AN ANALYSIS OF SOME HYDROMETEOROLOGICAL HAZARDS AND THEIR IMPACT ON THE ENVIRONEMENT IN TÂRGOVIŞTE PLAIN

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ABSTRACT. – An Analysis of some Hydrometeorological Hazards and Their Impact on the Environment in Târgovişte Plain. Through their impact on the environment and on the socio-economic activities hydrometeorological hazards trigger natural and ecological imbalances, having a negative influence on the geosystems evolution. The analysis of the main hydrometeorological elements allows for a characterization of the geographic area of Târgovişte Plain based on the data recorded at the meteorological stations from Târgovişte and Titu during the interval 1961–2007. In the present analysis, we took into account the thermo hazards (heat waves and cold waves), pluviometric hazards (periods of too much or too little rain) and their impact on the environment of Târgovişte Plain.
The most intense cold/heat occurrences are considered the moments when the extreme monthly temperatures go over certain threshold values: the absolute maximum monthly temperature ≥35°C or the absolute minimum monthly temperature ≤-20°C.
In point of the study of the periods with too much/too little rain, we calculated and interpreted the annual, seasonal and monthly values of the Standardized Precipitation Anomaly (SPA).

Keywords: Târgovişte plain, hydrometeorological hazards, standardized precipitation anomaly.

1. INTRODUCTION

The non-periodical climate variation is marked by numerous extreme phenomena. They are the direct result of the contact of the general atmospheric circulation with the characteristics of the active underlying surface, and can have both a general and a regional or local character. The statistic series allows for their differentiation. Taking into account that they come in a very large array, we presented just a few, having the value of climatic record, along with their most serious consequences (Bogdan, Niculescu, 1999).

It is known that the environment and the human society are often influenced by some extremely dangerous phenomena of different origins, either natural or anthropic, which can lead to destructive and brutal deregulations in the pre-established systems or situations.

Floods represent frequent phenomena, triggering serious risks for man and his activities. Being the most encountered hazard on the Globe, they occupy the

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first position in point of the damage caused by natural catastrophes, causing significant economic losses each year, the death of scores of thousands of people and different problems under different forms and with different degrees of gravity for several hundreds of thousands of other people (Bălteanu, 2004).

The analysis of the main climatic elements allows for a characterization of the geographic area of Târgovişte Plain from a hydrometeorological viewpoint.

Starting from the existence of a long series of statistic data, from the observations made at every station analyzed in Târgovişte Plain, from the existing specialized literature of geographic information, and of specific sites, we have been able to analyze the hydrometeorological hazards in Târgovişte Plain.

2. HYDROLOGICAL HAZARDS

For Târgovişte Plain, the study of the high floods was carried out taking into account the largest high floods occurred during the interval 1961–2007, on Dâmbovița and Ialomița Rivers (Sencovici, 2009).

The water flow of Dâmbovița River during the high floods reached very high values and this thing affected, in some sectors, the socio-economic activity. On Dâmbovița River, most of the high floods were caused by rain and occurred mostly during the 8th and 9th decennium of the 20th century (1975, 1979, 1982, 1983, 1988 and 1989). The most characteristic high floods occurred in 1975, 1979, 1982, 1983, 1988, when they affected especially the middle and lower sectors of Dâmbovița River.

The 1975 flood. Beginning with July, in the entire Dâmbovița County, high quantities of precipitations were recorded, causing floods that put to the test numerous economic units and thousands of families, disturbing the normal course of life and of the economic and social activity.

On Dâmbovița River, at the station of Malu cu Flori, two high floods occurred within a month. The first one occurred on June 3, the flow rising process beginning the previous day, when a flow of 29 m³/s had been reached. On June 3, at 8.30 p.m., the flow volume reaches 161 m³/s, and at 9.00 p.m. it attains the maximum value of 176 m³/s. Within just a few hours since the moment when the high flow peak was recorded, the flow goes down to about half of the top value (89.2 m³/s at 12.00 p.m.). Then follows a continual decrease of the water flow, so that in four days the flow decreases from 83 m³/s (June 4) to 43 m³/s (June 7).

The second high flow appears in the beginning of July 1975 and is much more brutal, lasting much longer than the previous one. It was present both on the middle and on the lower course of Dâmbovița River.

At Malu cu Flori, the high flow started to evolve on July 1, when, at 7 a.m., the water flow recorded the value of 64.6 m³/s. After just 31 hours, namely on July 2, at 3 p.m., the high flood records a top flow of 500 m³/s. During the following days, the flows record a descending curve, so that after 7 days, Dâmbovița River goes down to a flow of 46.1 m³/s.

At Conțeşti, the flow peak was recorded on July 3, at 0.30 a.m., so about 9 hours later than in Malu cu Flori, when the value of 444 m³ /s was reached. The

flow decreases after that, during the following days, from 407 m³/s (July 3, at 5.30 a.m.) to 81.6 m³/s (July 6, at 10.00 p.m.).

Both in June and in July, the high floods were generated by the rain and manifested themselves by means of just one peak. The floods caused numerous damages. Significant areas cultivated with corn, wheat, lucerne and technical plants were covered with water. So, a large concentration of forces was required to eliminate the excess water in order to ensure the normal plant development. The floods destroyed or depreciated the quality of important quantities of fodders. It was necessary to adopt measures to ensure the gathering of the fodders, so that each agricultural unit may cover its necessities in good conditions.

In some localities, the floods and the rains deteriorated the stables and other economic buildings. In Crângaşi village, 250 families were taken away from the flooded area to Conțeşti.

Dragomireşti Commune was strongly affected by the high flood of Dâmbovița River. Immediately after the rains stopped (Thursday, 4 p.m.), measures were taken to prevent further flooding and to limit the damage produced by the water. So, the 1000 evicted people returned home and did their best to take the water out from their houses, remove the mud and rebuild the small bridges. On July 3, the 180 animals evicted during the flooding, returned to their stables. On the same day, the people took part in the digging of ditches to drive away the water from the 80 ha cultivated with wheat and the 45 ha of corn. By the end of the day, thanks to these interventions, half of the agricultural area was freed from the waters.

In the industry, beginning with July 4, all the enterprises and headquarters affected by flooding started to function and on June 5, they neared their ordinary work conditions.

In agriculture, thousands of people struggled to remove the water from their lands, to pick up their wheat and vegetables, to gather and deposit their fruits. On June 6, people gathered the wheat on 1300 ha.

The 1975 flood. In 1979, Dâmbovița River recorded another high flow, signaled in June, both in Malu cu Flori and in Conțeşti.

In Malu cu Flori, following a series of very rich precipitations, which occurred during the second decade of June, significant increases of the water flow in Dâmbovița River were recorded beginning with June 20, at 7 a.m., when the flow reached the value of 37.9 m³/s. The high flow lasted until June 24, a period during which two maxima occurred, a principal one and a secondary one. On June 21, at 10 p.m., the main peak of the flow was recorded, with a value of 258 m³/s. After a decrease of the flow to 34.6 m³/s, on June 22 at 4 a.m., in just two hours, the second peak was recorded as well, with a secondary significance.

The high flow from Malu cu Flori passed on and, about 16 ore later, arrived to the hydrometric station of Conțeşti. There, on June 22, at 2 p.m., a peak flow was recorded, amounting to 546 m³/s. This high flow was peculiar in the sense that, after the maximum flow was reached, the flow evolved following a decreasing curve, so that, on June 25, at 11 p.m., the recorded flow was of 14 m³/s.

The high flow of 1982 affected especially the lower course, and the capital was threatened by the dark troubled waters of Dâmbovița River. At the hydrometric station of Conțeşti, the high flow lasted for about a week. The peak of the high flow occurred in about 24 hours.

On August 22, 1982, in Conțeşti, following some torrential rains, Dâmbovița River recorded a significant increase in the water flow. At 5 p.m., during the same day, the flow reaches a volume rate of 9.8 m³/s. On August 23, under the influence of the very intense torrential rains, the waters start to grow continually, so that, at 7 p.m., the high flow reaches a peak whose value is 226 m³/s. Just one hour after this hydrological maximum, the flow decreases by 50%, namely to 138 m³/s. Then, during the following days (August 24–28), the waters record a decreasing curve, with flows of 18–16 m³/s.

In 1988, the high flood occurred in July and concerned the alpine region at first, and then moved on from the hydrometric station of Podu Dâmboviței, until it got downstream of Conțeşti.

In Malu cu Flori, though the waterbed of Dâmbovița River becomes larger, on July 17, following the rains fallen, the special high flood records a 132 m³/s peak flow, at 8 a.m. Then the water flow decreases during the following 4 days.

In Conțeşti, the high flood wave became plain, and so it is of no scientific/hydrologic interest. However, at this hydrological station, a high flood occurred between June 2 and 6, 1988. It began on June 2, with flows ranging between 11 and 64.1 m³/s. On June 3, 1988, following a period of rich rain, the water flow reaches extraordinary values (162 m³/s). As the rain intensity decreases, during the same day, the water flow decreases to values ranging between 116 and 71 m³/s.

Out of the above-mentioned information, we can grasp that all the high floods that occurred in Dâmbovița basin were caused by the rain, and, except for the one of June 1979 from Malu cu Flori, which recorded two peaks, all the high floods had just one peak (Gâştescu, 2003).

The maximum flow for these high floods was recorded on June 22, 1975, at 2 p.m., when the peak of the high flood from Conțeşti reached 546 m³/s and on June 24, 1975, when the high flood peak reached 912 m³/s (fig. no. 1).

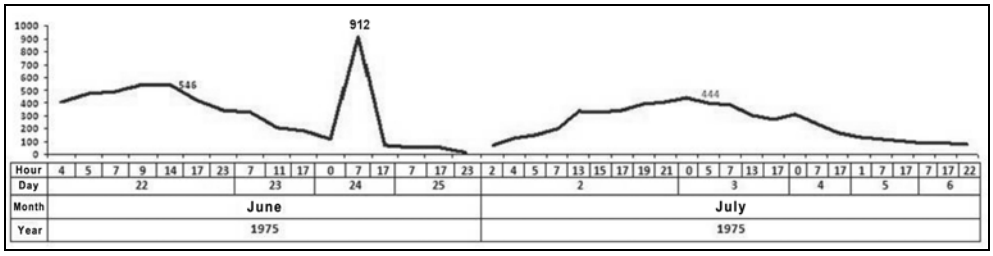


Fig.1. ***The evolution of the high floods of 1975 on the river Dambovita at the hydrometric station of Conțeşti***

The year 2005 hydrological events. Abundant rain and the flooding occurred in 2005 determine the character of an exceptional year, with a very rainy spring and summer. An area affected by the rainfall is that of Aninoasa Commune, situated nearby Târgovişte Town, made up of the villages: Aninoasa, Săteni, Viforâta. Here there were landslides, the lithology of the surface deposits, made up of clays and marls, playing a very significant role. The presence of a layer of clay, over which there is a drenched permeable layer, is the essential condition triggering the occurrence of landslides. So, the landslides caused by the flooding of 2005, combined with the melting of the snow, affected in April in Aninoasa the county road *DJ 712 A from the national road DN 72 to Dealu Monastery; 30 m wall from the building of the service personnel of the hospital; pillar no. 16, supporting the electric network, etc.* Also in Aninoasa Commune, during this period were flooded: *10 households; 4 ha of land used in agriculture; 4 potable water wells.* The flooding in May affected 15 ha of land used in agriculture; 5 houses; 0.5 km county road.

The torrential rains of August 14–25, 2005 affected Aninoasa Commune even more: 60 houses; 177 household annexes; 8 bridges; 2.11 km county road and communal road; 29 ha land used in agriculture; 250 dead animals. The torrential rains of September 1, 2005 affected the county road DJ 718 A, a parapet that used to consolidate the slope broke. All the above information shows that flooding can affect, at least temporarily, the quality of the environment, the negative effects of these phenomena being felt in the economy, in the social life and even in the physical environment.

The high quantities of precipitations fallen in the spring of 2005 affected other localities as well, such as Valea Voievozilor village, a component of Răzvad Commune situated near Târgovişte Town, Lucieni, Ulmi, Văcăreşti, Nucet. The precipitations triggered the occurrence of flooding, causing damages to the households and in the agriculture.

The rains of 2005 affected Târgovişte Town as well.Three areas were affected more significantly: Spitalul Județean (The County Hospital), Valahia University and the entrance in Târgovişte from the neighbourhood of Priseaca.

3. CLIMATIC HAZARDS

3.1. Heat waves

In the interval 1961–2007, 32 phases of massive heat were recorded (when the absolute temperature was ≥35°C). Their highest frequency occurred in July 1987, 2007 and August 2000, to which August 1968, and July and August 2000 can be added. The absolute maximum temperature went twice over 40^{o} Celsius at Titu station, 40.2 in July 1987 and 40.6 in July 2007(tab. no.1).

Table. 1. ***Parameters of the air temperature in July***

Station	Multiannual average temp. of July (1961–2007)	Average temp. of July 1987	Absolute maximum temp. July 1987	Average temp. of July 2007	Absolute maximum temp. July 2007
Târgovişte	19.2	20.8	39.1	24.7	39.3
Titu	20.9	23.3	40.2	25.4	40.6*

* absolute maximum temperature of the region

3.2. Cold waves

In Târgovişte Plain, the most intense cold periods were considered those when the minimum monthly temperatures reached or went below -20°C (January: 1954, 1963, 1968, 1969, 1972, 1980, 1985, 2000, February: 1950, 1954, 1956, 1963, 1965, 1985, December: 1998).

During the interval under analysis *16 phases of intense cold occurred*. The highest frequency appeared in January 1963, to which we can add January 1965, 1980, 1985, 2000 and February 1965, 1985. In more than 65% (13 years) of the total number of years with intense cold, just one such occurrence appeared a year. *January 1963 was* the coldest month in the interval 1961–2007, when the absolute minimum temperature was recorded, namely -29.6°C in Titu (tab.no.2).

Table. 2. ***Parameters of the air temperature during the month of January 1963***

Station	Multiannual average temp. for the month of January (1961–2007)	Average temp for the month of January 1963	ΔT (°C)	Absolute minimum temp. of the month of January 1963	Data of occurrence of the absolute minimum temp.	ΔT (°C) (Absolute minimum temp. of January – multiannual average temp. for January)	ΔT (°C) (Absolute minimum temp. of January 1963 – average temp for January 1963)
Târgovişte	-1.8	-8.1	-6.3	-25.5	17	-23.7	-17.4
Titu*	-2.5	-9.4	-6.9	-29.6	25	-27.1	-10.2

* absolute minimum temperature

3.3. Periods of rain excess

The study of the periods of rain excess relied on the calculation and interpretation of the annual, seasonal and monthly values of the Standardized Precipitation Anomaly (SPA). This indicator is calculated according to the formula: $SPA = (X_i - X_{med})/\delta$, where: x_i = term in the series; x_{med} = series average; δ = root mean square (standard deviation). We considered as cases of rain excess the situations when the SPA value was higher than 1.0 (tab.no. 3).

Table. 3. ***Pluviometric characterization of the time intervals according to the SPA value***

0.5…-0.5	Normal
0.5…1.0	little rainy
1.0…1.5	Rainy
1.5…2.0	very rainy
2.0…2.5	excessively rainy
>2.5	exceptionally rainy

Yearly pluviometric excess

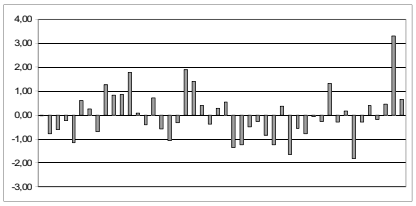
The frequency of the rain excess years is comprised between 25,6% (Târgovişte) and 23.4% (Titu), recording lower values than those of the rain deficit years (SPA<-0.5). It results that the normal years in point of rain with an SPA between -0.5 and 0.5 are predominant in the entire plain region, their frequency being of 44.7% in Târgovişte (tab.no. 4).

Table. 4. ***Frequency of the years of pluviometric normality, excess and shortage (1961–2007)***

Attribute of the year	Surplus		Shortage		Normal	
SPA	>0,5		<-0,5		-0,5...0,5	
Frequency / Station	Number of cases	%	Number of cases	%	Number of cases	%
Târgovişte	12	25.6	14	29.8	21	44.7
Titu	11	23.4	14	29.8	22	46.8

The exceptionally and excessively rainy years have a very low frequency: 2.1%. So, the rain excess is generally given by the rainy years, whose frequency is comprised between 6.4% (Târgovişte) and 10.6% (Titu).

Târgovişte



Titu

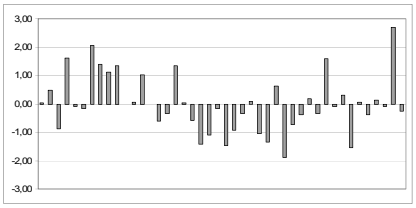


Fig. 2. ***Yearly SPA values***

As far as the frequency of the consecutive excess years is concerned, there is a clear dominance of the situations with two consecutive years, during the

periods 1970–1971 and 1979–1980. The situations with three consecutive rainy years had a lower frequency, just one such situation being recorded, in Titu (1970–1972)

The repartition of the rain excess seasons, according to the SPA, highlights a rare occurrence of the exceptionally and excessively rainy seasons, especially during spring and summer. The most frequent very rainy season was summer, while the most frequent rainy season was autumn.

A precipitation excess can be recorded for two or several seasons in a row. The most frequent coupling was of two consecutive seasons, with a maximum frequency for the spring-summer couple (both for Târgovişte and for Titu).

Monthly rain excess

Compared to the values considered normal, which have a frequency of 37–40%, the highest frequency goes to the months with little rain for each station: Târgovişte 9.2% and Titu 9.6% (Sencovici, 2009). (tab.no.5).

Tab. 5. ***Frequency of the months with pluviometric surplus***

	Exceptional rainy		Excessively rainy		Very rainy		Rainy		A little rainy		Total surplus	
SPA	>2.5		2.5…2.0		2.0…1.5		1.5…1.0		1.0…0.5		>0.5	
Station	No. of cases	%	No. of cases	%	No. of cases	%	No. of cases	%	No. of cases	%	No. of cases	%
Târgovişte	13	2.3	11	2.0	20	3.5	30	5.3	52	9.2	126	22.3
Titu	11	2.0	9	1.6	21	3.7	44	7.8	54	9.6	139	24.6

The follow, in a decreasing order, the rainy (5.3%–7.8%), very rainy (3.5%–3.7%), excessively rainy (2.0–1.6)) and then exceptionally rainy months (2.3%–2.0%). (fig.no. 3).

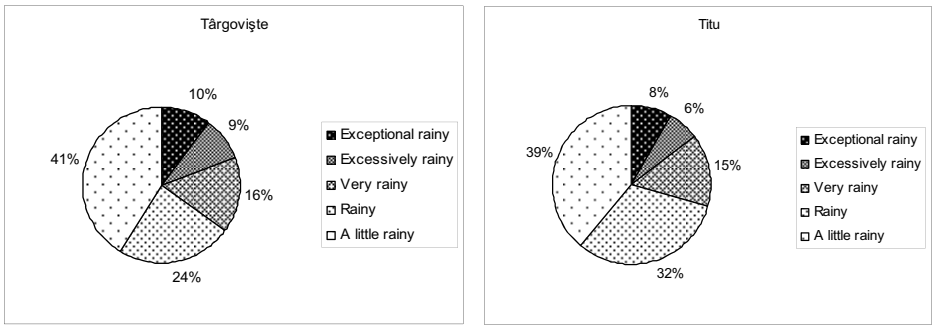


Fig. 3. ***Weight percent of months with different pluviometric excess categories***

Years of rain excess

Among the exceptionally rainy years, there are: 1969, 1972, 1979, and 2005.

In *1969*, the rain excess varied between 271 and 280.9 mm. The values recorded were of 927.4 mm in Titu, and 903.7 mm in Târgovişte.

The year 1979 is also part of the category of the extremely rainy years. The rain excess was of 280.9 mm. Extremely high water quantities were recorded in Târgovişte (1015.2 mm).

Then followed the year *2005* with extremely high precipitation values, which culminated in the month of August (268.3 mm in Târgovişte, 199.6 mm in Titu). Actually, in Titu, the recorded quantity was of 1269.7 mm, which represents the absolute extreme quantity, and in Târgovişte 1026.8 mm.

Rain excess seasons

The winter of 1969–1970 was exceptionally rainy (with liquid and solid precipitations). The recorded quantities were 318.6 mm in Târgovişte and 325.7 mm in Titu.

The summer of 1979 was remarkable for its very rich precipitations, which reached 443.1 mm in Titu and 605 mm in Târgovişte.

Rain excess months

The analysis of the highest monthly quantities of precipitations indicates the possibility of their occurrence during any month of the year, and especially during the months of pluviometric maximum, when the highest values are reached.

October 1972, despite being an autumn month, which generally means few precipitations, recorded rich precipitations: Târgovişte 242.5 mm, and Titu 195.3 mm.

In August 1997, abundant rains covered a large area: 295.4 mm (absolute monthly maximum) in Târgovişte.

August 2005 was extremely rainy in almost the entire plain, both of the stations recording high values: Târgovişte 268.3 mm and Titu 163.8 mm.

3.4. Drought

We analyzed the periods of dryness and drought accompanied by graphs or synthetic statistic tables with average multiannual, annual, seasonal , monthly and daily values.

In order to distinguish between the amplitude of the precipitation deficit and the series of pluviometric deficit periods, we calculated the negative deviations of the annual, seasonal and monthly quantities compared to the multi-annual average considered normal. We used the Standardized Precipitation Anomaly (SPA), applied to the data coming from two meteorological stations, for the interval 1961–2007.

Yearly rain deficit. Calculating the total of the rain deficit periods of different duration, determined according to the SPA criterion, we noticed that most of them were recorded by Titu station. There were neither exceptionally dry nor excessively dry years. The frequency increased from the very dry (4.3%), to the dry years (10.6%, 12.8%) and then to the years with little drought (14.9–12.8%). The highest frequency goes to the years with little drought, being recorded in Târgovişte (14.9%). (Tab.no. 6)

Table. 6. ***Frequency of the years of pluviometric shortage***

Station	Exceptionally dry		Excessively dry		Very dry		Dry		A little dry		Total shortage	
	<-2.5		-2.5…-2.0		-2.0…-1.5		-1.5…-1.0		-1.0…-0.5		<-0.5	
	No. of cases	%	No. of cases	%	No. of cases	%	No. of cases	%	No. of cases	%	No. of cases	%
Târgovişte					2	4.3	5	10.6	7	14.9	14	29.8
Titu					2	4.3	6	12.8	6	12.8	14	29.8

Seasonal rain deficit. Following the variation of the seasonal quantities, we notice that the highest negative deviations were recorded during the summer, for both of the meteorological stations (90–115 mm), during autumn, the negative deviations are of 73.8–73.9 mm, and during winter, the deviations recorded are lowest (50–60 mm). There are no exceptionally dry seasons, and the highest frequency goes to the autumn in Titu (29,75%)(fig.no.4).

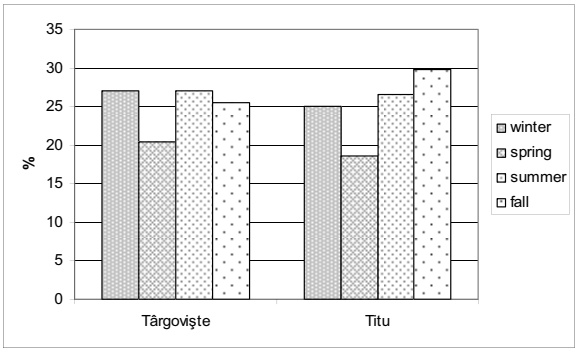


Fig. 4. ***Share of the seasons with pluviometric shortage***

It is very important to know the succession of the rain deficit seasons from one year to the next. So, the winters and springs with rain deficit can appear for three years in a row, the summers and autumns can appear consecutively for two years, while the winters never occur for two years in a row for either of the stations (Dumitraşcu, Dumitraşcu, Douguedroit, 2001).

It is important to know as well the frequency of the series of two seasons of rain shortage, during the same year. In this sense, it has been noticed that for Titu station, the frequency is higher (15%). This explains as well the vulnerability of these areas to the lack of humidity, which can last for a longer period of time.

Monthly pluviometric deficit. By comparison with the values considered normal (38.3–44%), the highest frequency for each station goes to the months with a little drought (23–27.8%). This frequency slightly decreases from 27.8% in Titu to 23% in Târgovişte. The most frequent very dry months are: October–November (Târgovişte) and October (Titu).

Drought effects

In the area of Târgovişte Plain, the droughts recorded had negative effects on the cultivated areas and on animal breeding, determining as well the decrease of the water resources in the rivers and the water table, and difficulties in the functioning of the micro-hydropower stations (Alexe, 2005). The lack of precipitations, corroborated with the hot temperatures, led in the year 2000 to the driest summer of the last hundred of years, the indicator of temperature-humidity recoded for the entire period going over 65%.

In the soil, following the intense evaporation processes, natural salinization phenomena occurred, accompanied by the formation of efflorescences.

Finally, the environmental and life quality were influenced, through the poor quality or absent food resources, leading to an increased morbidity among the animals and the population. The most conclusive examples are: in the year 2000 – July 5, 10 fires occur (burning up 3000 m^2 wheat field near the Târgovişte Special Steel Works – COS); 500 kg hay in Ulmi; 800m^2 dried vegetation along Calea Câmpulung; and other smaller fires in Dragomireşti, Lucieni, Gura Şuții); 2007 – July: the fields cultivated with corn were affected in a proportion of 90% in the localities: Sălcioara, Produleşti and those cultivated with potatoes in proportion of 80% in the locality of Finta; 2007 –August 25, a large fire destroyed 6 ha of land (Source – Direcția Agricolă Dâmbovița – The Agricultural Direction of Dâmbovița).

4. CONCLUSIONS

Târgovişte Plain was and remains a vulnerable region regarding the occurrence of both flood and drought, extreme meteorological phenomena being likely to occur during any season. The analysis of the graphs we have drawn shows that the above-mentioned phenomena often bring forth material and financial damages, endangering the cultivated fields, the lawns, the hay fields, the forests, the orchards, the surface waters and, so, the entire environment.

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