DROUGHT AND ARIDITY PHENOMENON'S IN SOUTH-WESTERN ROMANIA

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Abstract

The climatic records of the last century present a progressive heating of the atmosphere with a significant precipitations variation during short periods of time. Even drought is a normal, recurrent feature of nature, at the beginning of the 3rd millennium this phenomenon represents in many areas a meteorological pollution, result of the massive quantities of air pollutants released in nature. The climate responds at this situation in a very visible way and with increased impacts upon the society. Regarding Romania's case, if desertification is more common for southern and south-eastern part, the western and south-western parts are characterized by aridity (which is a long-term feature of climate) and periods with drought.
In South-Western Romania became obvious the climatic tendency of passing from wet and half wet climate to half-wet and half-arid (even arid in some areas) climate. Corroborated with the missing or the degradation of hydroameliorative works, were created the necessary conditions for the appearance of water scarcity phenomenon in different forms and at different scales. In western and south western Romania, an important role in drought phenomenon appearance is played by vertisols which are spread on large surfaces. It deserves to be mentioned here and the problem of the surface drainage and drainage arrangements which worked intensive till few years ago and decrease dramatically the water table level in soils.
The paper will present an image regarding the climatic situation in Romania's south-western part, consequence of the climatic changes in the last years. I will present some maps with different aridity indicators (De Martonne, Lang and Dantin Cereceda and Revenga Carbonell) for two counties, graphs with temperatures and precipitations evolution in the last years, problems regarding the Romanian legislation about water scarcity.

Keywords: *drought, aridity, climate, climatic changes, indicators, maps.*

1 INTRODUCTION

The climatic records of the last century present a progressive heating of atmosphere with large variations of precipitations regime from one year to another. These climatic factors proved to be obstacles for agricultural productions growing and development from the most geographical regions, also limiting the available resources for hydroameliorative measures.
Droughts appeared with a regularly frequency during the last 30 years in Europe and not only. Each event of this type affected a specific area with it population. In the last 17 years, at European level, exist many droughty periods (1989, 1990, 1991, 2000 – with a major negative impact on Romania's territory, 2003) which affected 800.000 km^2 cu 100 million inhabitants which represented 37% of Europe's surface and 20%

of its population. In comparison with 1976 – 1990 periods, between 1991 and 2006 the average European surface affected by drought increase from 6 to 13% and the number of inhabitants affected by these phenomenons presents an increasing with about 7%.
In Romania, the zones which are most exposed to aridity, drought and even desertification phenomenon are Dobrogea, Bărăgan, Oltenia, the South of Moldavia Hills, Romania's West Plain. Years with long periods of droughts were: 1894-1907, 1945-1951, 1983-1994, 2000 – 2003 and, according to the last records, 2007 which proved to be droughty than 2000. The drought from 2000, by its intensity, effects, and manifestation period, can be considered one of the severest which affected our territory. The precipitation regime presented a deficit of 33,4% from the normal value in 2000. Researchers continue to have a debate about which was the droughty year in the last decade: 2000 or 2007.
The stabilization of arid climate in Timiş County and the existence of a tendency of climate passing from wet and half-wet to half-arid and arid climate in Caraş-Severin County became obvious in the last 2 decades. Corroborated with the missing or degradation of hydroameliorative works, this situation create the necessary conditions for the appearance of drought phenomenon in different forms and at different scales.
This paper, being based on records from meteorological stations, proper equipped, of Meteorological Centre Banat-Crişana and on records from I.C.P.A. source (Institute of Agriculture and Soil Research) presents an image about the aridization level from South-Western Romania (Timiş and Caraş-Severin Counties) also mentioning the areas affected or which present risk at drought. The maps which were realized by author can be anytime improved and can constitute a base for future risk maps in drought researches and management.

2 CLIMATE IN SOUTH-WESTERN ROMANIA

Fig. 1 The position of Timiş County and Caraş-Severin County on Romania's map

Timiş County is dominated by a temperate climate of moderate continental type and which is characteristic for the south-east part of Pannonnian Depression with Mediterranean and oceanic influences. The annual average temperatures are

function of relief forms, increasing from 4º - 7º in mountain area to 10º - 11º. The cyclones and warm air masses influences from Adriatic Sea and Mediterranean Sea make their presence especially in the winter being observed the lack of frozen and solid precipitations while in the summer we can observe very warm periods. The precipitation regime has an irregular regime, with years wettest than the average and years with low precipitations. The most frequent are north-western winds (13%) and western winds (9.8%). In April - May, a high frequency has the southern winds (8.4% from total). As intensity, the winds reach sometimes level 10 (Beaufort scale), the storms with cyclone character coming all the time from west or south-west.

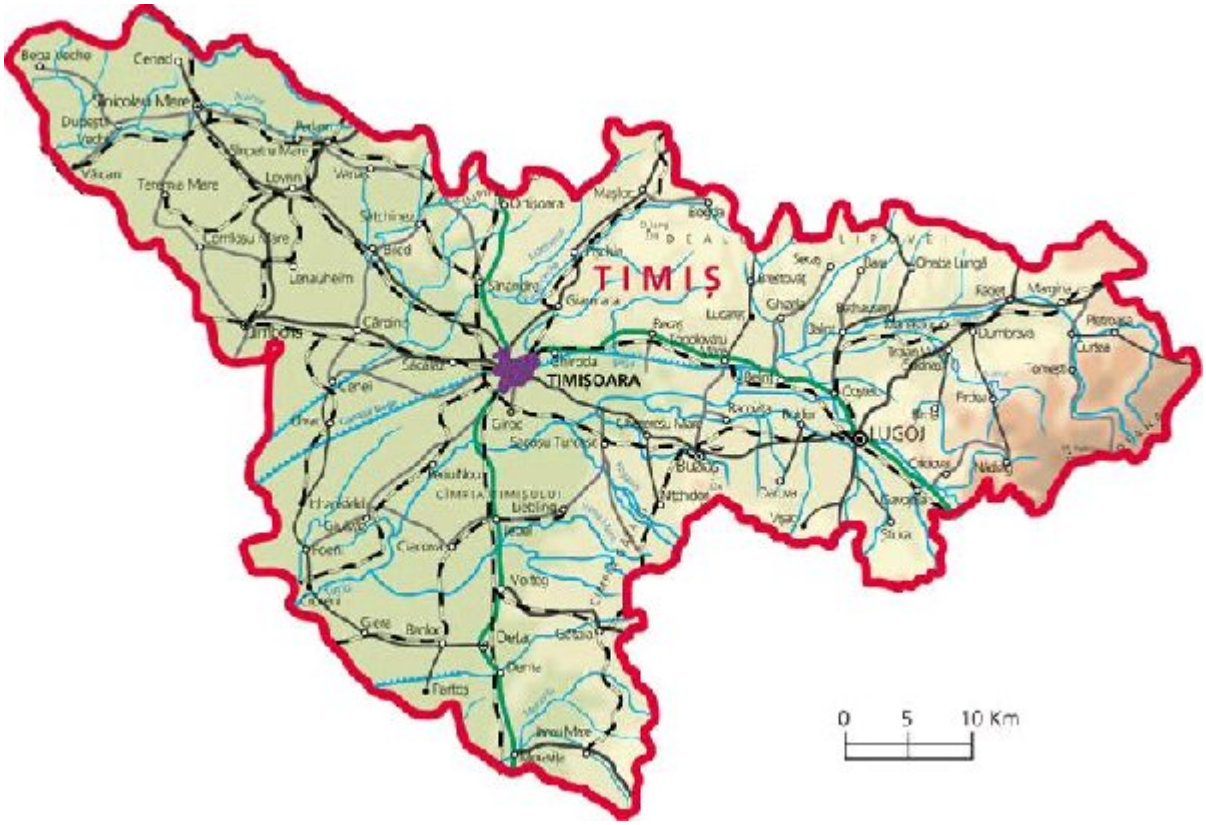

Fig. 2 Timiş County geographical map

Caraş-Severin County, in comparison with Timiş County, is formed in a larger proportion by high relief forms, this type of relief influencing the climatic factors. The geographical position of Caraş-Severin County determine decisive the installation of a particularly climatic regime of the entire western part of Romania's territory, significant obedient to the western and south-western atmospheric circulation influence.

The western circulation, with an average frequency of 165 days/year brings polar air masses during cold period, or, rarely, came with maritime air masses which support the installation of warm winters, with abundant precipitations, most of them being rains at low altitudes. During summers, this circulation determines a high degree of temperatures instability, emphasized by the rains frequency with electric discharges.

The Mediterranean cyclones activity from south-west presents importance in weather changes especially during cold season when they transport high masses with wet air which at the intersection with high area determine the abundant precipitation. From October to February, the south-western cyclones activity determine large quantities of solid precipitations and snow storms with reduce period of time.

The geographical position of Caraş-Severin county together with the variety of relief forms proved to be a compensator factor versus the climatic east European asperities determining the installation of a specific climate, with a concentrically displacement of isotherms accordingly to the relief forms, with direct impact upon all climatic parameters connected with this particularity.

Fig. 3 Caraş-Severin County geographical map

Daily, monthly and yearly temperatures presents values with follow very precisely the disposal on altitude of the observation points, the isotherms closing in concentrically circles corresponding to the relief forms.

The precipitations are following the same rules of repartitions function of relief forms altitudes, but they are presenting as a climatic element much stabile than temperature. The variation in time and space is as higher as the local conditions are presenting a larger variation. The annual repartition of precipitation which presents, statistically speaking, two maximum and two minimum annual values, represents prove of oceanic influence manifestation and especially of the Mediterranean influence.

3 FENOMENONS OF DROUGHT AND ARIDITY IN SOUTH-WESTERN ROMANIA

The maps which are going to be presented for these two counties: Timiş and Caraş-Severin were realized by inserting some indicators computed by the author, with the help of records from Banat-Crişana Meteorological Center, or from other sources as

Research Institute for Soil Science and Agrochemistry. I used the aridity indicator Land and De Martonne, D.R. indicator, relative humidity indicator (P/ETP – this indicator presents the climates taking in consideration the average long-term values) and respective the Palfay indicator.

In the following table are presented some indicators computed for different communes of Timiş and Caraş-Severin Counties. The formulas for De Martonne, Lang and D.R. indicator are:

De Martonne (A) = $\frac{P}{T+10}$ Lang (L) = $\frac{P}{T}$ D.R. = $\frac{100T}{P}$

- where P represents the annual precipitations and T the annual temperature.

Table 1. Indicators computed for some meteorological stations from Timiş and Caraş-Severin Counties

No.	Meteorological station/ County	De Martonne Indicator	Lang Indicator	D.R. Indicator
1	Beba Veche/ Timiş	24.92	47.79	2,092131
2	Teremia Mare/ Timiş	26.55	51.13	1,955459
3	Sânnicolau Mare/ Timiş	26.02	50.12	1,994828
4	Jimbolia/ Timiş	27.05	52.34	1,910373
5	Periam/ Timiş	25.61	49.56	2,017726
6	Cărpiniş/ Timiş	29.47	57.02	1,753523
7	Cenei/ Timiş	26.11	50.51	1,979648
8	Grăniceri/ Timiş	29.93	57.91	1,726642
9	Timişoara/ Timiş	29.17	56.69	1,763727
10	Banloc/ Timiş	29.01	56.13	1,781552
11	Liebling/ Timiş	28.47	55.33	1,807024
12	Recaş/ Timiş	29.87	58.05	1,722457
13	Orţişoara/ Timiş	26.53	51.8	1,930147
14	Giarmata/ Timiş	28.4	54.7	1,82803
15	Maşloc/ Timiş	29.82	57.69	1,733355
16	Buziaş/ Timiş	30.91	59.8	1,672136
17	Lugoj/ Timiş	33.52	65.16	1,534675
18	Cliciova/ Timiş	32.58	66.17	1,511139
19	Bunea Mare/ Timiş	32.12	65.58	1,524778
20	Coşteiu de Sus/ Timiş	41.94	82.1	1,088365
21	Hăuzeşti/ Timiş	45.28	95.04	1,052145
22	Vişag/ Timiş	31.73	62.25	1,606426
23	Tirol/ Caraş-Severin	36.91	79.84	1,252366
24	Forotic/ Caraş-Severin	35.66	70.98	1,408844
25	Oravița/ Caraş-Severin	41.07	83.36	1,247031
26	Naidăş/ Caraş-Severin	33.59	66.53	1,502873
27	Sasca Montană/ Caraş-Severin	44.55	98.22	1,01803
28	Recaş/ Caraş-Severin	37.4	89.43	1,387996
29	Caransebeş/ Caraş-Severin	35.63	73.67	1,500914
30	Bucova/ Caraş-Severin	52.61	125.68	0,795668
31	Borlova/ Caraş-Severin	52.08	118.02	0,847276
32	Pârvova/ Caraş-Severin	45.06	72.79	0,709541
33	Bozovici/ Caraş-Severin	32.91	68.68	1,455927

34	Băile Herculane/ Caraş-Severin	35.38	77.98	1,447677
35	Topleț/ Caraş-Severin	36.04	70.2	1,274554
36	Moldova Veche/ Caraş-Severin	30.79	59.3	1,686183
37	Berzasca/ Caraş-Severin	30.53	58.81	1,700252
38	Dognecea/ Caraş-Severin	42	91.41	1,093951
39	Anina/ Caraş-Severin	44.92	94.83	1,160933
40	Văliug/ Caraş-Severin	69.68	203.69	0,490937
41	Semenic/ Caraş-Severin	86.64	334.2	0,299222
42	Brebu Nou/ Caraş-Severin	52.66	120.17	0,832089
43	Rusca Montană/ Caraş-Severin	60.12	127.67	0,783244
44	Poiana Mărului/ Caraş-Severin	58.5	145.83	0,685703
45	Cuntu/ Caraş-Severin	74.71	256.95	0,389179
46	Vf. Țarcu/ Caraş-Severin	90.68	2357.75	0,042413
47	Gârnic/ Caraş-Severin	44.1	94.21	1,061392
48	Bigăr/ Caraş-Severin	33.43	64.98	1,538908
49	Eibenthal/ Caraş-Severin	33.24	64.01	1,562048

The international interpretation of these values is:
For De Martonne indicator: 0 < A < 5 – arid climate, 5 < A < 20 – half-arid climate, 20 < A < 30 – half-wet climate, A > 30 wet climate.
For Lang indicator: 0 < L < 20 – arid climate, 20 < L < 40 – Mediterranean climate, 40 < L < 70 – half-arid climate, L > 70 – wet climate.
For D.R. indicator: 0 < D.R. < 2 – wet climate, 2 < D.R. < 3 – half-wet/ half-arid climate, 3 < D.R. < 6 – arid climate, D.R. > 6 – desert climate. [4, 11]
With the help of the previous table were realized some maps at NUTS V level.

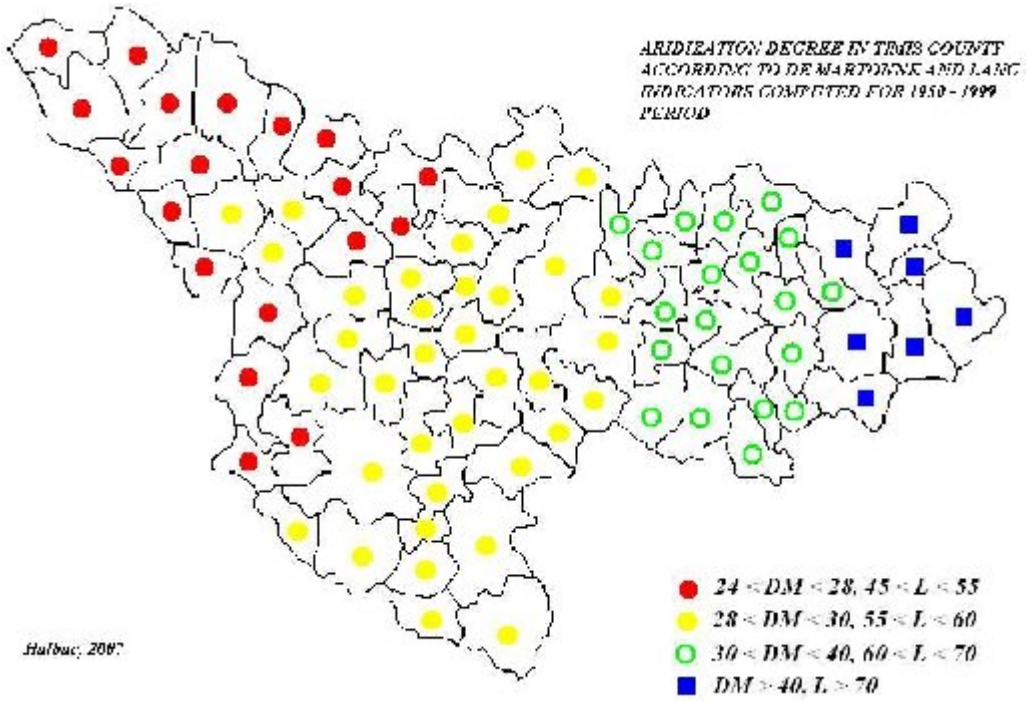

Fig. 4 Aridization degree in Timiş County according to De Martonne and Lang indicators

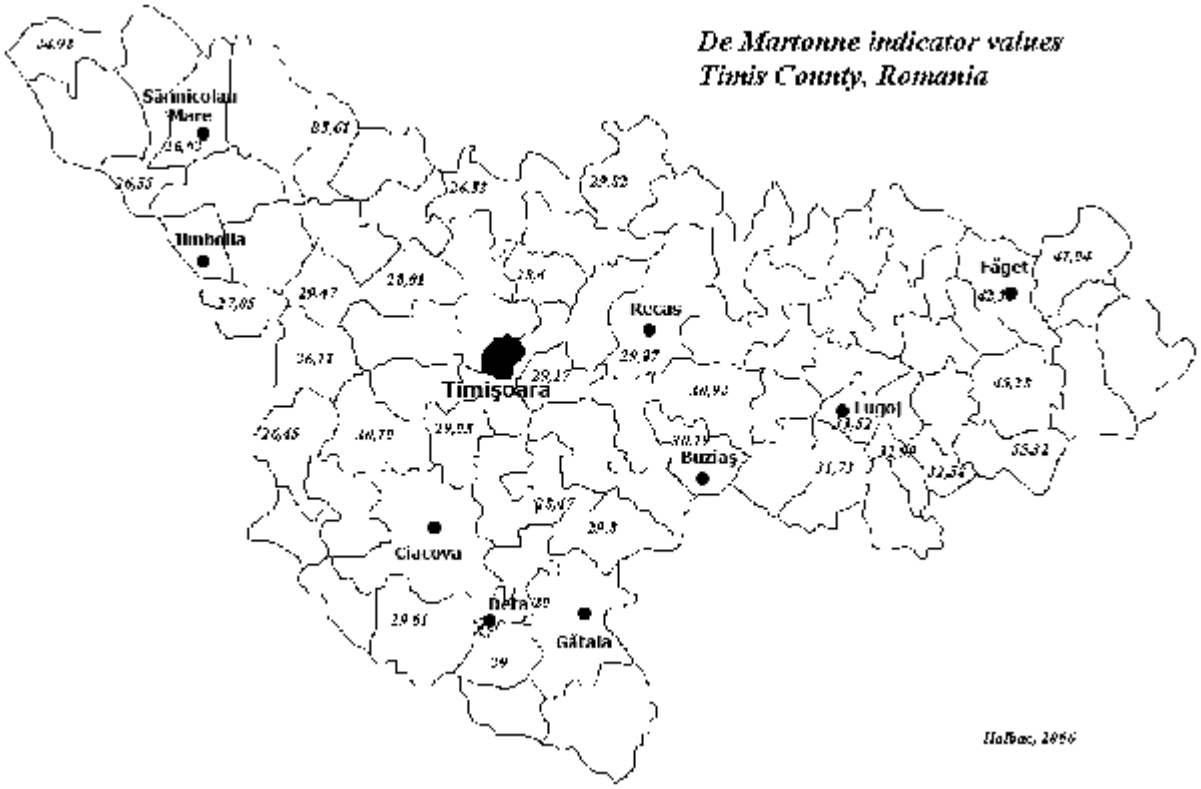

Fig. 5 De Martonne indicator values for Timiş County (1951 – 1999)

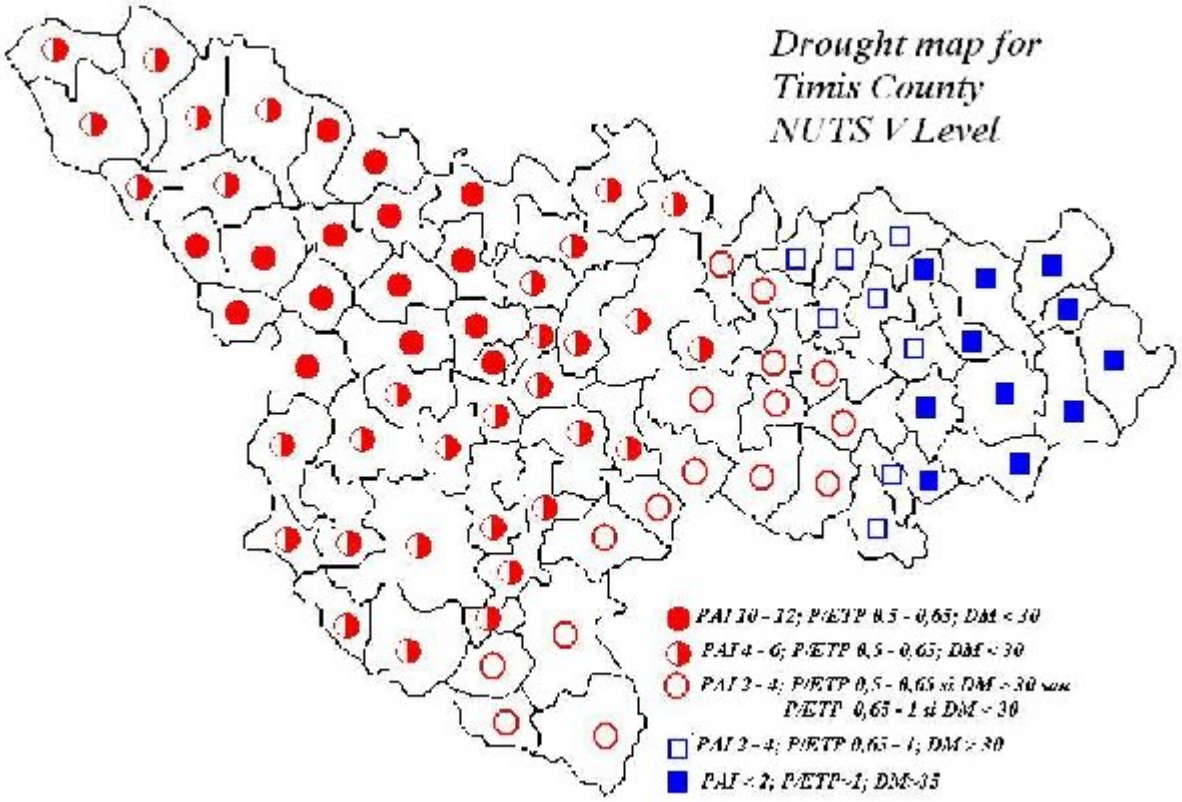

Fig. 6 Drought and aridity map for Timiş County according to P.A.I., P/ETP and DM indicators

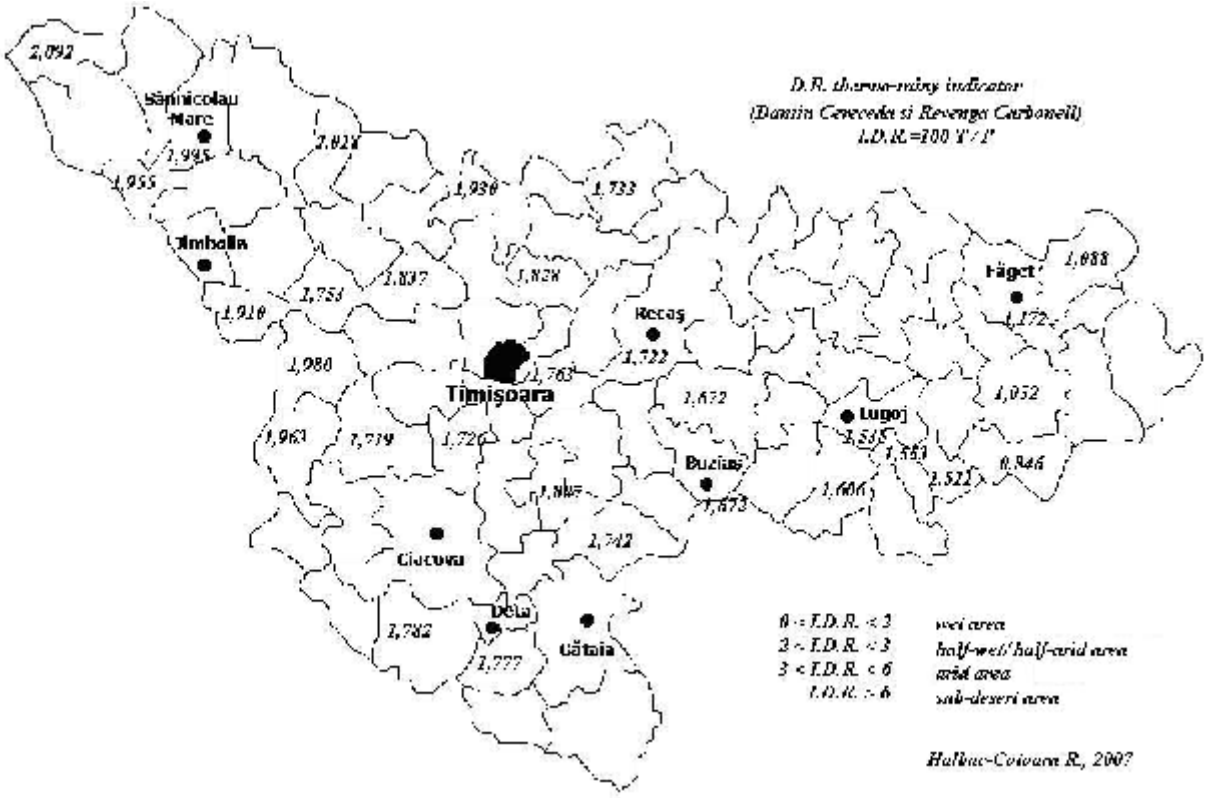

Fig. 7 Aridity map for Timiş County according to D.R. indicator

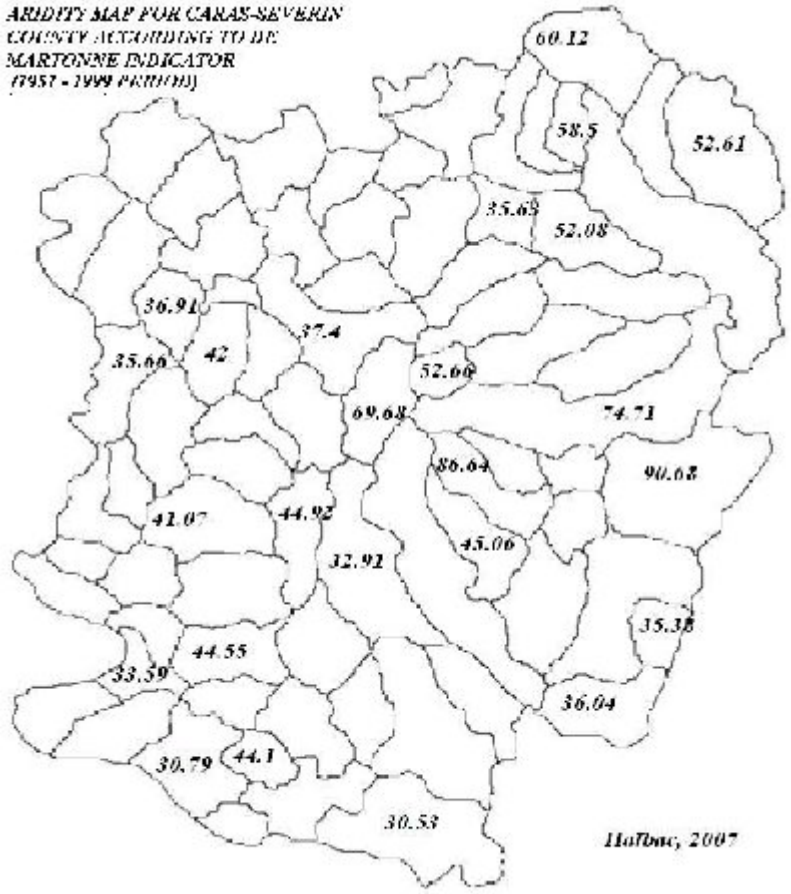

Fig. 8 Aridity map for Caraş-Severin County according to De Martonne indicator

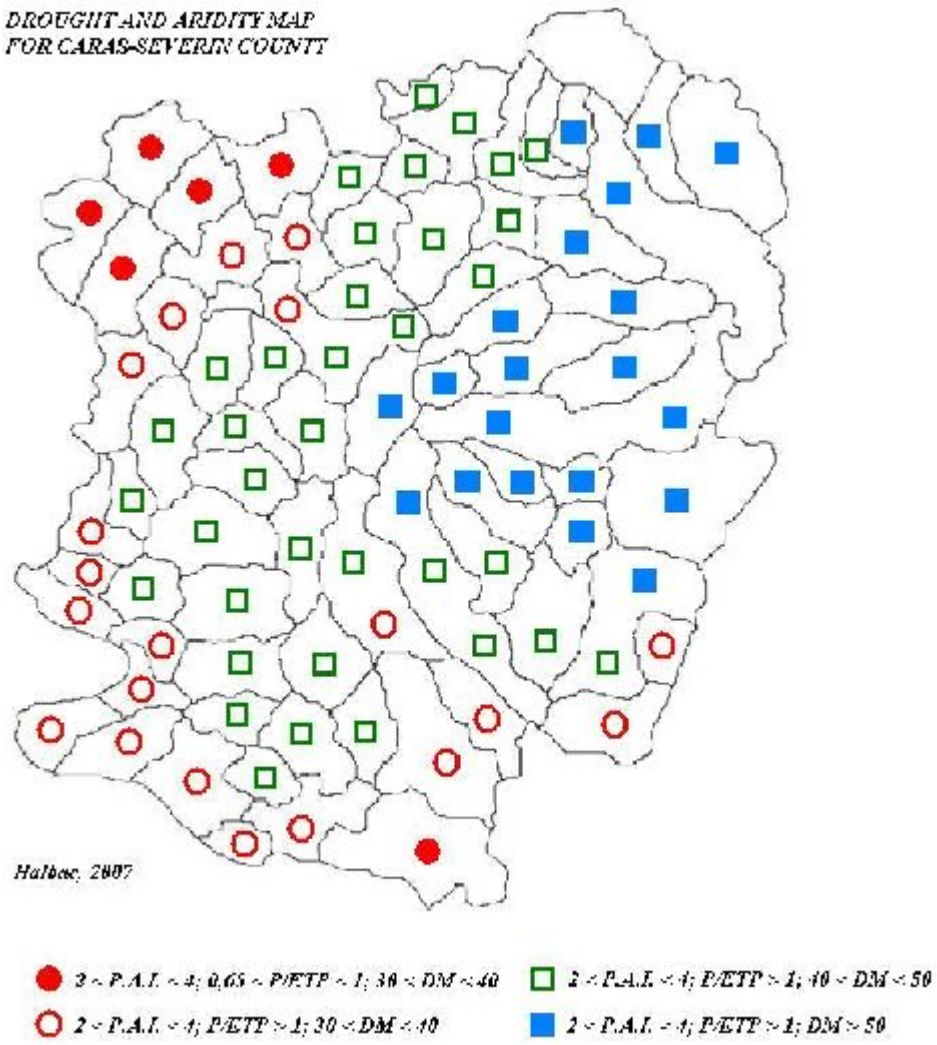

Fig. 9 Drought risk and aridity map for Caraş-Severin County

For Timişoara area, the climatologically analyzes identify many droughty years (on different degrees) during the last two decades. However, the climate tends to aridity followed by drought installation.
The analyzes of 1986-1989, 1991-1993, 2000 – 2004 periods according to Hellman criterion and N. Topor indicator for Timişoara area in presented in the following table:

Table 2 The characterization of Timişoara's area climate according to Hellman criterion and N. Topor indicator for 2000 - 2004 period

1986	N=3	P=4	S=5	I_a=0,846	Less drought year
1987	N=1	P=4	S=7	I_a=0,6	Very drought year
1988	N=2	P=4	S=6	I_a=0,714	Drought year
1989	N=2	P=4	S=6	I_a=0,714	Drought year
1991	N=3	P=4	S=5	I_a=0,846	Less drought year
1992	N=2	P=2	S=8	I_a=0,333	Excessive drought year
1993	N=1	P=3	S=8	I_a=0,411	Very drought year
2000	N=1	P=0	S=11	I_a=0,043	Exceptional drought year
2001	N=2	P=5	S=5	I_a=1	Less drought year
2002	N=7	P=2	S=3	I_a=0,79	Drought year

2003	N=3	P=3	S=6	I_a=0,6	Severe drought year
2004	N=2	P=7	S=3	I_a=2	Less rainy year

Where $I_a = \frac{N+2P}{N+2S}$, N is the number of normal months from precipitation point of view according to Hellman criterion, P is the number of rainy months and S the number of droughty months.

Also, are very representative the following graphs which are presenting the variation of water table levels in comparison with precipitation volumes from different decades. The studies were realized for some communes situated in Timiş County.

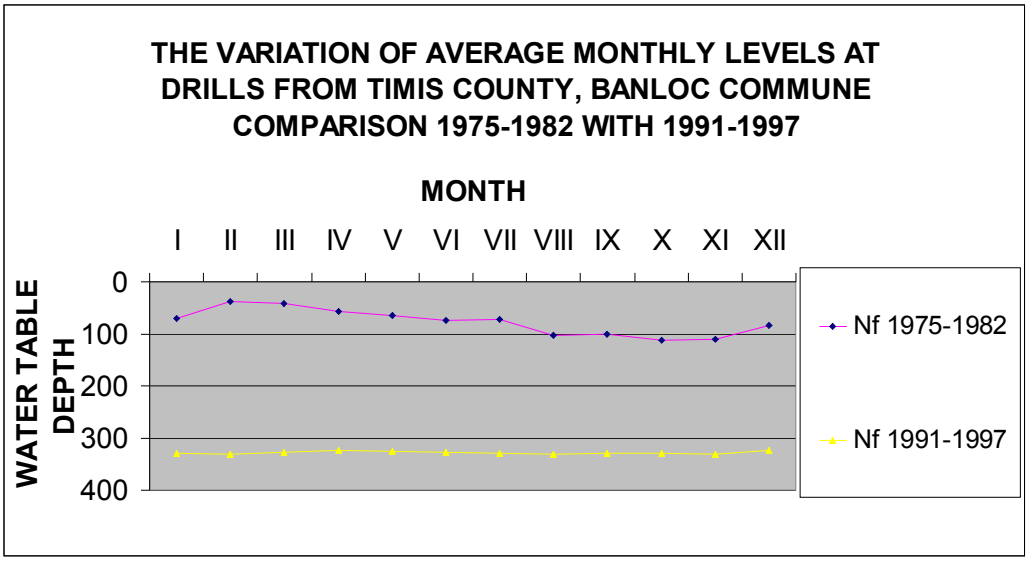

Fig. 10 The variation of average monthly levels of water at drills from Timiş County, Banloc Commune (a comparison 1975-1982 with 1991-1997)

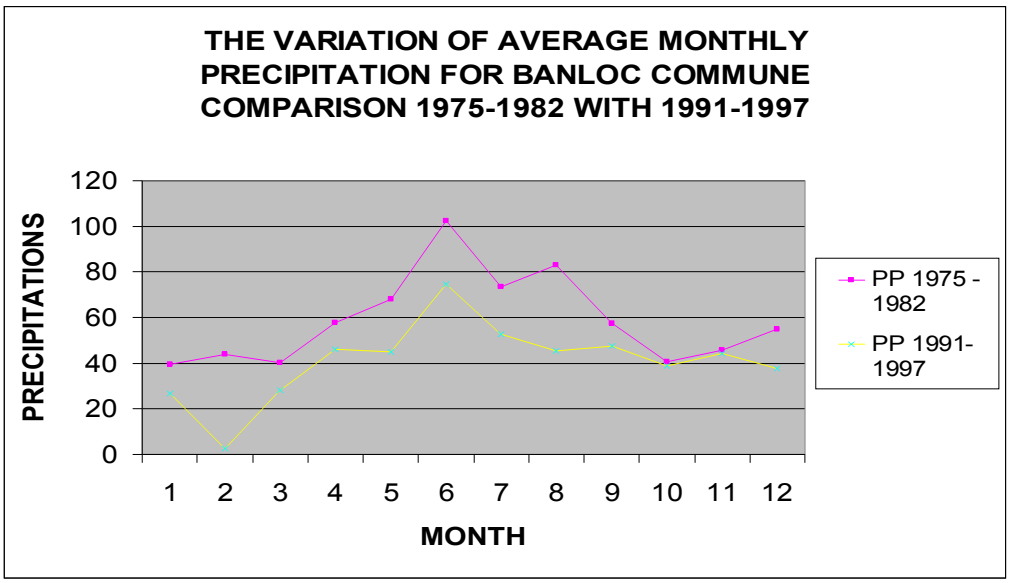

Fig. 11 The variation of average monthly precipitations quantities [mm] for Banloc Commune (comparison 1975-1982 with 1991-1997)

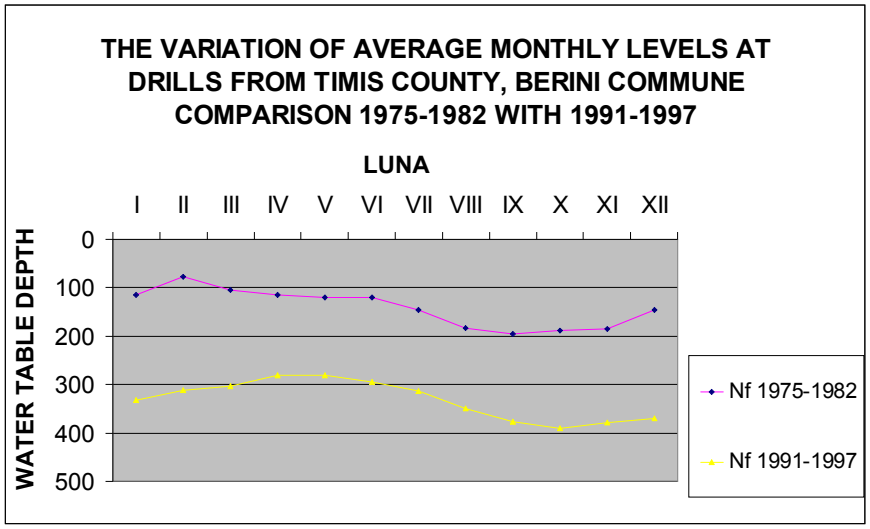

Fig. 12 The variation of average monthly levels of water at drills from Timiş County, Berini Commune (a comparison 1975-1982 with 1991-1997)

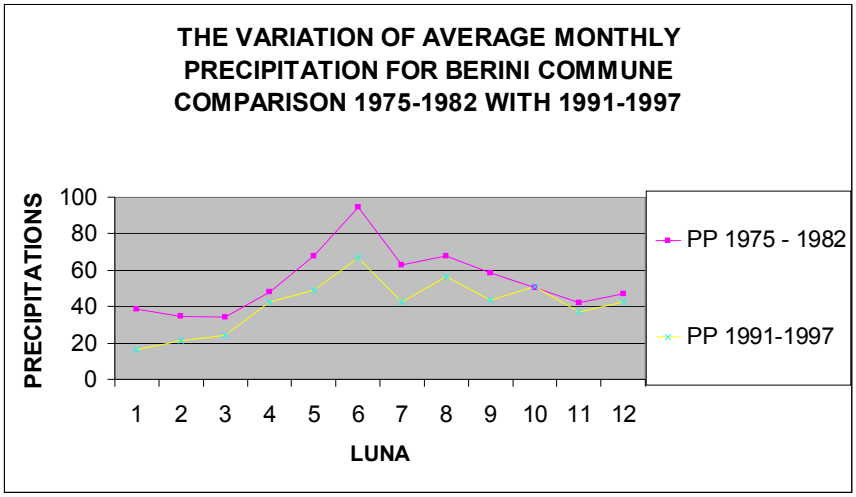

Fig. 13 The variation of average monthly precipitations quantities [mm] for Berini Commune (comparison 1975-1982 with 1991-1997)

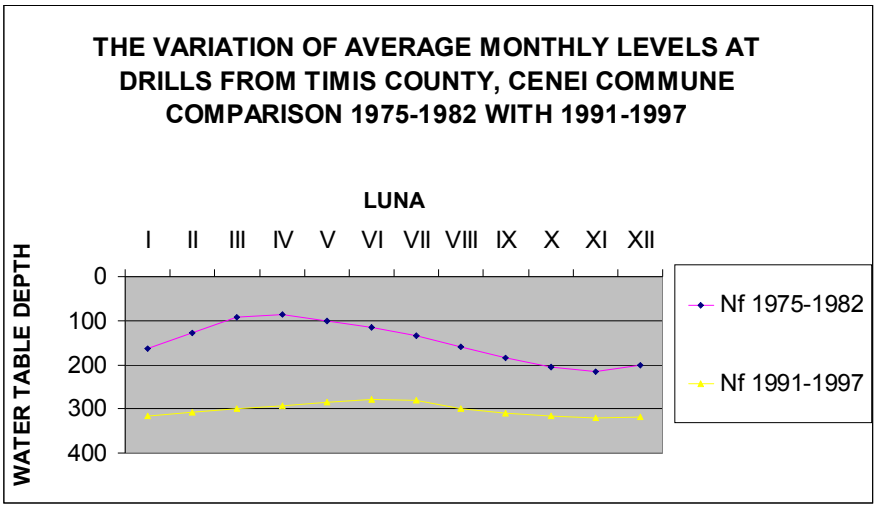

Fig. 14 The variation of average monthly levels of water at drills from Timiş County, Cenei Commune (a comparison 1975-1982 with 1991-1997)

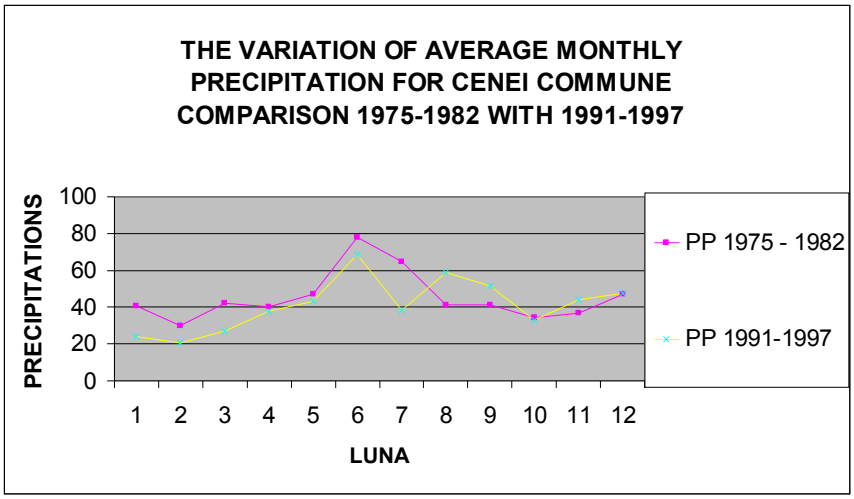

Fig. 11 The variation of average monthly precipitations quantities [mm] for Cenei Commune (comparison 1975-1982 with 1991-1997)

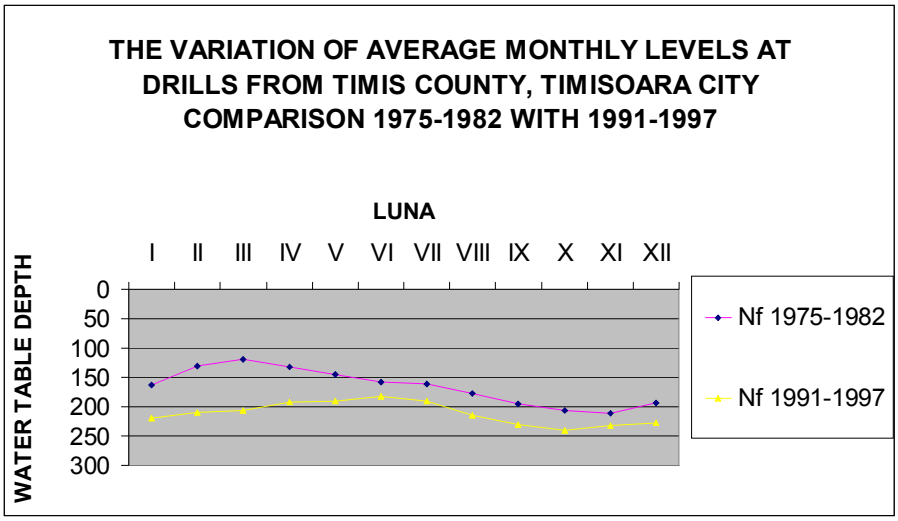

Fig. 16 The variation of average monthly levels of water at drills from Timiş County, Timişoara City (a comparison 1975-1982 with 1991-1997)

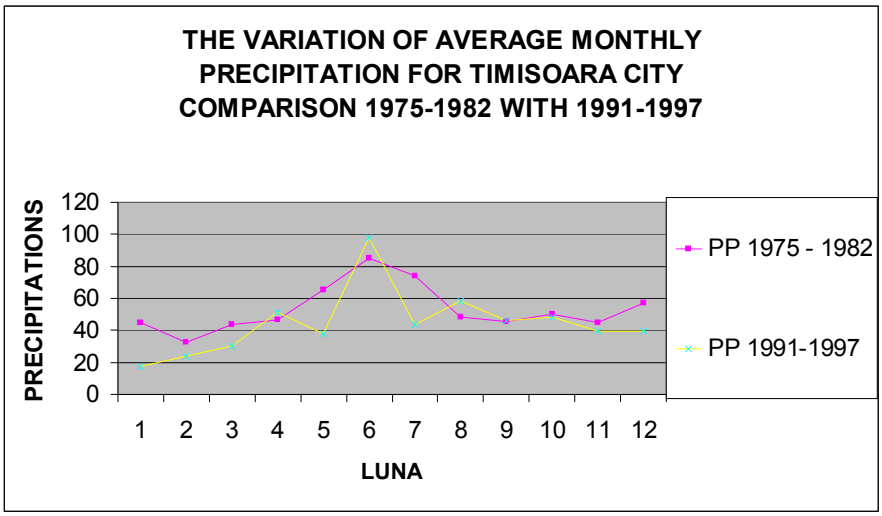

Fig. 17 The variation of average monthly precipitations quantities [mm] for Timişoara City (comparison 1975-1982 with 1991-1997)

4 ROMANIA'S LEGISLATION REGARDING WATER SCARCITY

In the Romanian national strategy regarding drought effects mitigation, the prevention and struggle of land degradation and desertification, on short, medium and long term (January 2008 version), the first definition, incomplete, of drought appears at the page 40 (the entire document has 61 pages). According to this strategy, drought can be operational defined as water scarcity situation in comparison with necessities of population and national economy branches, which creates discomfort and affects the social-economical activities, also having a negative impact upon other environment factors. In this sense we can conclude that drought can be a result of water pollution, resulting in relative small volumes of fresh water which can be used by population or by economy. This definition doesn't mention if drought is a natural or a human induced phenomenon, if it is a long or a short term phenomenon and is referring to a water deficit (water scarcity). At page 52 I found another interesting conclusion: "drought mustn't be considered only as a natural physical phenomenon. Its impact on the society is the result of an interrelation between a natural phenomenon (low volume of precipitations) and an anthropic process (local population water necessary)". In this case the error appears very clear. Drought is a strict natural phenomenon, recurrent, represented in the first place by a deficiency regarding precipitation quantities. The anthropic process, corroborated with a natural phenomenon (aridity or drought), conduct to the appearance of desertification or water shortage (depending of the phenomenon deployment in time – permanent or temporary). The impact is a situation, a perception of drought effects upon human physiology and psychology. It is true that drought may affect the population in many ways but the impact must be analyzed at regional or even local level because it's depending on many factors as water demands, water storage capacities, water use management, etc. The anthropic pressure creates the perception of hazard or disaster for the drought impact on society and doesn't create drought but increase the impact of the natural phenomenon. The continuous population growing is only one factor which makes us to percept drought as a disaster. We must be able to differentiate phenomenon as aridity and drought, desertification and water shortage because they present different time scales of manifestation and they presume different ways to manage them.

In the Romanian national strategy regarding drought effects mitigation, terms as risk and vulnerability appear even from beginning but without any explanation or definition. Also another important term in drought management is "hazard". What are representing these terms? The term of "hazard" represents what are the chances to occur a potential event with a high grade of damaging, in this case the possibility to appear an imbalance between water demands a and water supply. We are referring here strictly from natural phenomenon point of view. The Romanian legislation tackles this point with the help of statistical records. Vulnerability is given by several "symptoms", symptoms which are given by the phenomenon impact on the social life, economy sectors and environment resources. These symptoms can be translated as effects of the given phenomenon. We can say that, according to the previous phrases, that vulnerability represents the level of losses which result from a phenomenon with a damage potential. Can comprise terms as exposure (or how badly can be stroke by this phenomenon) and resistance (or the capacity to absorb the negative, destructive effects). Our national strategy presents this term classified in two types: "external" vulnerability which aim the drought influence on system's

input, more precisely on the water availability at source, and “internal” vulnerability which says that some systems are modifying there own risk level as result of management applied or because of inadequate strategies and technologies. The risk represents the quantification of the hazard and vulnerability. More accurate, it expresses the level of losses which are expected because of a hazard on a specified surface during a precisely period of time.

All the elements conduct us to the conclusion that drought, as singular element, is not a disaster, but can become one if the effects of this phenomenon presents a highly damage potential. Donald A. Wilhite says: “Drought by itself is not a disaster. Whether it becomes a disaster depends on its impact on local people and the environment. Therefore, the key to understanding drought is to understand both its natural and social dimensions.[...] We use the term hazard to describe the natural phenomenon of drought and the term disaster to describe its negative human and environmental impacts”. Droughts can also be defined according to the operation aspects. In this case we have meteorological, agricultural and hydrological droughts, each of them being based on a prime indicator which can be represented by precipitation, soil moisture, etc. It is obvious that we can give more complex definitions by taking in consideration a large scale of variables. This type of operation definition regarding drought phenomenon is given and by the Romanian legislation, being also presented some statistics and possible correlations between these operational types. Anyway, we can see that a generally fully and accurate definition of drought phenomenon is very difficult to be given because of the large aspects which comprises (it is a strong interdependence between a large scale of variables as climate, geological and geomorphologic situation) but we can adopt drought definitions for specific areas where intervene specific factors.

Another important issue debated or analyzed by the specific legislation is the problem of management. In order to manage a phenomenon, we must first define it and understand it, than we must see how this phenomenon deploys in our space and which factors intervene in its appearance and deployment.

The problem of drought management is a very complex one and must be carefully and precisely analyzed. The Romanian national strategy regarding drought effects mitigation, the prevention and struggle of land degradation and desertification, on short, medium and long term (January 2008 version) dedicates only 3 pages to a subchapter called „Actions, organizations, strategies and programs at national, European and international level”. Surprising, none of the Water Scarcity and Drought Reports are mentioned even these documents were realized by the European Commission. Also, I must mention the Mediterranean Water Scarcity and Drought Report Technical report on water scarcity and drought management in the Mediterranean and the Water Framework Directive, our country being much closed to the Mediterranean space.

Romania also adopted the Water Framework Directive but in our strategy regarding drought, this phenomenon is not analyzed in the context of WFD. It is true that in the Romanian documents appear a specification which says that a precisely directive or strategy regarding drought it wasn’t elaborated but as you can previously read, our national strategy should mention the existence of two draft documents (these documents include references about Romania). In drought planning and management is very important to make the difference between transitory periods of water deficiency, a cause of exceptional drought and long term imbalances available resources/demands

5 CONCLUSIONS

The climatic changes, drought, aridity, desertification and water scarcity are interconnected but these phenomenon should not be confused. The permanent water scarcity is connected with aridity and drought as natural phenomenon while a not sustainable use of available resources, the missing of a proper water management can take us to the desertification appearance, effect of a major and negative anthropic pressure.

In Timiş and Caraş-Severin counties, the massive appliance of surface drainage works few decades ago, together with a continuous degradation of irrigation arrangements, amplified the aridization phenomenon which had installed during the last years provoking the frequent manifestation of drought. The western part of Timiş County which till three decades ago, during droughty periods, presented very good conditions for plants growing, is now under the influence of aridity phenomenon because of climatic changes (a continuous heating phenomenon) and frequently is suffering because of drought, one of the causes being the practicing of an intensive drainage till 1990 decade. Caraş-Severin County presents a better situation being situated on high relief forms without being totally outside the influence of these water scarcity phenomenons.

Drought management plans must be realized before they are needed, they must have a solid base of specific and efficient legislation and must be the result of professional studies concerning drought definition, its effect and mitigation measures. Because it is a close link between water resources and drought phenomenon, the drought managements must be founded in any legislation, as an essential element of national water resources policy and strategies.

The Romanian national strategy regarding drought effects mitigation, the prevention and struggle of land degradation and desertification, on short, medium and long term is still in a very primary form and must be improved in order to have success in drought effects mitigation.

Also, if after 2005 we succeeded in realizing a handbook for local authorities regarding flooding problems, a similar material being necessary now but regarding drought in special and water scarcity in general.

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