CHARACTERISTICS OF ARIDITY CONDITIONS IN SOUTH DOBRUDJA

A.TISCOVSCHI, GABRIELA MANEA, O.COCOS, IULIANA VIJULIE, ROXANA CUCULICI

Abstract. - **Characteristics of Aridity Conditions in South Dobrudja.** For most people, the arid and semi-arid lands are those where precipitation is low (less than 200 mm per year), and yet enough for supplying streams capable of temporarily carrying the debris resulted from weathering, but insufficient for encouraging the development of a vegetal cover meant to protect the soil blanket against eroding agents. The drought is a major and permanent climatic risk for the Dobrudja territory as a whole and for South Dobrudja in particular, a territory where hydrographic network is underdeveloped, streams are ephemeral, and semi-endorheic areas are well developed. When the period of moisture deficiency lasts longer, it can bring about a significant water imbalance, which results in crop losses or restrictions in water consumption, thus leading to a number of economic problems. Under the circumstances, the risk of aridity expansion is significant, this being the reason why a better water management system in Romania is urgently needed. In the last decades, the numerous specialty studies undertaken in the area have emphasized an intensification of the process of dryness, because atmospheric and pedological droughts have become more and more serious. Romania is a member of the United Nations Convention to Combat Desertification (UNCCD) and the World Meteorological Organization (WMO). It actively participates within the drought management network and the Drought Management Center for Southeastern Europe, which comprises 11 countries. The scope is to work together and exchange experience with the neighboring countries that have recorded positive results and acquired a rich experience in terms of drought management. The employment of appropriate pluvial indices in identifying the areas prone to aridity may prove to be convenient tool for finding practical solutions meant to mitigate the impact of this phenomenon on the local communities living in South Dobrudja.

Key - words: aridity, pluvial indices, Dobrudja, mean precipitation, climate change

1. Introduction

This study aims at highlighting the frequency of aridity phenomena, since they are deemed to be a major permanent risk for South Dobrudja territory, which is a plateau area, with elevations exceeding 200 m, unfolding between the Danube valley (on the west) and the Black Sea (on the east). Here, water resources are dwindling and their quality is continuously decreasing, and this is a serious hindering factor not only for the Dobrudja territory, but also for many other regions of Romania, as is the case for instance of the Calnistea watershed (*Cocos et al., 2011*). The situation gets worse in other parts of the planet as well, while a number of recent studies estimate a further increase of the aridity conditions as a result of global warming effect. Thus, in order to assess the situation of South Dobrudja, we based our analysis on three representative weather stations (Constanta, Medgidia and Harsova) (fig. 1), having datasets for the period 1961-2000, which is considered a reference frame by the World Meteorological Organization (WMO). By looking at the long-term variations of the atmospheric precipitation in Romania, one may observe that the last decades have experienced a drop in the precipitation amount, which however remains within the limits of natural variability (*Ciulache et al., 2003*).

In the study area, the average monthly precipitation is unevenly distributed from month to month. This is due to the frequency and direction of the pressure cells, air masses and weather fronts, but also to the amplitude of the local climatic processes, which either encourage or hinder the formation of precipitation (*Mihailescu et al., 2000*). The incessant changes occurring from year to year in terms of the frequency and features of the air masses driven, on the one hand, by the prevailing winds and, on the other hand, by the mobile cyclones and anticyclones, bring about significant variations of the yearly amounts of precipitation *(Sorocovschi, 2009*). Consequently, these may record substantial negative or positive deviations with respect to the multiannual average of the entire region or of the weather stations.

South Dobrudja is a territory with mean annual precipitation ranging from 300 to 500 mm, but in the history of recordings there were also situations when the mean precipitation was less than 300 mm (Constanta 225 mm in 1983; Mangalia 246.6 mm in 1990; Harsova 271 mm in 1983; Medgidia 287.1 mm and Adamclisi 295.1 mm in 1976). When cyclonic activity was more intense and weather fronts more active (1965-2000), this region recorded amounts of precipitation that exceeded 600 mm per year (Constanta 604.3 mm in 1995 and 642.2 mm in 1997; Mangalia 671 mm in 1995 and 615 mm in 1997). From year to year, the mean monthly and annual values are very different, which suggests that a more detailed analysis is needed.

The present study relies on direct correlations between precipitation regime and air temperature, insisting on the characteristic months (January and July), when the non-periodic variations of these parameters may induce water scarcity and drought. The analysis has identified endorheic areas, like the Negru Voda Plateau and Cobadin Plateau, which lose significant amounts of water through evaporation.

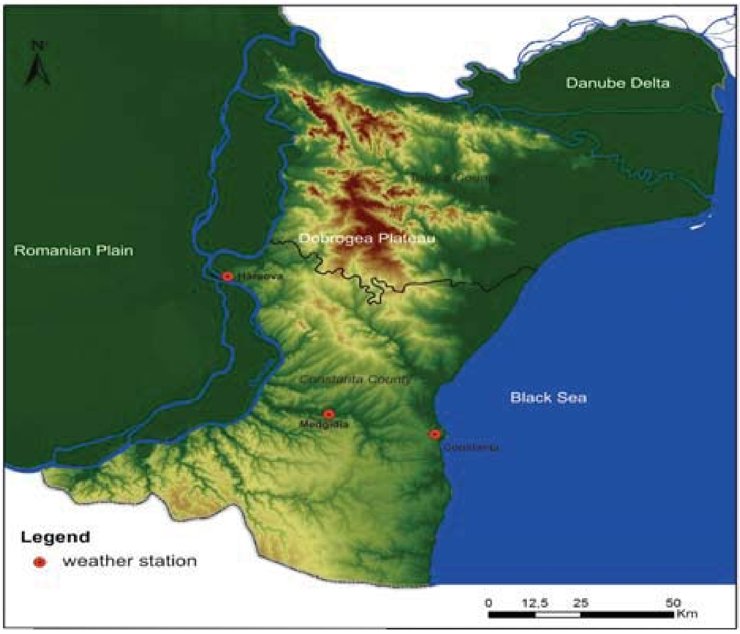

Figure.1. Geographical location of Constanta, Medgidia and Harsova weather stations

2. Data and methods

This study relies on the data recorded at the previously mentioned weather stations during the period 1961-2000, which allowed the computation of two significant pluviometric indices, namely the De Martonne aridity index (1926) and the Angot pluvial index. The aridity index (I_{ar},mm/^{0}C), with emphasis on January and July, was used in order to highlight the thermal-pluviometric features of the study area. This index is described by the following relation: $I_{ar} = 12p/t+10$, where *p* is the mean monthly precipitation (mm) and *t* is the mean monthly temperature (^{0}C). The supplementary 10^0 added to the numerator help us acquire positive values (*Gaceu, 2002*). Generally, the low values of the I_{ar} are specific for the dry areas, while the high ones characterize the wet regions. Instead, the Angot index emphasizes the climatic features of each month of the year, which means the subunit values define the dry months, while the values higher than one refer to the wet months. This coefficient was computed based on the following formula: $k = q \cdot 365/Q\ x \cdot n$, where *k* is the Angot Pluvial Index, *Q* is the mean annual precipitation and *n* is the number of days in a month.

The climate data employed for the present study were supplied by the three weather stations representative for South Dobrudja (table 1), which are located along an alignment oriented on a northwest-southeast direction. They were selected with the purpose of having a good perception of the influence exerted by the Danube and the Black Sea. However, it should be mentioned that Constanta station, at least during the last decades, has not totally complied with the rules referring to the location of the meteorological sites. The reason is the construction of a number of buildings, which through their position and height have had a total or partial influence on climatic parameters.

Although the prevailing western airflow reduces the climatic influence of the Black Sea to a strip of land of only 15-20 km wide, the seashore topoclimate is indicative for the effect that water bodies have on the weather parameters of the adjacent territories. The influence exerted by water (the Black Sea, the Danube, the Danube marshes and pools) is primarily due to its physical properties, and especially to the high specific heat, which makes the daily and annual temperature ranges be lower in its immediate vicinity in comparison with the areas lying farther away (Croitoru et al., 2012).

Table 1. Geographical coordinates of Constanta, Medgidia and Harsova weather stations

No.	Weather station	Latitude	Longitude	Elevation (m)
1	Constanta	$44^0$12'49"	$28^0$38'41"	14
2	Medgidia	$44^0$14'35"	$28^0$15'05"	70
3	Harsova	$44^0$41'15"	$27^0$57'13"	20

3. Results and discussion

Looking at the mean monthly values of the De Martonne aridity index, we may observe that during the last decades, in the eastern part of the study area (*fig.2, fig.4*), the values less than 40 have arisen more frequently, while in the Medgidia Plateau they ranged from 50 to 60. The low values suggest that the eastern part of the investigated territory is very prone to aridity, which has a negative impact on agricultural productivity (Bogdan, 2002).

Instead, during the warm season, the tendency of the De Martonne index (*fig.3, fig.5*) does not reveal significant differences between Constanta and Medgidia weather stations. It is worth noting that in summer precipitation variability is due to the frequency and direction of the pressure cells, air masses and weather fronts, which are responsible for the occurrence of drier or wetter years.

Over the South Dobrudja territory, the precipitation regime is influenced by the cyclonic activity and the penetration of anticylonic air masses. The last, are responsible for the occurrence of dryness or drought phenomena (more than 8 months per year of dryness and between one and three months of drought phenomena at all weather stations in the Dobrudja Plateau and on the Black Sea coast) (*Văduva, 2005*).

The values of the De Martonne aridity index computed for the period 1961-2000 have allowed the separation of the investigated territory into two large areas: a drier one in the east, which is strongly influenced by the nearness of the Black Sea, and a moderate one in the west. In conclusion, one may notice a general drop of the mean annual precipitation from south to north, both at the weather stations on the Black Sea coast and at those lying along the Danube, while on an east-west direction precipitation generally increases as we move away from the sea (*Păltineanu et al.,2007*).

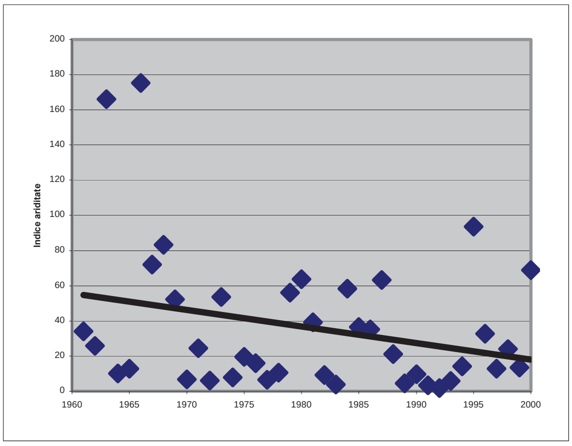

Fig. 2. The tendency of January values of De Martonne aridity index at at Constanta (1961-2000)

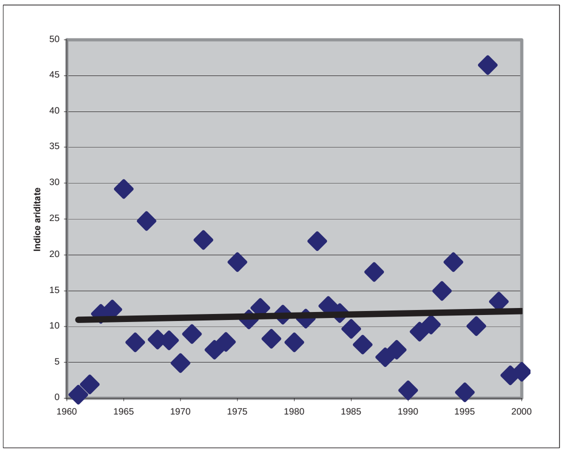

Fig. 3. The tendency of July values of De Martonne aridity index at Constanta (1961-2000)

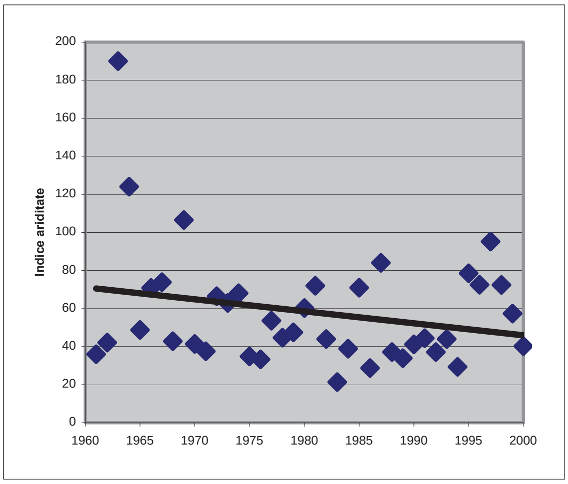

Fig. 4. The tendency of January values of De Martonne aridity index at Medgidia (1961- 2000)

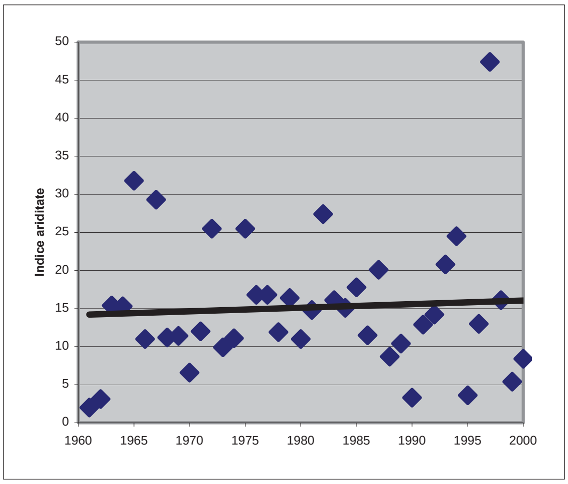

Fig. 5. The tendency of July values of De Martonne aridity index at Medgidia (1961- 2000)

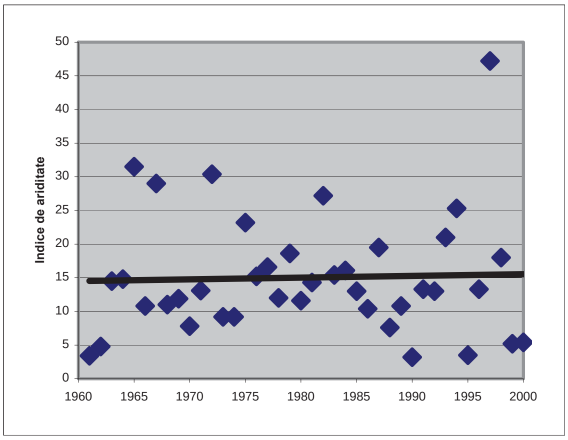

Fig. 6. The tendency of January values of De Martonne aridity index at Hârşova (1961-2000)

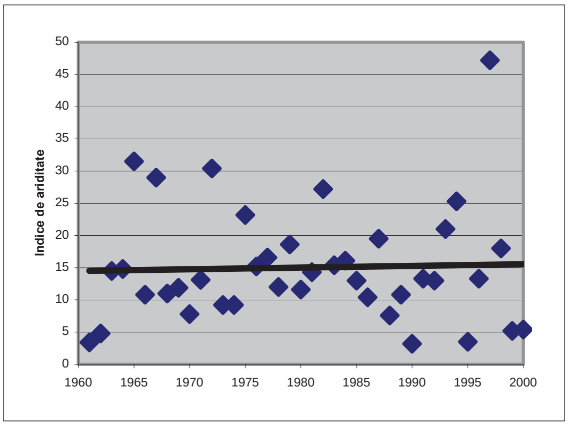

Fig. 7. The tendency of July values of De Martonne aridity index at Hârşova (1961-2000)

Another index taken into account for the present study is the Angot index, which is used in order to highlight the annual variability of atmospheric precipitation. It refers to the ratio between the mean daily precipitation in a month and the amount the respective month would get in case that precipitation would be evenly distributed for each day of the year.

In March, at the beginning of the vegetation season, the values are low both on the seashore (25.5-27.9 mm) and inland (20.7-24.7 mm), but June is wetter, having values of 34.4-42.5 mm and 45.5-48.8 mm, respectively. Although these values represent the pluvial maximum phase, the water amount is not enough for the entire vegetation season (*Albu, 2009*). The highest amount of water evaporates during the vegetation period (April-October), due to the temperature increase and the intensification of biological processes in plants, while in July, the warmest month of the year, the potential evapotranspiration values reach their maximum.

At Constanta weather station (*fig. 8*), the Angot index values are higher than one in May, June, November and December, while in the rest of the year the values are less than one, with the exception of September (when the values are very close to one). During the interval May-June, the local thermal and dynamic convection processes intensify, generating cumulonimbus clouds that bring about rain showers. In Dobrudja, the average precipitation of the warm season (the months IV to IX) accounts for more than 50 % of the annual amount on the seacoast and over 60% in the plateau area and the western territories (*Bogdan, 2001*).

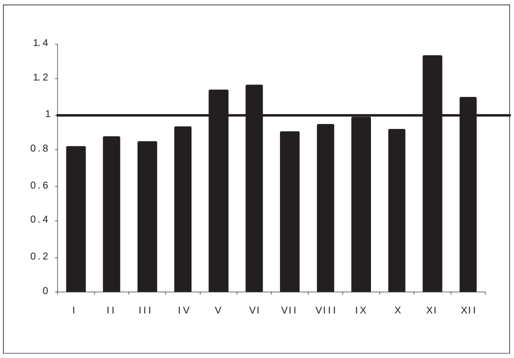

Fig. 8 Variation of Angot index at Constanta station (1961-2000)

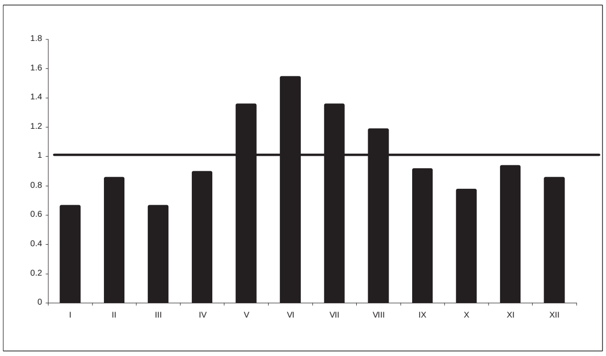

Fig. 9 Variation of Angot index at Medgidia station (1961-2000)

Instead, in the Medgidia Plateau (*fig*. 9), this coefficient has values higher than one for May, June, July and August, because in summertime, precipitation falls both from the frontal clouds and from the convective ones, with great vertical development.

4. Conclusions

The use of selected pluvial indexes (de Martonne, Angot) in the study of South Dobrudja aridity reveals that dryness phenomena, characteristic especially for the second part of the warm season, are also encountered in winter months (the de Martonne index was computed for January), when the dryness phenomena preceding the drought become increasingly frequent. Instead, the Angot index has been employed in order to highlight the specific features of the annual variations of precipitation, and especially for identifying the types of variation throughout the year.

The influence of the Black Sea on the climate of South Dobrudja Plateau leads to numerous specific features like the decrease from west to east of the maximum absolute temperatures, of the mean annual range, of the mean annual precipitation and of the atmospheric calm. However, on the same direction, one can note an increase of the mean annual temperatures, of the insolation and solar radiation, of the wind speed, of the duration of dryness and drought phenomena etc.

The most particular aspect in terms of climate singularity of this plateau is the high degree of continentality, which is a synthesis of the correlations among all climate parameters, but especially among temperature, precipitation and wind. These are the factors that define the semiarid character of Dobrudja Plateau, especially of its eastern side, which records long periods of dryness and drought whenever mean annual precipitation drops well below 400 mm. It is worth noting that atmospheric precipitation may be absent in any month of the year, or even on several months in a row. The aridity phenomenon occurs mostly during the warm season, to the end of summer, when the region is under the influence of a high-pressure cell (usually of continental type), with pluvial deficit, which influences pre-eminently the eastern division. The studies accomplished so far in Romania with respect to dryness phenomena and drought, which are based on the use of de Martonne aridity index, reveal that extra Carpathian regions are drier, and that aridity is a common phenomenon for the southeastern territories, where the investigated area lies, too.

The analysis of pluvial indices in correlation with the vegetal formations specific for South Dobrudja has revealed that there is a strong interdependence among temperatures, precipitation and the spatial distribution of vegetal formations, especially the spontaneous ones. This interdependence has a restrictive effect on vegetal cover, depending on climate conditions. In the last decades, the expansion of grassy vegetation to the detriment of the forest steppe has become more prominent.

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