RAINFALL AND FLOW VARIATION IN CÂLNĂU'S WATERSHED

Diana A. GIURGIU[1]

ABSTRACT. - Rainfall and flow variation in Câlnău's watershed. Changes inflicted on the evolution of climate parameters such as temperature, rainfall, snow depth etc. represent a critical point in conducted studies, because of the increasing number of extreme events from one season to another. At the same time, hydrological aspects must be taken into consideration, because in the river's drainage system significant changes have also been recorded, such as the frequency of reaching or exceeding high flows values on record. The correlation between climate and hydrological aspects shows an overview of how they interact. This helps us analyze feedback processes and how they affect the evolution of a river over a period of time. Duration, intensity and frequency are key characteristics for the analyzed parameter, because they emphasize the response time. The overall objective of the study is two folded. On one hand, it can highlight periods of a year with high or low levels of flow rate, more precisely periods likely or not to produce flood phenomena and their extent: overrunning or not the three levels of alert. On the other hand, there is the situation of identifying the wettest years as compared to the driest ones and the connection with the general context available for Romania for those years, or on the contrary obtaining some local circumstances - specific for Câlnău's watershed. Such an analysis is always welcome, especially for underlining the flood phenomena, which represent a major socio-economic threat, because damage before such dangers are considerable, from crops destruction to deaths among humans.

Keywords: watershed, flow, rainfall, temperature, climate

1. INTRODUCTION

All over the world, social, ecological and economic systems are being affected by the warming of the planet's climate. Nowadays, due to the interaction between the climate system and the hydrological cycle, the impacts of climate change on water resources represents one of the most significant challenges that researches confront with. Patz et al. (2005); IPCC (2007); Howat et al. (2007); Hein et al. (2009); Dai (2010); van der Velde et al. (2012); Smith and Katz (2013); Mearns and Norton (2010); UN (2011) Herrera-Pantoja M. and Hiscock K.M. (2015); Gaňová et al. (2016)

Câlnău's watershed is situated in the south-eastern part of Romania and of the Curvature Carpathian Mountains, confined within the administrative border of Buzau County (Fig. 1). The watershed mathematically spreads out on coordinates 0º21'05" northern latitude, between the following values, 45º10'10" and

45º31’15”, and to 0º38’05” eastern longitude, between values of 26º45’00” and 26º83’05”.

Câlnău’s watershed overlaps the following main units of landform: the outer Sub Carpathian region, the inner Sub Carpathian region, (Vrancea’s Subcarpathia), the Slănic-Câlnău foothill platform and the Râmnic foothill plain.

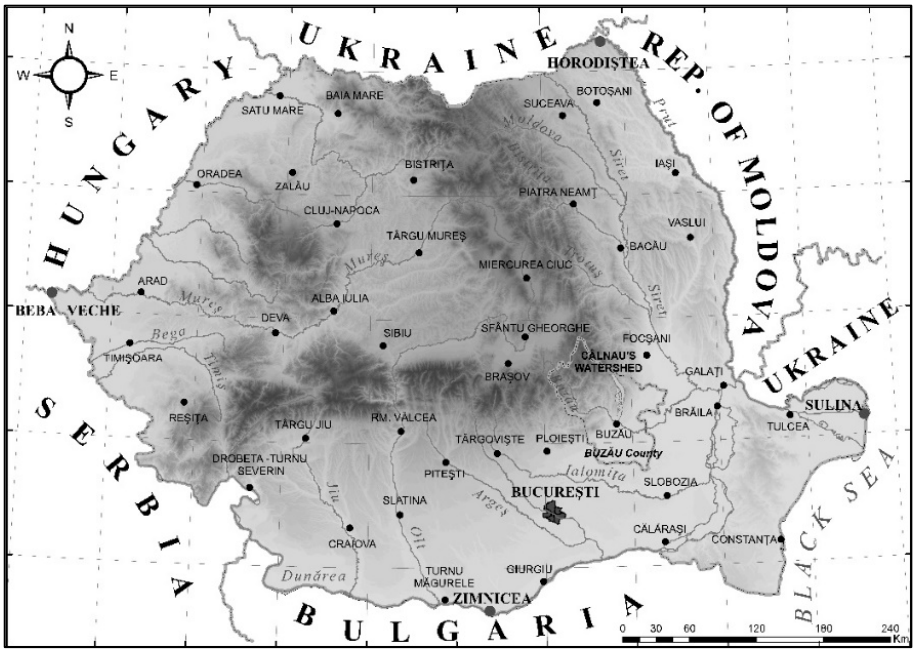

Fig. 1. ***Câlnău’s watershed’s location within the country and Buzău County (Source: data from Military Topographic Directorate, personal analysis)***

Altitude influences the climate regime and, consequently, the hydrological one to an obvious and extensive degree. The air temperature drops with the increase of altitude (the thermal gradient has a value of 0.65ºC/100 meters), the atmospheric pressure is indirectly proportional with the increase of altitude, while the quantity of precipitation is directly proportional with the increase of altitude.

A river’ watershed regime is also influenced by altitude. Throughout the year, rivers are fed by rainfall and groundwater regimes and in the cold season, with the increase of altitude, temperatures drop and rivers also benefit from snowfall or rainfall, as in spring the melting of ice and snow supplies them with more water.

2. METHODOLOGY

This study was conducted with the meteorological and hydrological data provided by entities from the given field: National Meteorological Administration

and Buzău-Ialomiţa Water Branch. These data were processed with Microsoft Excel where different formulas were applied for obtaining the necessary graphic materials. For the spatial localization of the studied area data from Military Topographic Directorate were used in conjunction with those from open GIS sources, which were operated in specialized GIS programs.

3. ANALYSIS OF THE RAINFALL

The contradistinction between space and time represents a main feature for the expansion of atmospheric precipitations, given their abruptness in time and dissimilar quantities over a surface. Precipitations appearance is influenced by the following factors: air masses circulation, thermodynamic convection, physical-geographical elements that enforce different characteristic of the underlying surface (Constantin et al. 2014).

The quantity of rainfall pertaining to a watershed has, in its turn, a periodicity of approximately 25 years, alternating high and low values, thus correlating to the variation of the annual average flow rate. The tendency is one of relative stagnation, which means that it is not the average quantity of rainfall that determines the variation in liquid flow, but the way in which it is distributed throughout the watershed.

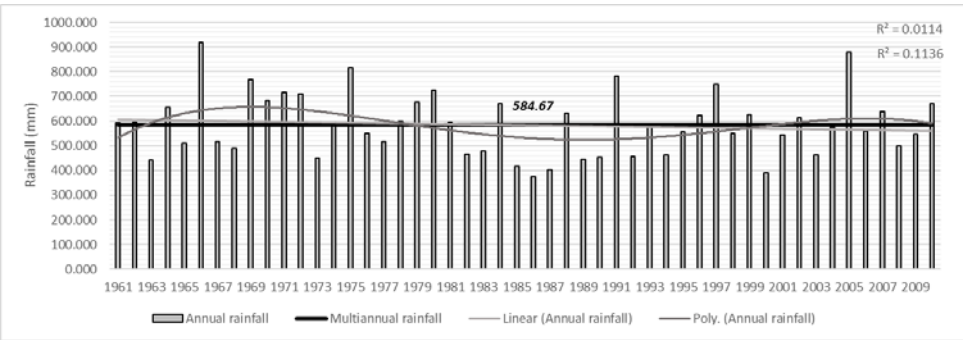

Fig. 2. ***The annual variation of rainfall quantities in the Câlnău watershed (Source: meteorological data provided by National Meteorological Administration, personal analysis)***

The peaks in values are salient and correlate with the ones in the figure showing the variation of annual average flow rates, which demonstrates that the two parameters are directly proportional.

In the periods in which the tendency indicates an increase in values, the annual average values come close or surpass the multiannual average value of the quantity of rainfall, while in the opposite situation the reported values are slightly lower.

The distribution of the quantity of rainfall in the case of multiannual monthly average values is projected as the Gauss distribution which indicates a

maximum in the summer months when the flow also records among its highest values, thus confirming the previous observations regarding multiannual monthly average values of the flow rate. Reduced precipitations in the form of showers, thus in high intensity, occurring mostly during the summer, determine this type of distribution.

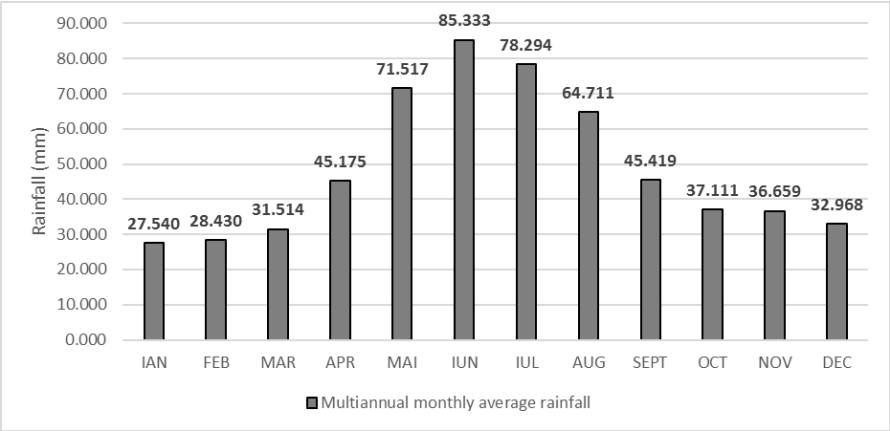

Fig. 3. ***The monthly multiannual variation of rainfall quantities in the Câlnău watershed (Source: meteorological data provided by National Meteorological Administration, personal analysis)***

4. THE ANALYSIS OF THE AVERAGE FLOW

Climate change as presented in various researches worldwide also bares a significant influence over Câlnău's watershed as one can observe from the study of the annual average flow rate (Fig. 4, 5). The annual average flow rate records a decreasing tendency, according to the analysis of both its representations for the subsequent water level stations, as is implied by the linear tendency. The decreasing of flow rate can be caused either by a reduced quantity of rainfall or a disruption in the water level regime, which can lead to various forms of downpours that produce short term higher water levels instead of long-term ones.

The polynomial tendency indicates a periodicity of approximately 25 years, which evolves in the following manner: a period with high annual flow rate values followed by one with slightly reduced values. We can observe that the amplitude of the events decreases significantly with the passing of time.

Peaks as those recorded in 1955, 1972, and 2005 are salient and are known in the country for the large quantity of rainfall accumulated throughout one year. These synoptic conditions which lead to unusually high flow rates are also responsible for destructive freshets and violent floods which have caused significant material damages but, most importantly, human casualties.

One of the most common natural phenomena considered a calamity, that has an important influence over the human society, is represented by the floods.

The aftermath left by flood events has entailed a need for planning and preemptive actions to be taken in case of such an event. The surface most prone to flooding also has to be identified and studied further (Stoica and Iancu 2010).

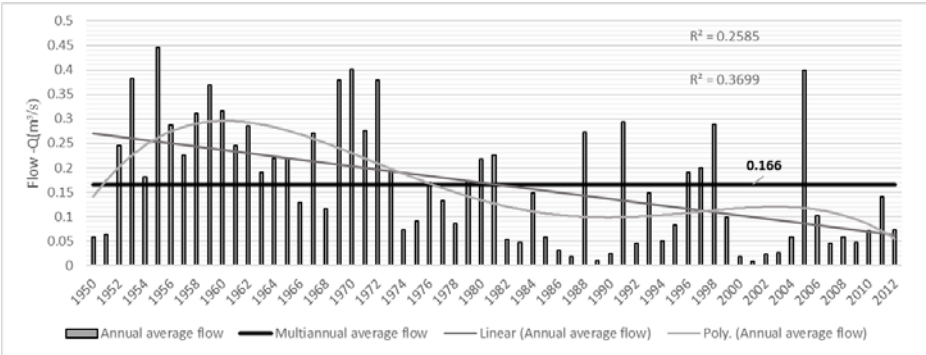

Fig. 4. ***Variation of the annual average flow rate in relation with the multiannual average flow rate recorded by the Costomiru Hydrometric Station, Câlnău river, between 1950-2012 (Source: hydrological data provided by Buzău-Ialomiţa Water Branch, personal analysis)***

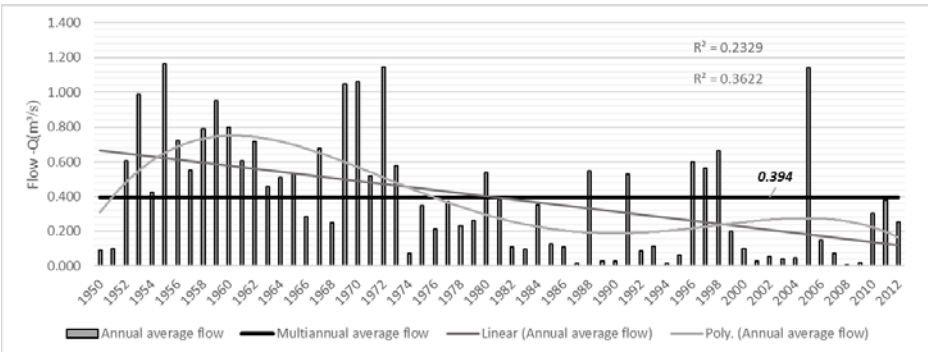

Fig. 5. ***Variation of the annual average flow rate in relation with the multiannual average flow rate recorded by the Potârnicheşti Hydrometric Station, Câlnău river, between 1950-2012 (Source: hydrological data provided by Buzău-Ialomiţa Water Branch, personal analysis)***

The highest flow rates are recorded in the months of spring, when melting show is the decisive factor of liquid flow, and in summer months when cloud systems form over the water basins with localized short-term development, of the Cumulonimbus type, which produce showers.

Câlnău river's flow rates, as specific values, are not higher than those of other rivers in the country, as it records extended periods of drying up in both the warm and the cold season, when the value of the minimum flow rate reaches the threshold of 0 m^3/s. Freshets and floods are common phenomena in Câlnău's case,

and the authorities are especially involved in protecting local communities, the agricultural fields, the roads, and other socio-economic landmarks.

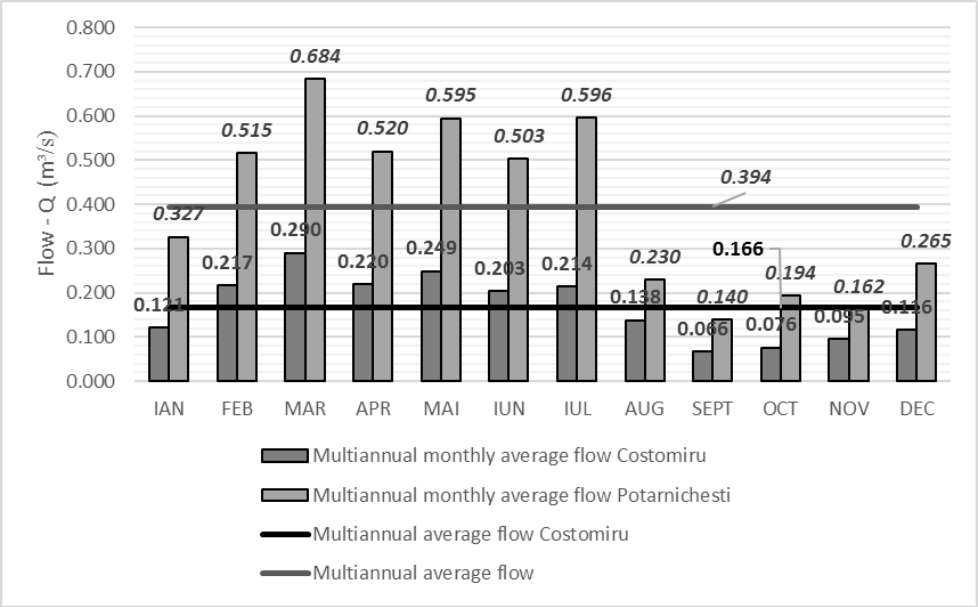

Fig. 6. ***Variation of the multiannual monthly average flow rate in relation with the multiannual average flow rate recorded by both hydrometric stations between 1950-2012 (Source: hydrological data provided by Buzău-Ialomiţa Water Branch, personal analysis)***

Forecasting flood events is still an uncertain filed, therefore they are one of the natural phenomena that cannot be entirely averted. The human factor and anthropic elements such as a growing number of human establishments that affects the extent of water infiltration, industry, infrastructure, economic matters and the increasing effect of climate change make flooding a more common threat than ever (Myeong and Hyun 2009).

If the timespan is divided in two (Fig. 7), a prominent decrease of liquid flow can be observed in the last decades. The causes can be both hydro-meteorological (e.g. global warming) and man-made, the latter having a significant impact. The industrial development has led to an increase in the quantity of water used for regional activities and the area's development, while the area's population contributed to reducing the flow rate.

The increased occurrence of risk phenomena: meteorological and hydrological draughts, violent storms, powerful winds bare a significant influence over the natural course of a river, forcing it to often evolve in a violent manner in order to attain a state of balance. This can lead to a positive feedback that will only amplify the extent of the phenomena, possibly resulting in the actual disappearance of the water course.

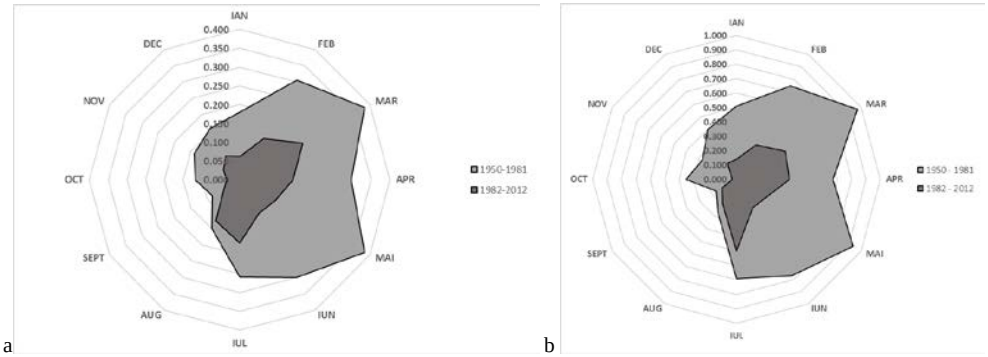

Fig. 7. ***Variations of the multiannual monthly average flow rate (mc/s) between 1950-1981 compared to those between 1982-2012 recorded at the Costomiru Hydrometric Station (a) and Potârnicheşti Hydrometric Station (b) (Source: hydrological data provided by Buzău-Ialomiţa Water Branch, personal analysis)***

5. CONCLUSIONS

The present article has set out to analyze the relation between the factors that influence the climate and their impact over hydrography. The main topic is represented by the climate and hydrological parameters which depend on physical-geographical factors which influence to a great extent the way in which the phenomena unfold.

The article addresses liquid flow in the Câlnău watershed through a detailed analysis of the annual and multiannual monthly flow rates, but also that of the annual and annual monthly quantity of rainfall. The risk hydrological phenomenon – high water and flooding, which endangers people's lives, is characteristic to this particular river.

From the entire period addressed in this study, the year 2005 is the most salient, from all point of views. In the context of a nationwide atmospheric instability, higher quantities of rainfall were recorded which were followed by powerful high water phenomena and floods with major damages. The historical highest flow rate was surpassed in 2011, when a new record was set, of 358 m^3/s compared to 126 m^3/s (1972).

Câlnău has a flow regime that only poses issues during torrential rains, mostly during the warm season, when their intensity is exceptionally high in a short time span. Situations susceptible to ensue due to this phenomenon are: the flooding of towns and villages, two of which are immediately and completely evacuated when the prognosis indicates imminent impact of the high waters, such as erosion of the river banks, the destruction of gardens, deaths of animals and, due to the involvement of the authorities, a decreasing number of human deaths.

REFERENCES

1. Constantin (Oprea), D.M., Cîrciumaru, E., Vătămanu, V.V. (2014), *The land's susceptibility, due to atmospheric precipitations, within the catchment area of Câlnău,* PESD, VOL. 8, no.1
2. Dai, A. (2010) *Drought under global warming: a review.* Clim. Change 2, 45–65, http://dx.doi.org/10.1002/wcc.81
3. Gaňová, L., Zeleňáková, M., Purcz, P., Diaconu, D.C., Orfánus, T., Kuzevičová, Z. (2016), *Identification of urban flood vulnerability in Eastern Slovakia by mapping the potential natural sources of flooding – implications for territorial planning, Urbanism.* Arhitectură. Construcții, 2017 Vol. 8, nr. 4. pp 365-376.
4. Hein, L., Metzger, M.J., Leemans, R. (2009) *The local impacts of climate change in the Ferlo, Western Sahel.* Clim. Change 93, 465–483.
5. Herrera-Pantoja, M., Hiscock, K.M. (2015) *Projected impacts of climate change on water availability indicators in a semi-arid region of central Mexico*, Environmental Science & Policy 54, 81-89
6. Howat, I.M., Joughin, I., Scambos, T.A. (2007) *Rapid changes in ice discharge from Greenland outlet glaciers.* Science 315, 1559–1561.
7. IPCC (2007) Technical summary. In: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., Miller, H.L. (Eds.), Climate Change 2007: The Physical Science Basis Conference. Contribution of Working Group1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.
8. Myeong, S., Hyun, J. (2009), *Developing Flood Vulnerability Map For North Korea*, ASPRS 2009 Annual Conference, Caltimore, Maryland, March 9-13
9. Mearns, R., Norton, A. (Eds.) (2010) *Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World.* World Bank, Washington, DC.
10. Patz, J.A., Campbell-Lendrum, D., Holloway, T., Foley, J.A. (2005) *Impact of regional climate change on human health.* Nature 438, 310–317.
11. Smith, A.B., Katz, R.W. (2013) *US billion-dollar weather and climate disasters: data sources, trends, accuracy and biases.* Nat. Hazards 67, 387–410.
12. Stoica, A-E., Iancu, I. (2010), *Flood vulnerability assessment based on mathematical modeling*, Scientific Journal -Mathematical Modelling in Civil Engineering, No. 5
13. UN (2011) World population prospects: the 2010 revision, highlights and advance tables. In: Working Paper No. ESA/P/WP.220. United Nations, Department of Economic and Social Affairs, Population Division.
14. van der Velde, M., Tubiello, F.N., Vrieling, A., Bouraoui, F. (2012) *Impacts of extreme weather on wheat and maize in France: evaluating regional crop simulations against observed data.* Clim. Change 113, 751–765.