ESTIMATING THE TENDENCY AND THE VARIABILITY OF THE RAINFALL AMOUNT IN IALOMITA RIVER BASIN AND THEIR INFLUENCE UPON THE LIQUID RUN-OFF

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ABSTRACT: Estimating the tendency and the variability of the rainfall amount in Ialomita river basin and their influence upon the liquid run-off. The paper focuses on an analysis of the spatial and temporal variability of rainfall amounts (meteorological parameter) from Ialomita River Basin and also the influence that rainfall has upon the liquid run-off, expressed by the mean monthly discharges (hydrologic parameter) in a common period of time (1961-2007).

The study of the evolution of the above mentioned parameters has been based upon the data recorded from 6 weather and river stations which we considered to be representative for the studied area.

For these weather stations we have used, calculated and statistically interpreted the chronological data series of the mean monthly and annually rainfall amounts while for the river stations we have taken into account the mean monthly and yearly liquid discharges.

We have also tried to establish inter-connections between the two parameters, in order to demonstrate the tight link that is between them on both a time-space scale and in a regional context.

Any alteration of the liquid drainage is caused by alterations in the climatic system, mainly the rainfall patterns.

In order to identify the tendencies in the dynamics of the rainfall amounts and the mean liquid run-off and also to establish their statistic significance we have used the Mann-Kendall test (with the help of MAKENSIS programme).

Keywords: hydrological and climatic parameters, spatial and time tendencies, inter-connectivity, Ialomita river basin.

1. OBJECTIVES

In this paper we have tried to identify the supposed tendencies in the variability of the mean monthly rainfall (the climatic parameter) as well as the tendencies in the evolution of the mean monthly and annual liquid discharges (the hydrologic parameter) on basis of the Mann-Kendall statistical test. The run-off volume of the hydrographical surface network is always inter-connected with the climatic parameter. Rainfall always represents the genetic key factor in the constitution of the liquid run-off both on slopes and in river beds. The highest water discharges are usually triggered by heavy prolonged rainfall, while the lack of rainfall or scarce rainfall determines a poor liquid run-off.

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In order to study and identify the interdependence between these two parameters (climatic and hydrological) we have chosen a vast area of land, represented by the Ialomita river basin, which encompasses a large variety of landforms and climatic conditions, but overall acts unitary from a hydrological point of view.

2. MORPHOMETRIC CHARACTERISTICS OF IALOMITA RIVER BASIN

The Ialomita River Basin gathers very different geographical conditions, especially when talking about landforms. These tend to descent gradually in altitude from north to south, from a maximum altitude of 2505 m (Omu Peak, Bucegi Mountains) to a minimum level of 6-10 m, close to the confluence with the Danube.

Thus, the mountain region represents 14.31% of the total area of the basin, the hills and plateaus region takes about 23.6% of the total area while the rest of 55.8% is represented by plains and lowland territories.

The Ialomita River Basin is covered by mountains in its northern extremity (Bucegi Mts, Clabucetelor Mts), then its central territories are covered by a transition sub-Carpathian step (The Prahova and Buzau Sub Carpathians), while the south and east of the basin are occupied mainly by low land territories, which include primarily plains of different types that extent to its confluence with the Danube River, south from the village of Giurgeni.

3. THE DATA BASE AND METHODOLOGY USED

3.1 The data base

Ialomita River Basin offers ideal conditions for performing hydrological studies (it has a very well developed hydrometric network, with a total number of 21 stations) but less favorable for climatic analysis, since only 6 weather stations activate on its territory.

In order to perform such an analysis we have used:

- series of pluviometric data: monthly and yearly rainfall for the 1961-2007 period for six weather stations (fig.1) and also the maximum amount of rainfall recorded over a 24 hours period for the same time lapse and the same locations
- series of hydrological data: mean monthly and yearly liquid discharges for the same period of time 1961-2007 at six corresponding hydrometric stations.

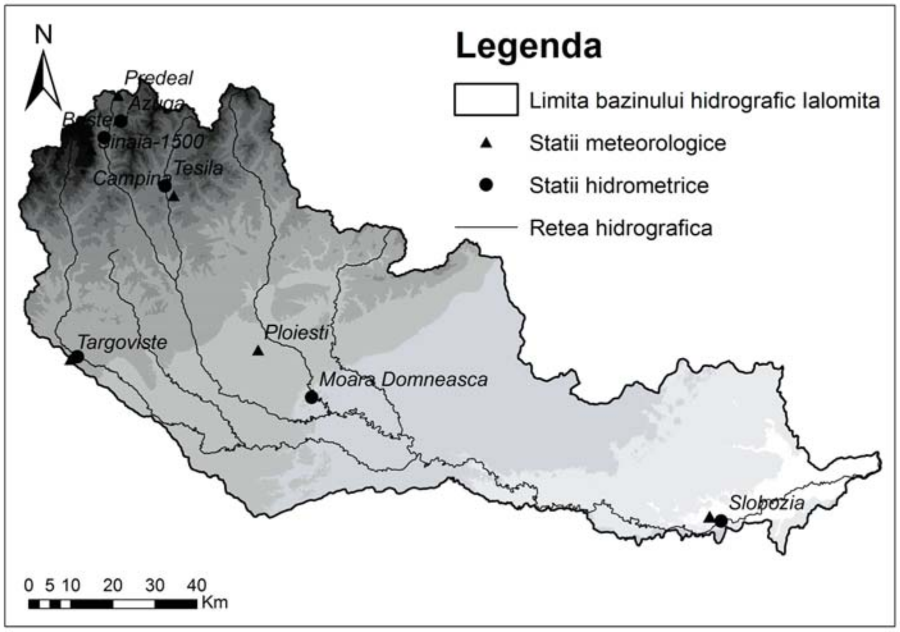

Fig.1. ***The map of the hydro-meteorological network in Ialomita River Basin*.**

The analyzed weather and river stations are presented in tables 1 and 2.

Table 1. ***Data regarding the hydrometric stations in Ialomita River Basin***

Nr. crt	River	River Station	F (Km^2)	Mean liquid discharge	Maximum liquid discharge
1	Azuga	Azuga	83	1,91	94
2	Prahova	Busteni	136	2,85	123
3	Doftana	Tesila	288	4,52	311
4	Ialomiţa	Targoviste	686	8,35	691
5	Teleajen	Moara Domnească	1398	9.11	850
6	Ialomiţa	Slobozia	9154	45.5	818

**According to NIHWM data*

Table 2. ***Data regarding the weather stations that we have used in our analysis***

Nr. crt	River	Multiannual average	The altitude of the station	The maximum amount of rainfall in 24 hours)
1	Predeal	947	1090	122.1
2	Sinaia	1034	1510	106
3	Campina	770	461	118.4
4	Targoviste	679	293	137.6
5	Ploiesti	635	164	102.4
6	Slobozia	468	40	62.6

**According to NAM data*

3.2. Methodology

The statistical analysis of the weather and hydrological data series consisted by adopting the Mann Kendall test. The Mann Kendall test (a test used for identifying the tendencies) takes into account the analysis of two types of statistic analysis: for data series with less than 10 cases the S test is used, while for data series consisting of more than 10 cases one must apply the Z test, which displays a normal distribution pattern. In order to identify the correct tendency of the analyzed parameters, we use four levels of significance, table 3.

Table 3. ***The meaning of the symbols corresponding to the four levels of significance of the Mann Kendall test***

***	$\alpha = 0.001$
**	α= 0.01
*	α = 0.0 5
+	α= 0.1

This means that the level of significance 0.001 corresponds to a 0.1% probability of being wrong in the estimation of the correct tendency, which in turn shows that the estimation performed by the test has a very high degree of accuracy.

Using the inter correlation functions we have tried to determine a correspondence between rainfall and liquid run-off, while for the maps and spatial analysis we have used GIS methods (extensions of the ArcGis 9.2. soft).

4. OUTCOMES

Our performing of the Mann Kendall test upon the series of rainfall data suggested that the weather stations of Predeal, Campina, Targoviste and Slobozia exhibit an increase tendency especially for the month of September (a significance level of 0.05 to 0.1). We have also identified increase tendencies for the months of March and October at Slobozia weather station (significance level of 0.05).

The only weather station showing decrease tendency is Campina (with a significance level between 0.05 and 0.01) in the months of February (significance level = 0.01) and may (significance level = 0.05). Regarding the Mann Kendall test performed upon series of annual rainfall data we can observe decrease tendencies only for Sinaia 1500 weather station.

Ploiesti weather station, even if it is located in a transition area between the mountainous region to the north and the plain region to the south and east, does not show any decrease or increase tendencies regarding the monthly or yearly rainfall.

Table 4. ***The monthly and yearly tendencies of rainfall for several weather stations in the Ialomita River Basin***

Time	Mean rainfall					
	Predeal	Sinaia 1500	Campina	Targoviste	Ploiesti	Slobozia
I						
II			**(-)			
III						*(+)
IV		* (-)				
V		*(-)	*(-)			
VI						
VII						
VIII						
IX	+ (+)		+(+)	*(+)		*(+)
X						+(+)
XI						
XII						
AN		*(-)				

(-) decrease tendency
(+) – increase/rise tendency

Our performing of the Mann Kendall test upon the series of hydrological data pointed out the following aspects: for most of the river stations we have identified decrease tendencies of the mean monthly and annual discharges.

For the majority of the hydrometrical stations we have observed decrease tendencies of the mean monthly and annual discharges. Only Busteni river station exhibited increase tendencies of the mean monthly and yearly liquid discharges. These decrease tendencies are situated between the significance level 0.01 in May for Azuga river station and 0.1 in January (Azuga, Targoviste), february (Azuga, Moara Domneasca), may (Moara Domneasca and Slobozia) and june (Slobozia).

Regarding the entire area of the Ialomita River Basin for the period 1961-2007 we can identify a general decrease tendency of the mean monthly liquid discharges concerning 75% of the river stations that we have focused upon.

Increase tendencies of these monthly and yearly liquid discharges are easily observed at 25% of the river stations located in Ialomita River Basin, mostly in Prahova River Basin.

Table 5. ***The monthly and yearly general tendencies of the mean liquid discharges in Ialomita River Basin, calculated with Mann Kendall statistics test (river stations)***

Stations / Months	*Azuga*	*Buşteni*	*Teşila*	*Târgovişte*	*Moara Domnească*	*Slobozia*
I	+(-)			+(-)		
II	+(-)			*(-)	+(-)	+(-)
III		+(+)	*(-)	*(-)		

Stations / Months	*Azuga*	*Buşteni*	*Teşila*	*Târgovişte*	*Moara Domnească*	*Slobozia*
IV	*(-)					
V	**(-)		*(-)	*(-)	+(-)	+(-)
VI	*(-)		*(-)			+(-)
VII	*(-)		*(-)	+(-)		
VIII						
IX						
X		+(+)				
XI						
XII						
Annual	**(-)		*(-)			

(+) decrease tendency
(-) increase tendency

Even if the period 1961-2007 shows a general trend of increase regarding the surface liquid run-off, this has not reflected completely in the run-off regime. Besides Prahova River Basin, the other sub-basins that together form the Ialomita River Basin exhibited a decrease tendency, with significance levels of 0.1 which means a 10% possibility of us being wrong in our estimations.

5. THE INTERDEPENDENCE BETWEEN RAINFALL AND LIQUID DISCHARGES

We have calculated for the period 1961-2007 the variation of the rainfall amounts for each month and year. Since in most of the cases the variability is common for the majority of the stations (80%) we have defined as an index of the average the series of monthly data that exhibit under average liquid run-off. Similarly we have calculated the rainfall index by averaging the data series for the weather stations that we have taken into consideration.

The interdependence function between the indexes of rainfall and run-off, when considering all the months of the year, shows that the rainfall fluctuations usually stand 2-3 months ahead the run-off fluctuations. These represent the difference between the moment in which the rainfall occurs and the subsequent liquid run-off that it triggers. Positive values demonstrate that an increase in the amount of rainfall usually produces an increase in the liquid run-off (for the cold season). We have analyzed the variation of the correlation coefficient between rainfall amounts for each month of the year and the liquid run-off for the next 3 months. Thus the rainfall that falls in January and February influences the liquid run-off in March or April, which corresponds to a significance level of 95%. This is because the snow that accumulates in winter months melts gradually and transforms into liquid discharges over the first one or two spring months. This time lapse decreases to 0 during summer months.

6. CONCLUSIONS AND PERSPECTIVES

The statistic interpretation of hydrological and meteorological data series in Ialomita River Basin allowed us to identify certain tendencies regarding the variability of the analyzed parameters (mean monthly and yearly rainfall amounts and discharges).

Tendencies are less obvious when discussing about rainfall amounts, yet an increase can be observed, especially for September (significance levels of 0.1 and 0.05). Regarding the surface run-off, the tendencies are more obvious and are representative for all the river stations that we have analyzed, especially for the winter months (february) and spring (may) with different levels of significance (most of them being situated between 0.1 and 0.01).

As a consequence we intend to analyze these modifications in order to understand the role they play in the drainage processes.

Also, the analysis of the correlations between the liquid run off and rainfall show that there is usually a 2-3 months delay in winter time period between the moment of the specific rainfall or snowfall and the moment in which the highest discharges are recorded and no difference in summer. We have identified dry periods in 1973-1975, 1986-1995 and 2000-2004.

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