SOME ISSUES RELATED TO DRYNESS AND DROUGHT PHENOMENA IN THE BUCHAREST METROPOLITAN AREA

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ABSTRACT. – Some issues related to dryness and drought phenomena in the Bucharest Metropolitan Area. Dryness and drought phenomena are the most complex climatic hazards occurred in southern Romania. Assessing these restrictive climatic phenomena is fundamental in explaining their role in landscape dynamics and vulnerabilities. The paper is willing to point out some aspects related to climatic conditions of dryness and drought in the Bucharest Metropolitan Area based on annual, monthly and daily extreme climatic values from all the meteorological stations of concern (1961…2007).

The authors aim at assessing dryness and drought phenomena by means of the main related parameters: the frequency of summer days with characteristic temperatures, heat waves (case-studies: 2000 and 2007) and positive thermal singularities, relevant climatic indexes (Palfy Aridity Index).

Keywords: dryness and drought, Bucharest Metropolitan Area, heat waves, thermal singularities.

1. INTRODUCTION

According to the World Meteorological Organization, ***dryness and drought*** are generally described by two main groups of climatic indicators, the pluvial (the lack of precipitation or deficient amounts) and thermal ones (high values of temperature), which condition the increase in evapotranspitration, inducing a reduced air and soil humidity. Since they are complex meteorological phenomena, genetically conditioned by multiple factors, they define the dryness or draughtiness of weather characteristic for a certain time frame, usually related to environment's exposure to this climatic hazard. According to the UN Convention, drought is defined as a natural phenomenon that occurs when the fallen rainfall amounts are less than the multi-annual average, coupled with high temperatures, which leads to intense ground level evaporation and reduced crop productivity. It is important to distinguish between aridity and drought, although both are characterized by the lack of water. Thus, aridity is a permanent feature of climate, while drought is an extreme feature of a temporaly/spacialy process Maheras et al., (1999), quoted by Ghioca (2008).

Plafai, Petrasovits and Vermes (1995) make the difference between *dryness and drought* phenomena pointing out that dryness represents a certain hydro-meteorological water deficit while drought is an extended and continuous water

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shortage which affects specific plant species and crops Ghioca (2008). Therefore, drought is a more complex phenomenon, characterized by insufficient moisture in the atmosphere and soil (especially affecting the water table and the root system) resulting in the increase of potential evapotranspiration Păltineanu et al. (2007a). According to Topor (1964), after 17 to 20 days without rain drought, the thermal conditions of the May - September timeframe in Romania could provoke irreversible damages on all crops.

Dryness and drought phenomena must be taken into consideration together with the complementary genetic climatic factors such as: the frequency of the *days with different characteristic temperatures* which are related to *heat waves* and *positive thermal singularities*.

Due to its position in the central part of the Romanian Plain, also known as Lower Danube Plain Bălteanu et al. (2006), Bucharest Metropolitan Area mirrors the environmental peculiarities of this relief unit. The study area is situated in a temperate-continental area, which is specific to the South-East of Romanian Plain, characterized by a continentalization tendency, from the West to the East, as a result of the climatic influences of transition in the West and excessive in the East. The wide range of local climatic factors, typical for the metropolitan area of Bucharest municipality, overlapping the general climatic features of the Romanian Plain, renders specific dynamic to dryness and drought phenomena in the study-area Dragotă and Grigorescu (2010).

2. GENETIC CAUSES OF DRYNESS AND DROUGHT

The causes of dryness and drought phenomena are of a *dynamic nature* (the general circulation features of the atmosphere) and *thermal nature* (which overlap with the active surface characteristics, those of a dynamic nature). Thus, lack of rain is determined by the persistence of the anticyclone regime characterized by high atmospheric pressure, high frequency of clear and stable time, sunlight and high temperatures especially during the warm season. Increased dryness and drought phenomena occur because of the predominance of anticyclonic stationary baric configurations extending largely over Europe covering Romania: the anticyclones formed over Central Europe, Northeast and Southeast Europe and the anticyclonic dorsal over the Northern part of the Atlantic Ocean. In certain circumstances one might add, the baric cyclonic formations consisting of dry air masses or of uniform pressure fields close to the normal value and without displaying a cyclonic or anti-cyclonic circulation at ground level. The duration of the dry regime is directly related to the intensity of the anticyclone, its height, to the volume of hot air from the column located above its central part and to the origin of the hot air supply in the upper parts of the troposphere.

To the dynamic factor of the atmosphere and to the parameters of the meteorological elements - rainfall, air temperature, evapotranspiration – other factors which define the active surface (terrain, soil, groundwater depth, vegetation coverage etc.) are added as well as, the physiological features of plants (phenological phase, the degree of resistance to drought, crop type), the water sources, the agricultural techniques used etc. During the period without precipitation, the soil absorbs about 44% of direct solar energy that becomes heat and participates in the overheating of the air in the lower atmosphere. In turn, soil and air warming increases the evapotranspiration leading to a gradual reduction of water reserves available for the plants Donciu (1965).

During the growing season, crops and plant associations have different requirements in terms of water supply, so that a period of drought does not affect the entire cultivated or natural vegetation cover simultaneously. In addition, the dryness and drought phenomena display differentiated issues in the context of soil mosaics, the varied landscape, the numerous crops and plants etc. Lack of rainfall, inducing dryness and drought phenomena, can occur all throughout the year, with repercussions mainly on agriculture, but also on population's health and on the water supply both for the population and for irrigation, mainly affecting the southern and eastern part of Romania (Fig. 1).

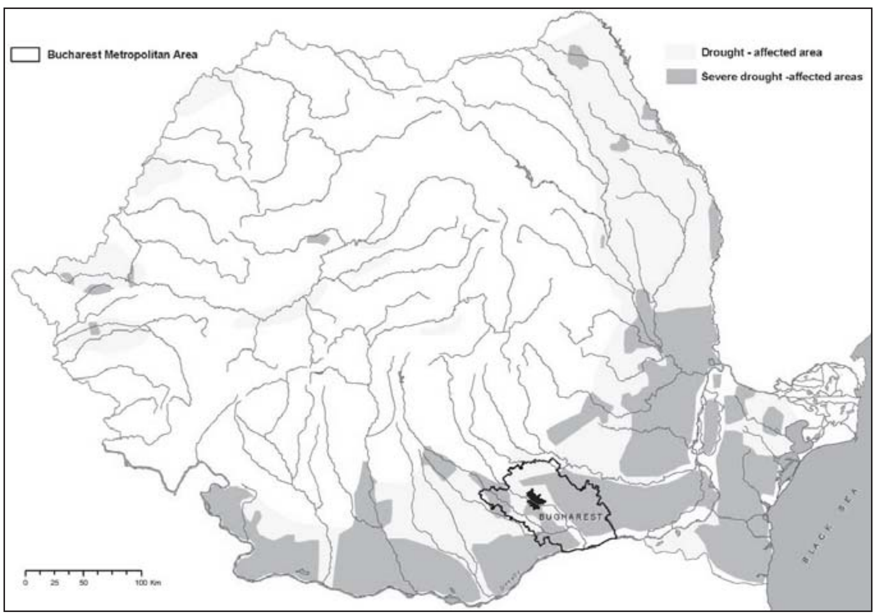

Fig. 1. ***Drought-affected areas in Romania (processed after the Ministry of Waters and Environmental Protection)***

Dryness and drought consist of two distinct stages: the first is a stage prior to the drought that usually occurs in the air, and plants don't yet suffer from the lack of moisture (which is provided by the soil water reserves), and when it persists, drought comes to be. The dry period is characterized by the absence of rainfall in five consecutive days, or the totalled rainfall amounts have not exceeded the daily average. The drought period is characterized by the absence of rainfall in at least 14 consecutive days during the cold semester of the year (October-March) and in at least 10 consecutive days during the warm semester of the year (April to September) or when there is no precipitation at all (<0.1 mm) Dragotă and Grigorescu (2010).

Droughts have different degrees of severity depending on their genetic factors and area of occurrence: atmospheric drought, soil drought or mixed and agricultural drought. Like dryness, drought occurs first in the air - atmospheric drought in periods without rain or reduced rainfall amounts on a background of high air temperatures and a relative humidity of below 30%. The dryness and drought phenomena may last from several days to several months, one year or more consecutive years as defined in relation to the intensity of genetic factors, while excessively dry years occur in every 5-6 consecutive years.

3. SOME ISSUES RELATED TO DRYNESS AND DROUGHT PHENOMENA

According to the hierarchy of natural hazards conducted by Bryant, 1991 at global scale and yet adapted by Croitoru and Moldovan, 2005 for the Romanian territory, dryness and drought phenomena are ranked first, based on their spatial distribution and extent, the evolution trend as well as human victims and material losses they cause.

Certain circumstances related to drought genesis and occurrence may worsen them up to the extreme Bogdan and Niculescu (1999), such as: their prolongation over several months and the climatic water deficit; the association of several meteorological factors during drought: high isolation, high temperatures, high evapotranspiration, low air humidity, strong and dry winds, lack of rain; the correlation between the soil and atmospheric drought; the lack of the productive moisture reserve during winter, which delays the vegetative cycle; the beginning of drought during the hot season and important phenological stages of crops (sprouting, flowering, binding); droughts occurrence after winter frost or other winter phenomena that have damaged the plants; inadequate agro-technical measures (lack of irrigation) etc.

Fig. 2. ***Drought-affected area in the Mostiştea Plain (June, 2007)***

One of the best way to highlight the drought phenomenon is by means of ***Palfay aridity index*** (1995), which considers an initial complex of factors (air temperature and precipitation) corrected by some meteorological parameters such as the number of extremely hot days, the number of days with precipitation amounts $\leq$ 0.5 mm and the groundwater contribution Ghioca (2008). In the Bucharest Metropolitan Area the Palfay aridity index features indicate three different degrees of *vulnerability* to drought: *strong* with annual Palfay index values ranging between 6-8, for which the frequency of dry years is of 40 - 63% in the south (the floodplain and terraces of the Danube River), southeast

(Mostiştea Plain) of the metropolitan area (Fig. 2); *moderate* with annual Palfay index values ranging between 4-6, with the frequency of dry years from 5% - 34% in the South-West, North, North-East of Bucharest Municipality (Bucharest Plain) and *weak* with annual Palfay index values between 2-4 in the northwest and east of the Capital-city (Fig. 3).

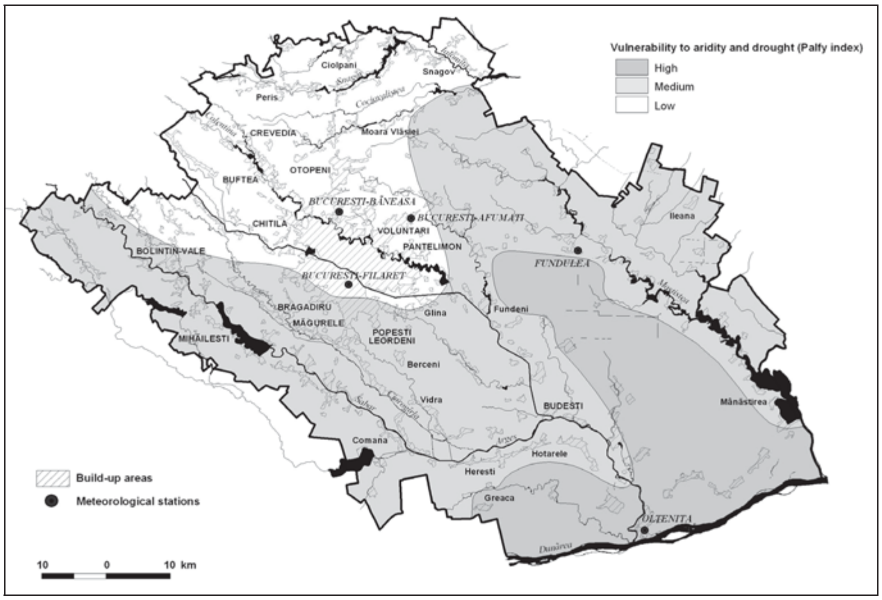

Fig. 3. ***Areas affected by aridity and drought according to Palfy Aridity Index***

Days with different characteristic temperatures come to complete the summer thermal regime inducing aridity and drought phenomena**.** Therefore, the prevalence of maximum temperatures exceeding the critical thresholds of *summer days (T max. ≥ 25 ^{0}C), tropical days (T max. ≥ 30 ^{0}C), tropical nights (T max. ≥ 20 ^{0}C)* as well as *extremely hot days (T max. ≥ 35 ^{0}C)* stresses the conditions of a temperate climate featuring excessive continental influences, much more significant after 1983 – a landmark year when it comes to the highlighting the climate changes (Fig. 4).

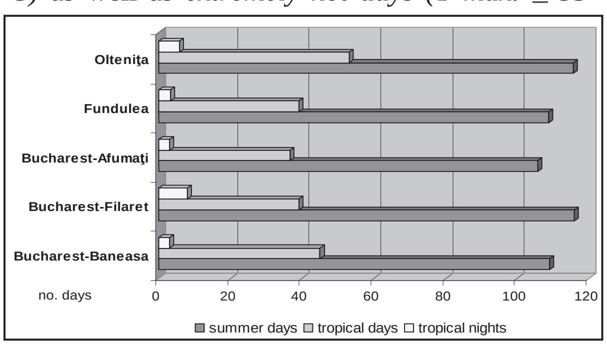

Fig. 4. ***The annual average of summer days with different characteristic temperatures in the Bucharest Metropolitan Area (1961...2007)***

The higher frequency of maximum temperatures over the above-mentioned thresholds (characteristic summer days) has underlined the excessive climatic aspects of Bucharest Metropolitan Area.

An important feature when dealing with the extreme daily temperatures in the Bucharest Metropolitan Area is indicated by the distribution of the mean monthly and annual values registered during the meteorological observation period 1961...2007. Their variability ecart and spatial-temporal differences points out the dimension and the influence of the *heat island* of the Bucharest Municipality on one hand and the moderator role of the Danube River on the other.

Heat waves and positive thermal singularities are generated by the advections of warm, usually topical air, and the criteria of their classification entail (Bogdan and Niculescu, 1999): the monthly medium temperatures of the hottest months (July, August) ≥ 35 ^{0}C; the maximum daily temperatures that exceed 35 ^{0}C (tropical days); the minimum nocturnal temperatures ≥ 20 ^{0}C (tropical nights).

Regarding the impact that maximum daily temperatures have on the human body, the exceeding of the 35 ^{0}C thermal threshold is acutely felt and it has a negative effect people's health and comfort as well as on the normal development of the phenophases of different vegetation types. In the Bucharest Metropolitan Area, absolute maximum values of the air temperature have exceeded 40°C, reaching even 44°C, which emphasis a maximum vulnerability to this thermal hazard triggering different environmental effects related to dryness and drought phenomena (tab. 1).

Table 1. ***Absolute maximum temperature on value classes within Bucharest Metropolitan Area (1895…2007)***

Value classes				
40.0 – 40.9 ^{0}C	**41.0 – 41.9 ^{0}C**	**42.0 – 42.9 ^{0}C**	**43.0 – 43.9 ^{0}C**	**≥ 44 ^{0}C**
Bucharest-Afumaţi 40.0/5.VIII.1998	**Bucharest-Afumaţi 41.1/5.VII.2000; 24.VII.2007**	**Bucharest-Băneasa 42.2/5.VII.2000**	-	Valea Argovei (Argova Valley) 44.0/10.VIII.1951
Bucharest-Băneasa 40.0/16.VIII.1963	Fundulea 41.3/16.08.1963	**Bucharest-Filaret 42.4/5.VII.2000**	-	-
Bucharest-Filaret 40.4/5.VIII.1998	Budeşti 41.4/16.VIII.1963	**Fundulea 42.4/5.VII.2000**	-	-
Bucharest-Filaret 40.8/7.VIII.1896	Bucharest-Filaret 41.1/20.VIII.1945	**Olteniţa 42.7/5.VII.2000**	-	-
Snagov 40.0/10.VII.1945	Bucharest-Băneasa 41.1/20.VIII.1945	-	-	-
Gurbaneşti 40.5/3.VII.1938	**Budeşti 41.5/20.VIII.1945**	-	-	-

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Most of the absolute maximum values have been registered in the month of July, highlighting as particular situation the ***massive warming of the summers 2000 (July, 4-5th) and 2007 (July 15-25th),*** which can be considered as the hottest in Europe over the last century. In both cases the intensity of the heat coincided with the *year of maximum solar activity for the entire period of meteorological instrumental observation* in Romania whose synoptic configuration highlights two extreme situations July 5th 2000 and July 24th 2007 (Fig. 5 and 6).

In southern Romania, during the summer of 2007 several thermal records were registered: the absolute daily maximum temperatures, the days with maximum temperatures equal or higher than 40°C and particularly the consecutive days with maximum temperatures equal or exceeding 35°C (ex: 10 consecutive days registered at Bucharest-Filaret meteorological station).

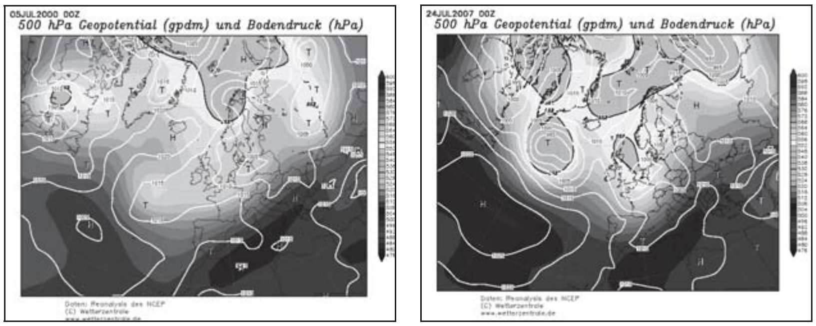

Fig. 5 and 6. ***The baric configuration in Europe on July 5^{th} 2000 and July 24^{th} 2007, respectively*** (www.wetterzentrale.de)

These thermal records overlapped the consecutive days without precipitation, which, in the Bucharest Metropolitan Area have reached in July 2007 a record number of 19 days at Bucharest-Filaret as compared to only 11 in 2000, during the same month. During the two heat waves, at all the meteorological stations within the study area absolute maximum temperatures exceeded 40° C (tab. 2) were recorded. Subsequently, in both cases, during several consecutive sequences spreading over the month of August, tropical heat waves came one after another, completing the massive heating situation. These temperatures associated with minimum precipitation amounts resulted in droughty weather which made even worse the extreme heat.

Table 2. ***Absolute maximum temperatures recorded in the Bucharest Metropolitan Area in July 2000 and 2007***

Meteorological Station	Absolute maximum temperatures (^{0} C)			
	2000		2007	
	Value	Data	Value	Data
Bucharest Afumaţi	41.1	5. VII	41.1	24. VII
Bucharest Băneasa	42.2	5. VII	40.7	22. VII
Bucharest Filaret	42.4	5. VII	41.8	23. VII
Fundulea	42.4	5. VII	40. 7	23. VII
Olteniţa	42.7	5. VII	41.5	23. VII

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Following the heat wave in the Summer of 2000, the Romanian Government has issued the 99/2000 Government Ordinance regarding protection measures for the population in the case of extreme climatic phenomena. By their duration and frequency, the heat waves could be framed into the extreme climatic phenomena through the perturbation of economic activities and the human causalities they produce. Heat waves have a great impact on plants in general and especially on crops, leading to physiological and phenological changes. On the human body it leads to an increase in the risk of illness and even to the death of people exposed.

4. CONCLUSIONS

Over the last period, at international level the preoccupations for assessing dryness and drought phenomena become of great interest to the global scientific community. The significance of these complex approaches points at knowing better their genetic causes, spreading areas, frequency and intensity in order to diminish their negative impact on the environment. Therefore, the dryness and drought phenomena occurred in southern Romania, displays an increasing evolution trend supported by extended periods with consecutive days without precipitations overlying the highest temperatures registered during the heat waves with long-term durations and intensities. In urban areas, these climatic features overlapping the local conditions of built-up ecosystems are even more noticeable. The importance of evaluating dryness and drought phenomena through forecasting and analysing their key components would help the improvement of local environmental conditions (human health, agricultural practices etc.) both in urban and rural areas.

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