

IMPACTS OF DRYNESS AND DROUGHT PHENOMENA ON AGRICULTURAL LANDSCAPE IN THE TITU PLAIN

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ABSTRACT. – **Impacts of dryness and drought phenomena on agricultural landscape in the Titu Plain.** The authors analyze the dryness and drought phenomena in one of the subsidence areas of the Romanian Plain, namely Titu Plain, located in its central-north part, a region frequently affected by such phenomena, under the influence of persistent continental anticyclones. The topic approached in this study is in line with the current concerns of agriculture stakeholders to undertake climate change adaptation measures for a better management of water resources for crops in the the main agricultural regions of the country. In this paper we focused mainly on the impact of dryness and drought on agricultural landscape, although their direct and indirect effects affect not only agriculture, but also the whole economic activity of the region. The impact of these phenomena was assessed by using relevant statistical-climatological methods (e.g. the Helmann method, the Walter-Lieth climatic diagrams), applied on the monthly temperature and precipitation datasets from four weather stations located in the study region covering a 47-year period of meteorological observations (1961-2007): Târgoviște, Ploiești, Titu și Videle. The distribution of elements at risk within the Titu Plain region, included in the vulnerability analysis, was determined using land use map of the region extracted from CLC (*Corine Land Cover*, 2006), by reclassifying the primary land use classes under GIS, resulting six categories of vulnerable items to dryness and drought. Among these items, the agricultural lands have a share of 66.5% across the study region, the main crops being represented by cereals (wheat and corn), potatoes and sunflowers.

Keywords: the Titu Plain, agricultural landscape, vulnerability, dryness and drought phenomena.

1. INTRODUCTION

The Romanian Plain region ranks the first among the agricultural regions of Romania, with old traditions from this point of view. The region is particularly vulnerable to dryness and drought phenomena in relation to the characteristics of their main triggering factors during the active vegetation season of crops, such as: high temperatures, low frequency of rainfall days, low soil water reserves available to cultivated plants, strong evapotranspiration, light winds (Bogdan, 1987). A large number of studies have been devoted to drought analysis and to its impacts in various regions of Romania, showing that southern plain regions are particularly

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subject to significant warming and drying, inducing a significant decrease of available water resources necessary for crop development. These climate change signals were mostly observed during the active vegetation season (with a peak during the summer months), affecting the agricultural productivity and limiting the potential of crop yields (Micu et. al., 2014).

During the growing season of crops, the crops have different water requirements (Păltineanu et. al., 2007) and drought does not affecting simultaneously the cultivated or natural plants. The impact of dryness and drought phenomena is different in relation to the regional and local physico-geographical context (e.g. types of soil, landforms, crops).

This study contributes to the understanding of dryness and drought vulnerability of agriculture at local scale, under the current temperature and precipitation change signals observed at regional scale, particularly since the mid 1980s.

2. DATA AND METHODS

The study uses the monthly mean temperature and precipitation data from four weather stations located in the Titu Plain (Titu weather station) and its surroundings with similar topographic conditions (Ploiești, Târgoviște and Videle) (Table 1, Fig. 1). The selected weather stations are situated in areas with different vegetation types (forest and steppe) (*Geografia României, I, Geografie Fizică*, 1983). The datasets have less than 10% missing data and cover the 1961-2007 period.

Table 1. Geographical coordinates of the weather station and their affiliation on relief units

No.	Weather station	Altitude (m)	Latitude	Longitude	Relief unit	Analyzed period
1	Târgoviște	296	44°93'	25°43'	Târgoviște Plain	1961-2007
2	Ploiești	177	44°95'	26°00'	Ploiești Plain	
3	Titu	159	44°65'	25°58'	Titu Plain	
4	Videle	106	44°28'	25°53'	Găvanu Plain	

The dryness and drought intervals were identified using the Helmann criteria (Bogdan, Niculescu, 1999 e.g.), applied to the annual mean and monthly precipitation and the Walter-Lieth climatic diagrams (Walter, Lieth, 1960).

The vulnerability of the case study region to the intensity of dryness and drought phenomena, was assessed based on the CLC land use map (*Corine Land Cover*, 2006).

The reclassification of the primary land use classes (22) under GIS, resulted in six categories vulnerable items: settlements, agricultural land, pastures and natural grasslands, orchards and vineyards, forests, other items (Fig. 2).

The clusterization of land use classes into the new six ones has been done on the basis of similarity.

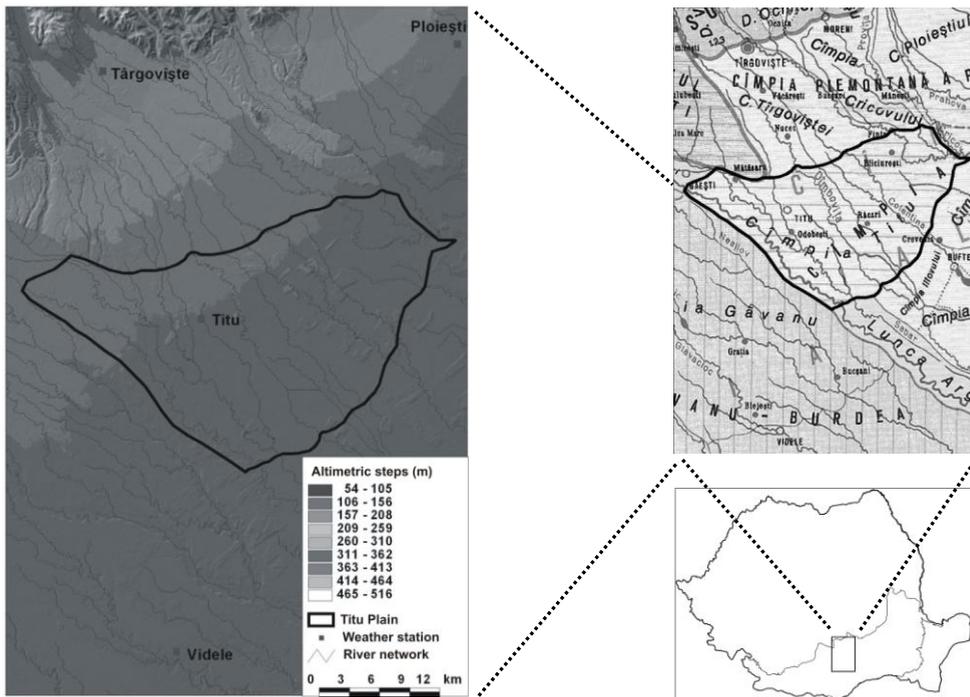


Fig. 1. Location of weather stations and of study area within Romania

In the assesment of vulnerability to dryness and drought, as well as of the impact of these phenomena on agriculture, the analyses focused particularly on the *second class (agricultural land)*, which have the largest spatial distribution among all the other land use categories (66.5% of the study area).

The impact of dryness phenomena to agricultural landscape is manifested by the deterioration of vegetation conditions for crops, due to the changes in water balance in plants (between absorption and transpiration), and by the increase of daily moisture deficit in air and soil, until reaching the critical fading threshold of crops.

The prolonged dryness favour the occurrence of drought, which leads to a significant decrease of the available water resources for crops and implicitly, to

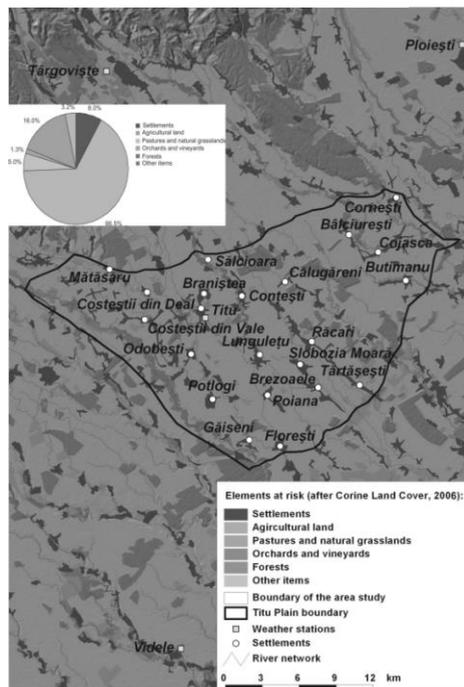


Fig. 2. Types of elements at risk (after Corine Land Cover, 2006)

important crop losses. The severe droughts could determine visible changes in the agricultural landscape, due the changes in agricultural land use (Bogdan, 1987; Bogdan, Niculescu, 1999). The study is focus on the main types of crops which define the agricultural landscape of the Titu Plain. These are represented by *cereals (wheat and corn)*, which are occupying 3/4 of the arable land of the region, *potato* and *sunflower* (5.3% and respectively, 5.1%). Secondary, the vegetables have an average share of 2.4% in the total agricultural land of the region (*Geografia României, V, Câmpia Română, Dunărea, Podișul Dobrogei, Litoralul românesc al Mării Negre și Platforma Continentală*, 2005).

3. RESULTS

According to Helmann criterion, the *frequency of negative deviations of monthly precipitation* is significant at all the weather stations of the region (30-48%), compared to the values assigning the normal precipitation domain (20-27%) (Table 2). At the Videle and Ploiești weather stations, *the dry months* have the *highest frequency* (15-16%), while at Titu station, *the very dry months are the most frequent* (16.31%). The frequency of classes assigning the dry domain decreases slightly in the northwestern part of the region e.g. at Târgoviște station *the moderately dry and dry months* are prevailing, (8.51%).

Table 2. Frequency of rain-deficient months with different characteristics after Helmann criterion (1961-2007)

Weather station	Normal		Moderately dry		Dry		Very dry		Excessively dry	
	No. years	Frecv. %	No. years	Frecv. %	No. years	Frecv. %	No. years	Frecv. %	No. years	Frecv. %
Târgoviște	146	25.88	48	8.51	48	8.51	43	7.62	38	6.73
Ploiești	126	22.34	84	14.89	91	16.13	81	14.36	8	1.41
Titu	111	19.68	77	13.65	91	16.13	92	16.31	11	1.95
Videle	153	27.12	83	14.71	85	15.07	71	12.58	9	1.59

*Source: data processed after N.M.A. Archive

In a decrease order of frequency, the *moderately dry* months at Ploiești and Videle stations (about 15%), the *dry* ones at Titu (16.13%) and the *very dry* ones at Târgoviște (7.62%) are the following classes of the dry domain within the region. The very dry months at Târgoviște count half of their frequency recorded at Videle and Ploiești weather stations, reaching 12-14%. At Titu weather station, the *moderate dry* months rank the third if considering the share of 13.65% in the total number of pluviometric deficit months of the entire period of observations. *The excessively dry months* have the *lowest frequency across the region*, generally below 2% at three out of the four weather stations analyzed. Exceptionally, at Târgoviște, the frequency of these months is the highest (about 7%), in response to a greater influence of continental anticyclones. **Over the year** the wet domain across the region is in general, less represented than the dry one. *The very rainy months* have the highest frequency at Târgoviște (27.7%, in September) (Fig. 3).

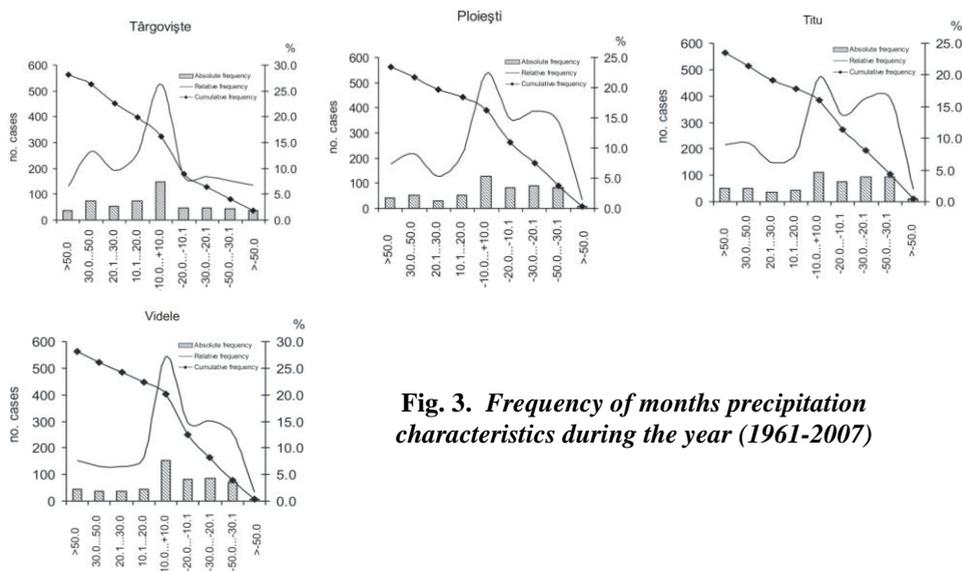


Fig. 3. Frequency of months precipitation characteristics during the year (1961-2007)

At this station, most months of the year belong to the *wet domain*, with deviations between $>50.0...+20.0\%$, while only January and February months being assigned to the *dry domain* ($-20.0...>-50.0\%$), namely to the *moderately dry* (14.9% in January and 17.0% in February) and *dry classes* (14.9% in January and February). At the rest of weather stations analyzed (Fig. 3), the highest frequency of months are, also, the *moderately dry ones*, with the highest values in February (32-34% at Ploiești and Titu stations) and December (27.7% at Videle).

Compared to the Târgoviște Plain (overlapping the north-eastern and the central-south part of the case study region), respectively in Ploiești, Titu and Găvanu Plains, all the months of the year belong to the *dry domain*, with no dry months (>-50.0) at none of the three weather stations analyzed, but with only very dry months ($-50.0...-30.1$). In the southern part of the case study region (at Videle weather station), the dry and very dry months are characteristic to the June – August interval and delay with one month in the northeastern part of the region to the July – September interval, at Ploiești weather station. At Videle and Ploiești weather stations, November is also a *very dry* or a *moderate dry* month, while December, could be assigned as a *dry* month (14.9%). In the central part of the area analyzed, at Titu weather station, the frequency of *very dry* class covers an extended interval, from June to September and has the highest frequency (29.8% in June and September). Application of the Helmann criterion to the **annual precipitation amounts** (Table 3), show that *excessive dry class* has the highest frequencies, in all the four weather stations analyzed, especially in the Târgoviște-Ploiești Plain (53.2%), which compared to the analysis months increased the frequency of this time type also at the Ploiești weather station. From the above table, it is observed that if the years, compared with analysis of all months, *dry time* completely missing all four weather stations analyzed, and the *moderately dry* and *very dry* at Ploiești and Videle weather stations and respectively, Târgoviște and

Videle. At the same time, the *frequency of normal years in terms of rainfall has decreased significantly*, especially in Târgoviște-Ploiești Plain (2.1%), this percentage is equal to the product when *moderately dry* time of Târgoviște weather station and the characteristic *very dry* time from Ploiești and Titu weather stations.

Table 3. Frequency of dry years with different characteristics after Helmann criterion (1961-2007)

Weather station	Normal		Moderately dry		Dry		Very dry		Excessively dry	
	No. years	Frecv. %	No. years	Frecv. %	No. years	Frecv. %	No. years	Frecv. %	No. years	Frecv. %
Târgoviște	1	2.1	1	2.1	0	0.0	0	0.0	25	53.2
Ploiești	1	2.1	0	0.0	0	0.0	1	2.1	25	53.2
Titu	4	8.5	2	4.3	0	0.0	1	2.1	22	46.8
Videle	3	6.4	0	0.0	0	0.0	0	0.0	20	42.6

*Source: data processed after N.M.A. Archive

Overall, in Târgoviște-Ploiești Plain prevails *deficient rainfall years* (57.4%), compared with Găvanu and Titu Plains, where prevailing *surplus rainfall years* (between 51 and 55%). Knowing the size of the impact generated by the intensity of dryness and drought phenomena allows assessment on *the vulnerability degree of the Titu Plain*, to these two types of climate hazards. In the whole country, Bogdan, Niculescu (1999) and Bogdan, Marinică (2007) have defined three levels of vulnerability (low, moderate and high), determined by Walter-Lieth climatic diagrams, who had just basic criterion for average annual number of months with dryness and drought phenomena. Thus, the analysis Walter-Lieth climatic diagrams built for each weather station (Fig. 4), showed that, related to the whole country (Fig. 5), the area chosen for investigation show a low vulnerability in relation to intensity of dryness and drought phenomena, as it is in the area of interference of the western circulation to the east from the southern Romania, which *stands only dryness phenomena with a frequency <3 months/year*, due to a higher rainfall, so the *vulnerability degree of land with different agricultural uses, should be considered individually* (Bogdan, Niculescu, 1999).

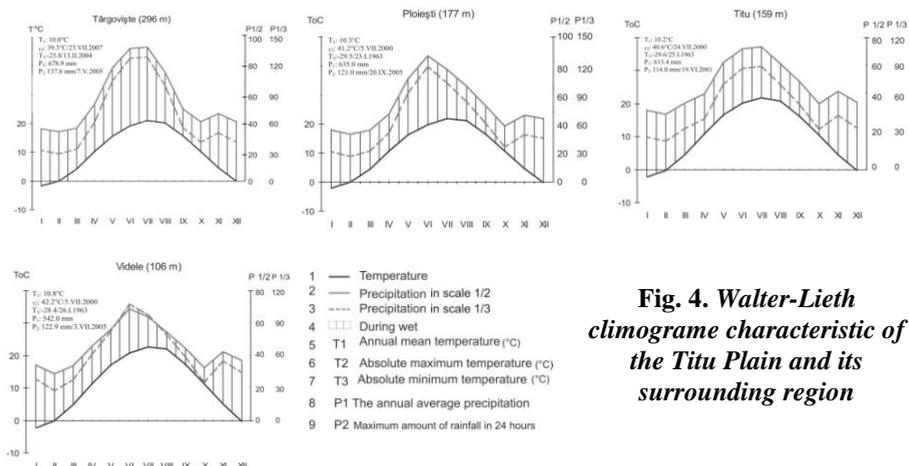


Fig. 4. Walter-Lieth climogram characteristic of the Titu Plain and its surrounding region

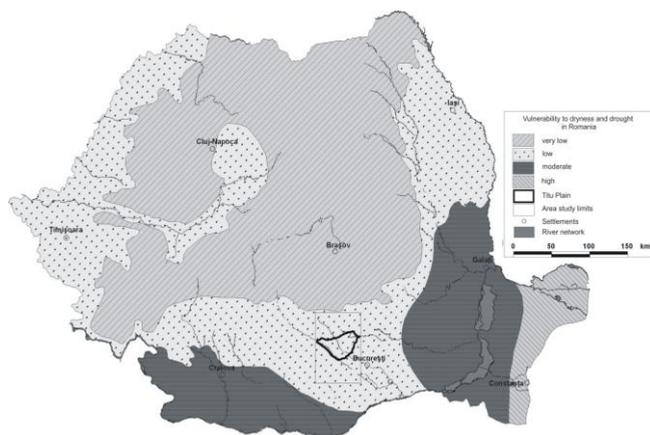


Fig. 5. Vulnerability to dryness and drought in Romania (modified after Bogdan, Niculescu, 1999; Bogdan Marinică, 2007)

4. CONCLUSIONS

The frequency of short pluviometric time based on the Helmann criterion showed that, over the 47 years analyzed, there were negative deviations both of the monthly precipitation amounts – where, the highest frequency returns dry time (Videle and Ploiești, 15-16%) and the very dry (Titu, >16%), or moderately dry and dry time (Târgoviște, >8%), which, as may be noted, has halved frequency values compared with other types of time from the rest of weather stations analyzed. At the same time, the lowest frequency, at all four stations analyzed returns excessively dry time (2-7%); and the annual quantities – where, due to homogenization annual values, the highest frequency for the whole studied area just returns to the overly dry time (43-53%). The graphic representations of the Walter-Lieth climatic diagrams type presents a annual average situation of the 1961-2007 interval, which shows that wet periods are dominant for three of the four weather stations analyzed (Târgoviște, Ploiești and Titu) – exception make Videle weather station located at the lowest altitude (106 m), which in October occurs and dry periods highlighted through the intersection between temperature and precipitation represented in a 1/3 scale. Although, the atmospheric precipitation is higher in Târgoviște-Ploiești Plain and în Titu Plain, the dryness phenomena are more frequently in the Găvanu Plain, responsible for this situation is particularly the higher air temperature at the Videle weather station (10.8°C). From the above it appears that, in the Titu Plain, dryness and drought phenomena have a small degree of vulnerability, in relation to other areas of the Romanian Plain, but also with other romanian territories. In fact, in the study area make their presence only the dryness phenomena, only in Găvanu Plain, as evidenced by Walter-Lieth climatic diagrams through Videle weather station, so that the plants do not suffer yet for humidity, because water reserve soil is ensured. In conclusion, we think, not the end, this study can serve as a working instrument from specialists of various

fields in order to take necessary measures to mitigate or eliminate the negative effects they can have the dryness and drought phenomena on agricultural landscape, both locally and regionally level.

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