

An analysis of the evolution of droughts emphasized their stationary character and even their slightly decreasing intensity. The drought is an accidental phenomenon and there are no connections with the permanent climatic tendencies.

The dryness phenomenon is more obvious due to its length and intensity, keeping the same patterns as far as its distribution is concerned. As regards its evolution, all stations under observation registered an increase in the periods and days of dryness.

References: