THE VARIABILITY OF RAINFALL REGIME, INDUCED BY CLIMATE CHANGES, IN DOLJ COUNTY AND IT IMPACT ON THE ENVIRONMENT

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ABSTRACT. – The Variability of Rainfall Regime, Induced by Climate Changes, in Dolj County and Its Impact on the Environment. Climate change is now widely recognized as an actual fact: temperatures are rising, rainfall patterns are changing, glaciers and snow melts, and average global sea level rises. We expect these changes to continue and extreme weather conditions that lead to risks like floods and droughts to become more frequent and increase their intensity. Drought and phenomena associated with it, namely aridization (lowering excessive groundwater level) and desertification (reduced area of ground covered by vegetation and a considerable depletion and soil erosion) represents, after pollution, the second largest problem facing humanity, currently affecting all regions of the globe. In Dolj County, the area between Calafat-Poiana Mare-Sadova-Bechet-Dăbuleni and the Danube, covering about 104 600 hectares, represents the most typical aspect of semi-arid zone with accents of aridity and even desertification in Romania, the phenomenon being favored by the presence of sandy soils. In Dolj County, there may be seen an important manifestation of climate change on the rainfall regime: increasing linear trend especially in the northern part of the county compared to the extreme south of the country, where atmospheric circulation interaction with local relief conditions,often causes diminishing rainfall..

Keywords: Climate change, drought, rainfall, floods, aridity.

1. INTRODUCTION

For Dolj County the total area is 7414 square kilometers and represents 3.1% of the country. Temperate climate characterizes Dolj County, with Mediterranean influences due to the south – western location. The position and the lowland character of the land it occupies, near the curve of the Carpathian-Balkan mountain range, determine, overall, a warmer climate than the central and northern part of the country, with an annual average air temperature of 10-11.5 °C. Climate change is the greatest environmental threat facing humanity. Global warming is an urgent threat, because in the past decade there have been nine of the warmest ten years in the history of climate data records. Thus, according to the State Report on the Environment Report in 2013, catastrophic climate changse can be avoided only if the industrialized countries transform rapidly their economies in "green" economy,

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effective in terms of resource use, and poorer countries follow an sustainable development path, with international financial and technological support.

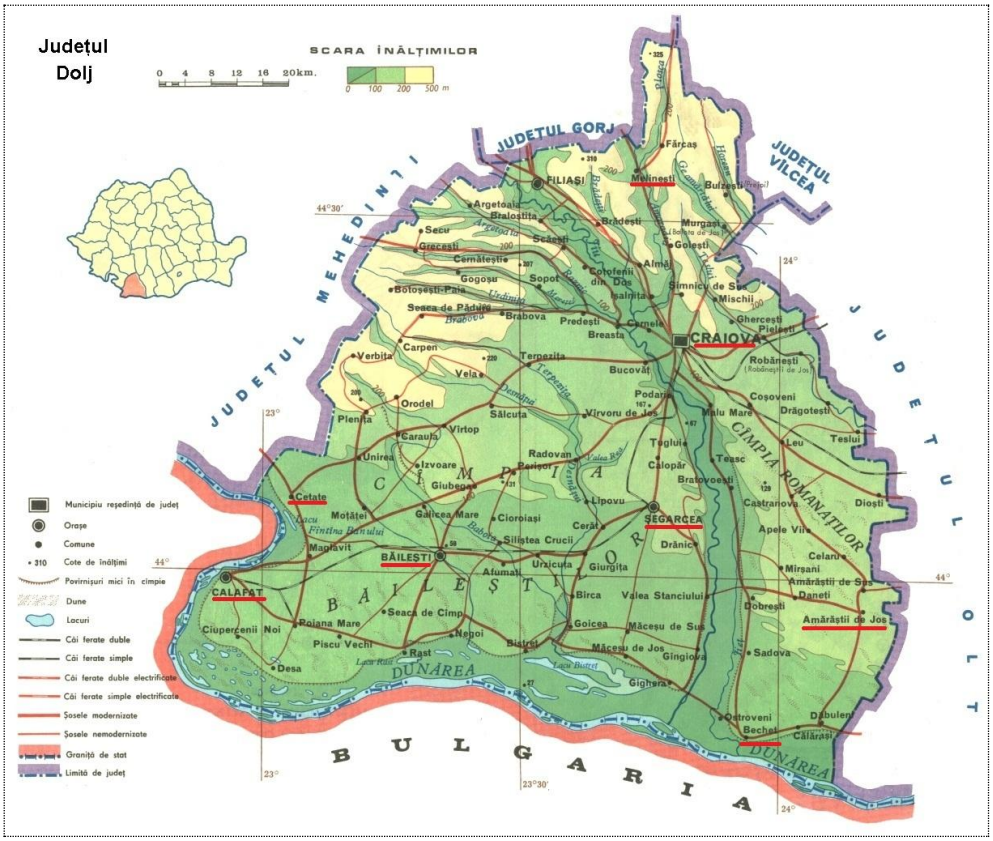

Fig. 1. ***Physical map Dolj County (weather stations and rainfall stations are underlined in red; based on the Geographical Atlas of Romania)***

2. DATA AND METHODS

Meteorological data come from weather stations (Craiova, Băileşti, Calafat and Bechet, and rainfall stations with long strings of data: Amărăştii Lower Citadel Melineşti, Segarcea) located in all steps of the county relief (Table 1, Fig . 1). **The data of rainfall covers a 54 year period from 1961-2014.**

Research methods. For complex analysis of climate risk phenomena related to rainfall in Dolj county as drought, dryness, excess humidity, torrential rain, hail, etc., there were used classical data processing methods as well as modern ones, mainly used in recent years both internationally and nationally in climatological research. The methods employed were the deductive and inductive method of analysis, comparison, and statistical and mathematical methods and graphs. Among the methods of processing and data interpretation for precipitation,

Table 1. ***Meteorological stations and rainfall stations in Dolj County (weather stations are marked with*** *).*

No.	Meteo station (county)	Indicative	Coordinates		Observations compact period	Altit. (m)	Starting of obs. period
			latitude	longitude			
1	Cetate (DJ)	406303	44°06`N	23°03`E	1961-2014	25.0	1961
2	Bechet*(DJ)	15494	43°47`N	23°57`E	1961-2014	35.9	1961
3	Băileşti*(DJ)	15465	44°01`N	23°21`E	1961-2014	57.0	1961
4	Calafat*(DJ)	15482	43°59`N	22°57`E	1961-2014	61.0	1904
5	Amărăştii de Jos (DJ)	357410	43°57`N	24°10`E	1961-2014	118.0	1961
6	Segarcea (DJ)	406345	44°06`N	23°45`E	1961-2014	145.0	1961
7	Melineşti (Dj)	434343	44°34`N	23°43`E	1961-2014	151.0	1961
8	Craiova*(DJ)	15450	44°14`N	23°52`E	1961-2014	192.0	1881

there are the method of calculating the averages, frequencies and insurance, standardized anomaly of precipitation for illustrating the excess and the deficit, the rainfall trends (linear and polynomial regression) for temperature and precipitation, the coefficient of variation.

3. RESULTS

3.1. Characteristics of rainfall

The average precipitation amounts for this period of 54 years (1961-2014) (taking into account both weather and rainfall stations) were between 510.4 mm at Segarcea and 646.8 mm at Melineşti (northern part of the county), with an average of 576.3 mm for the entire county. At the meteorological stations, the annual average ranged between 522.9 mm in the extreme south of the county and 604.3 mm in Craiova - the northernmost county weather station located in the southern hills. This distribution complies with the altitudinal zoning in the territory, while the distribution based on the data from the rainfall stations no longer agrees with this zoning due to missing data in the long-term data records. The mean annual rainfall amounts calculated for the entire region with data from meteorological stationswas 557.4 mm (Table 2).

The minimum annual quantities of rainfall recorded in this interval ranged from 262.7 mm (registered at Băileşti in 1992) and 407.2 mm recorded at Cetate in 1961. Tha analysis based on data from weather stations shows that minimum amounts of rainfall ranged between 262.7 mm (at Băileşti, in 1992) and 303.6 mm (recorded at Bechet in 2000); the years 1992 and 2000 were the driest years of the analyzed interval which corresponds perfectly with the reality of climate(same contradictory situation we encounter in analysis of annual rainfall maxima if we take into consideration the rainfall stations whose data shows the lack of data intervals). Average annual rainfall for the entire county (calculated only with data from weather stations) was 279.6 mm.

Table 2. ***The minimum annual, the mean annual and the maximum annual rainfall (mm) in Dolj County (Hm = altitude meteorological station / post precipitation, / year = Year, the weather stations are marked with*** *.

No.	Meteo (Pluvio) station	H (m)	Min./Year	Average	Max./Year
1	Cetate	25.0	**407.2**/61	614.0	859.0/05
2	Bechet*	35.9	303.6/00	522.9	***840.9***/14
3	Băileşti*	57.0	***262.7***/92	566.1	1032.8/14
4	Calafat*	61.0	258.8/00	536.4	979.1/14
5	Amărăştii de Jos	118.0	366.8/62	609.2	956.8/05
6	Segarcea	145.0	315.1/83	***510.4***	869.4/05
7	Melineşti	151.0	383.8/11	**646.8**	959.7/05
8	Craiova*	192.0	293.3/92	604.3	**1147.2**/14
	Dolj county average		323.9	576.3	955.6
	Dolj county (Meteo st.) average		279.6	557.4	1000

The annual precipitation maxima, based on data from weather stations, ranged between 840.9 mm at Bechet and 1147.2 mm at Craiova and they were recorded in the wettest year in this period in 2014 (Table 2). Average annual rainfall maxima calculated for the whole county was 1000 mm and it was also recorded during the rainy year 2014.

The main maximum in the annual rainfall is observed mainly between April to July and the values range between 215.5 mm at Calafat and 256.1 mm att Craiova, representing from the annual average percentage values between 29.7% for Bailesti and 42.4% for Bechet and Craiova. (Table. 2). The main maximum average rainfall for the whole county is 229.8 mm which represents 41.2% of the annual average for the region. It is observed during the period of the year when the vegetation cover and crop plants have the highest water requirements. The secondary maximum annual precipitation is observed during October-December and ranges between 121.6 mm at Bechet and 142.0 mm at Craiova, representing ,from the annual average percentage, values between 23.2% at Bechet and 25.0% at Calafat. The county-averaged mean value of the secondary maximum rainfall is 134.4 mm which represents 24.1% of the annual average for the region. It is recorded during the agricultural campaign for autumn sowings which contributes to good conditions for the start of the agricultural year. The minimum annual rainfall is recorded during the period January - March and ranges between 101.6 mm at Bechet and 116.9 mm at Băileşti, representing, from the annual average percentage, values between 18.9% at Craiova and 20.7% at Băileşti.

The mean minimum annual rainfall is 110.4 mm for the whole county, which represents 19.8% of the annual average for the region. It helps to maintain soil water reserve and also stimulates drainage of excess water from certain areas of land where it occurred. Absolute maxima for 24 hours rainfall recorded at the four meteorological stations were 98.2 mm recorded on 8.VII.1970 at Bechet,; 83.8 mm recorded on 3.VII.1979 at Băileşti; 77.8 mm recorded on 28.VII.2014 at Calafat; 84.8 mm recorded

on 27.VII.1972 at Craiova. It may be seen that during July there were recorded the highest amounts of precipitation within 24 hours at all weather stations in Dolj county, which shows that July is the most unstable month of the year, when torrential rains reach their maximum amounts in 24 hours. There should be noted also that 11 records (highest amounts) were observed after 2003, and 4 of them were registered in 2014, which means an increase in the intensity of heavy rains in the last 12 years.

The annual quantities of rainfall recorded in Dolj during this long interval present a large variability. Thus: at Bechet, the annual rainfall ranged from 303.6 mm (recorded the driest year – 2000) and 840.9 mm (in the wettest year recorded - in 2014) (Fig. 2). As it can be seen, during the period analyzed there are outlined three sub-periods: the first, for the years 1961-1980, when surpluses prevail, the second, during 1981-2001, when the amounts where mostly low, and the last, (2002-2014), with values well above normal, especially in 2005 and 2014.

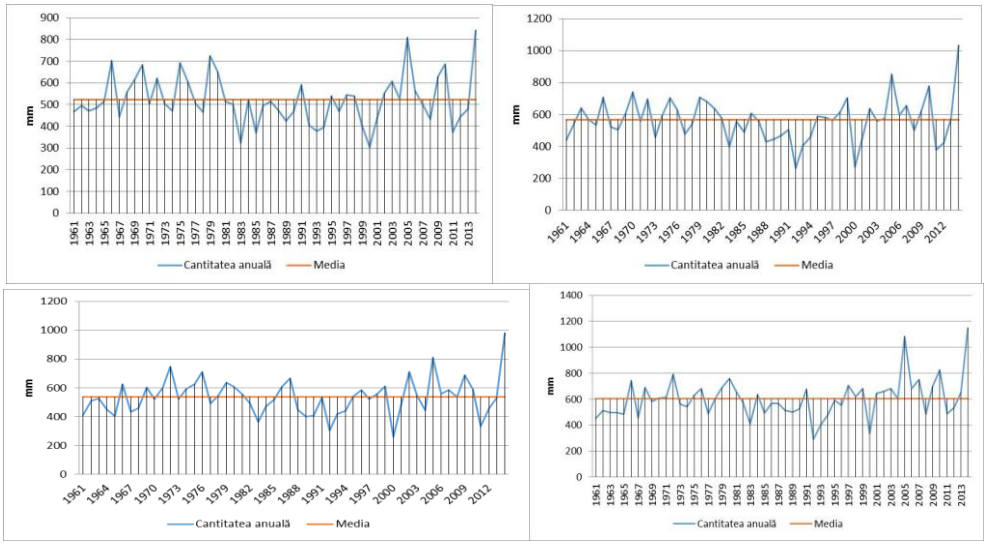

Fig. 2. ***Quantities of rainfall at Bechet, Băileşti, Calafat and Craiova stations recorded between 1961-2014***

At Băileşti , the annual rainfall ranged from 262.7 mm recorded the driest year - 2000 and 1032.8 mm in the wettest year recorded in 2014 (Fig. 2). Even if the three periods in question do not appear so obvious as to Bechet, they are visible. It may be seen, in particular, the excess period 2002-2014, when the maximum mount mentioned before was recorded. It is the first year when the threshold of 1,000 mm Băileşti station is exceeded.

In Calafat, the annual rainfall ranged from 258.8 mm, recorded the driest year - 2000 to 979.1 mm in the wettest year recorded in 2014 (Fig. 2). Even if the quantity of 1000 mm is not exeeded during the wettest year, at Calafat station there still can be observed a slightly upward linear trend of annual precipitation amounts compared to previous stations. where such a trend can not be seen.

In Craiova, the annual rainfall ranged from 293.3 mm in the driest year - 2000 to 1147.2 mm in the wettest year recorded in 2014 (Fig. 2). The trend is clearly an upward one in the northern part of the county as a result of the surplus quantities in the last period (2002-2014).

3.2. Trends in annual precipitation amounts

The graphs of variation of annual rainfall amounts in Dolj county weather stations (Fig. 3) show significant increasing linear trend with one exception - Bechet meteorological station, where the trend is slightly decreasing, the coefficient of the decrease being -0.0687 (Fig. 3). For Băileşti and Calafat stations, there is a slightly upward linear trend (Fig. 3).

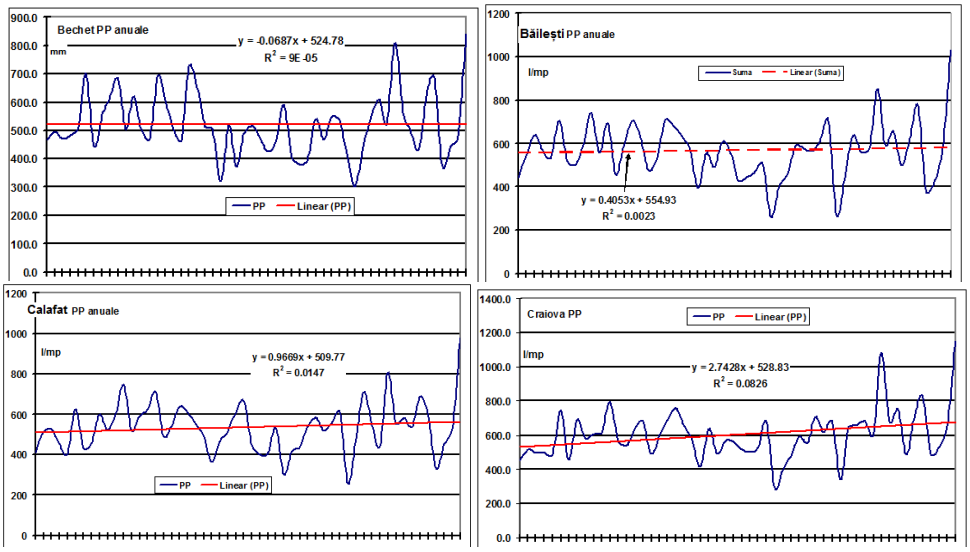

Fig. 7. ***Change in annual rainfall amounts between 1961-2014 Bechet, Băileşti, Calafat and Craiova stations.***

The most pronounced upward trend is found at the meteorological station in Craiova, for which the increment is 2.7428 (Fig. 3). This is explained by the very low quantities during the period 1981-2001 followed by well above the normal amounts for the period 2002-2014, the average of which is about 110 mm higher than normal whole period; for the other weather stations, positive deviation from the mean of this period is between 50 and 70 mm of the normal. One can observe an important manifestation of climate change in precipitation: strong linear trend upwards in nearly all weather stations except in the extreme south of the county where the interaction of atmospheric circulation relief with local conditions often causes diminishing rainfall. In Craiova, where meteorological station is located in the southern hills, the atmospheric circulation interaction with local relief conditions frequently causes intensifying rainfall.

3.3. Impact of environmental variability rainfall

Agriculture is the economic sector most vulnerable to drought, hail, excessive rain, etc. In the county of Dolj during 2013 there were very high temperatures in July and August, specialists in agriculture saying that during this year the crops were undermined both by drought and because the irrigation system in Dolj was destroyed. According to data published by the Department of Agriculture Dolj (http://www.editie.ro) from 2009 to 2013, the area cultivated with wheat constantly increased. Compared with autumn 2013, in autumn 2014 because of prolonged heavy rains, wheat was cultivated only on 162 439 ha surface, representing 88.4% of the programmed area, also, melons were cultivated on 21 635 hectares less than in the autumn of 2013.

The melon production was higher in 2014, but because of the abundant rain, the crops were affected. The Director of the Department of Agriculture of Dolj noted that the average yields obtained per hectare have shown some variations related to climatic characteristics of the years; the most significant quantitative increase occurred in 2014 because it rained a lot, but sometimes the high amounts of precipitation harmed the crop quality or hindered the harvesting process; the products obtained had suffered from pests and diseases, difficult to combat due to excess rainfall manifested at short-time intervals.

The canola crops have been seriously affected by climate change in recent years. Between the years 2011-2013 due to lack of water during sowing or because there were low temperatures in winter, significantly decreased production was obtained. In the 2009-2010 agriculture year, the canola crop covered 28.872 hectares, and during agricultural year 2013-2014 there were 8260 hectares. In Dolj there is a clear trend towards intensification and expansion of the phenomenon of drought and desertification of natural causes, but also because of anthropogenic factors (deforestation, destruction of irrigation etc.). Flooding is a destructive, natural phenomenon with the greatest frequency in the world. They produce many casualties and property damage. The main causes of flooding are related to climatic conditions, which, due to global warming have altered their characteristics (large amounts of rainfall in a short time, high frequency of rainfall in some years, alternating rainy periods with dry periods, the presence of wind intensification during rains).

5. CONCLUSIONS

Changes of climate characteristics affected extended areas du to their impact on all components of the environment. In the county of Dolj we have found a number of changes in the regime of some key climate parameters, changes that are part of the general trend of climate on the European continent. Climate risks affecting the society are extremely diverse, and their study can not be done based only on generally-valid criteria, because a particular phenomenon becomes a phenomenon of risk according to specific local conditions. Drought, for example, is a phenomenon characterized by different parameters depending on the region. Thus, local studies are of special importance in building a picture of climate change on a local scale.

Dolj County, located in the southern part of Oltenia is a region exposed at certain categories of climate risks, which may manifest during the entire year, like the deficit of rainfall –associated with drought, ore to risks characteristic for the warm semester – like torrential rain, hail, heat waves and so on. Therefore, the determination of evolution trends in temperature and precipitation are important, contributing to the understanding of climate processes. In Dolj County, there may be seen s an important manifestation of climate changes in precipitation regime, namely the increasing linear trend especially in the northern part of the county compared to the extreme south of the country, where atmospheric circulation interaction with local relief conditions, often causes diminishing rainfall.

The most pronounced upward trend is found at the meteorological station in Craiova, for which the increment is 2.7428. In Craiova, where meteorological station is located in the southern hills, the interaction between the atmospheric circulation and local relief conditions often causes the intensification of precipitation. Nevertheless, droughts manifested after rainy periods, and, associated with high temperatures, had an increasingly damaging impact on agriculture. Although the situation seems paradoxical, even the precipitations present an increased tendency, the intensity and duration of droughts is also increasing, which led to the aridization phenomenon manifesting in Dolj county.

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