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Flood frequency analysis of river Casimcea

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ABSTRACT

Flood frequency analysis is the most important statistical technique in understanding the nature and magnitude of high discharge in a river, and is used for establishing a relationship between flood magnitude and frequency of occurrence (return period). This study aims to carry out the flood frequency analysis of river Casimcea. The Casimcea catchment is located in the Dobrogea-Littoral basin of south-eastern Romania, and covers parts of two counties, Tulcea and Constanta. The main river of Casimcea catchment flows into the Tasaul lake and has two main tributaries (Ramnic and Cartal). In the present study, Log Normal, Log Pearson III and Gumbel probability distribution has applied on flood time series data of four hydrological stations Casimcea and Cheia on Casimcea River and Pantelimonu on its main tributaries Ramnic and Cartal. The annual maximum series data spanning 29 to 52 years have been used for the present study. The frequential analysis will be performed with Hydrognomon - open source software for the analysis of hydrological data. Hydrognomon is free software under the General Public License (GPLv3).

1. INTRODUCTION

Floods occurring due to variety of natural and anthropogenic factors are most common environmental hazard effecting people globally. Flooding has been a larger concern today due to rapid development in the river catchment area which increases the river runoff and decreasing the river capacity.

A return period is known as a recurrence interval which is an estimate of the interval of time between events like an earthquake, flood or river discharge flow of a certain intensity or size (Rakhecha and Singh, 2009). The terms "10 year", "50 year", "100 year" and "500 year" floods are used to describe the estimated probability of a flood event happening in any given year (Watson and Adams, 2010).

Flood frequency analysis is the procedure for estimating the frequency of occurrence (return period) of a hydrological event such as flood. The technique involves using observed annual peak flow discharge data to calculate statistical information such as mean values, standard deviations, skewness and recurrence intervals.

The Kolmogorov-Smirnov test and the distributions Normal, Log Normal, Log Pearson III and Gumbel distribution are used to fit the annual extremes rainfall data with 10, 25, 50, 100 and 200 years return periods.

2. MATERIAL AND METHODS

2.1 Study area

The Casimcea catchment is located in the Dobrogea-Littoral basin of south-eastern Romania, as shown in Figure 1, and covers parts of two counties, Tulcea and Constanta.

In the present study 29 to 52 years of annual maximum peak discharge data was used for analysis (Figure 2). The size of the sample data can be considered as reliable for projecting discharge scenarios. The data has been collected from three gauge stations, Casimcea (upstream), Pantelimonu (tributaries Cartal and Ramnic), and Cheia (downstream) by the „Romanian Waters" National Administration.

2.2 Methods

In order to predict extreme hydrological discharge using frequency analysis, Hydrognomon software (http://www.hydrognomon.org/) and EasyFit software (https://easyfit.soft32.com/) are used. The most common probability distribution function (PDF) used for extreme discharge data are: Log Normal, Pearson III, Log Pearson III and Gumbel distribution. Water Resources Council (1967, 1982) of the United States (IACWD, 1982; Sing, 1998) recommend Log Pearson III PDF method which has been found to be yielding good results in many applications, particularly for flood peak data. AL-Mashidani et al., 1978, Hosking and Wallis, 1997 consider that Gumbel PDF procedure are a reasonable approach to predict the flood recurrence interval.

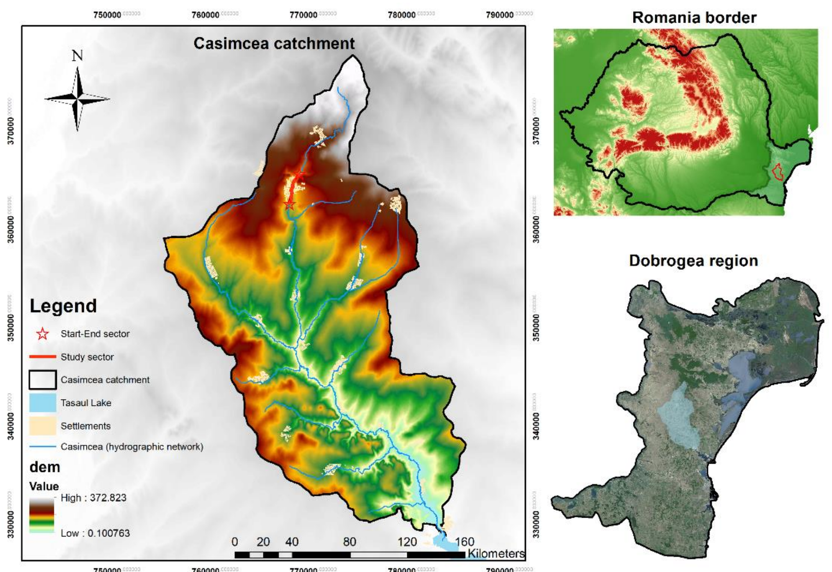

Figure 1. Study area

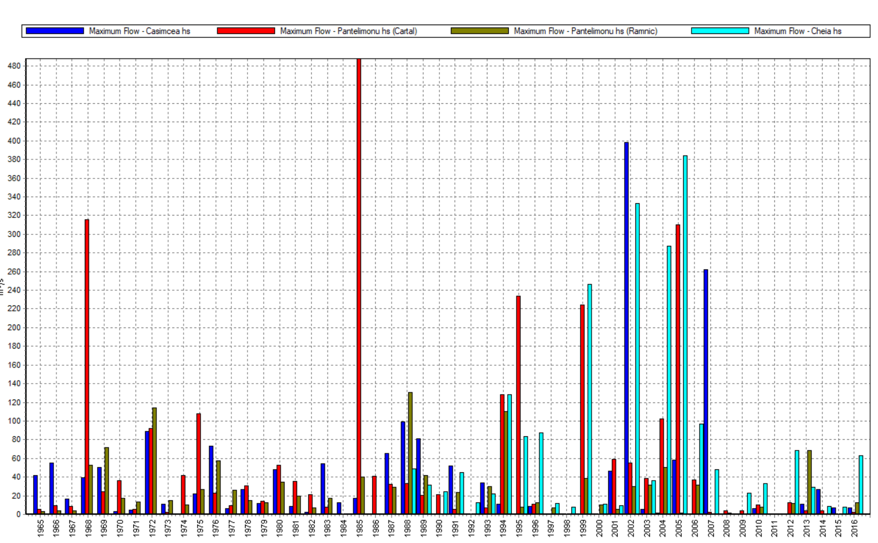

Figure 2. Flow hydrograph (1965-2016)

Kolmogorov-Smirnov test from Hydrognomon and Anderson Darling (AD) from EasyFit are used in order to test if the discharge sample comes from a specific PDF. The Anderson-Darling test are similar with Kolmogorov-Smirnov but is more powerful because this test used all the values not that produces the maximum difference.

3. RESULTS AND DISCUSSION

According with Kolmogorov-Smirnov (table 1), the Log Normal PDF are not accepted for all station investigated. Pearson III are rejected for Pantelimonu station situated on Cartal tributary River. Log Pearson III are not accepted for Pantelimonu station situated on Ramnic tributary River. We observe that the Pearson III distribution for Casimcea station and Log Pearson III distribution for Cheia station have have the best fitting with "attained α" of 51.5% and 66.6% respectively. For Pantelimonu station on Ramnic Tributary the better distribution are Gumbel ("attained α" is 15.74%).

Table 1. The results of the Kolmogorov-Smirnov for all station investigated

Kolmogorov-Smirnov test	α = 1, 5 and 10 %	Attained α (attained threshold)
Casimcea st. on Casimcea river		
Log Normal	REJECTED	0.23%
Pearson III	ACCEPT	51.50%
Log Pearson III	ACCEPT	23.28%
EV1-Max (Gumbel)	ACCEPT	0.05%
Cheia st. on Casimcea river		
Log Normal	ACCEPT	22.28%
Pearson III	ACCEPT	14.34%
Log Pearson III	ACCEPT	66.61%
EV1-Max (Gumbel)	ACCEPT	13.79%
Pantelimonu st. on Cartal tributary		
Log Normal	REJECTED for 1% and ACCEPT for 5 and 10%	1.37%
Pearson III	REJECTED	0.00%
Log Pearson III	ACCEPT	42.53%
EV1-Max (Gumbel)	REJECTED	0.01%
Pantelimonu st. on Ramnic tributary		
LogNormal	REJECTED for 1% and ACCEPT for 5 and 10	1.44%
Pearson III	ACCEPT	15.74%
Log Pearson III	REJECTED	0.55%
EV1-Max (Gumbel)	ACCEPT	5.11%

Face to the situation presented below, in order to choose the better PDF the Anderson-Darling test under EasyFit has perform. The A^2 (table 2) statistic results show that the better distribution function for all station are Log Pearson III because the A^2 value is less than Log Normal distribution. The Gumbel distribution was rejected for all station and for all α level of significance.

Table 2. The results perform with EasyFit

AD test	α = 1, 5 and 10 %	A^2 statistic
Casimcea on Casimcea river		
Log Normal	ACCEPT	1.047
Log Pearson III	ACCEPT	0.61
Cheia on Casimcea river		
Log Normal	ACCEPT	0.64
Log Pearson III	ACCEPT	0.3
Pantelimonu st. on Cartal tributary		
Log Normal		1.047
Log Pearson III	ACCEPT	0.89
Pantelimonu st. on Ramnic tributary		
Log Normal	ACCEPT	0.44
Log Pearson III	ACCEPT	0.36

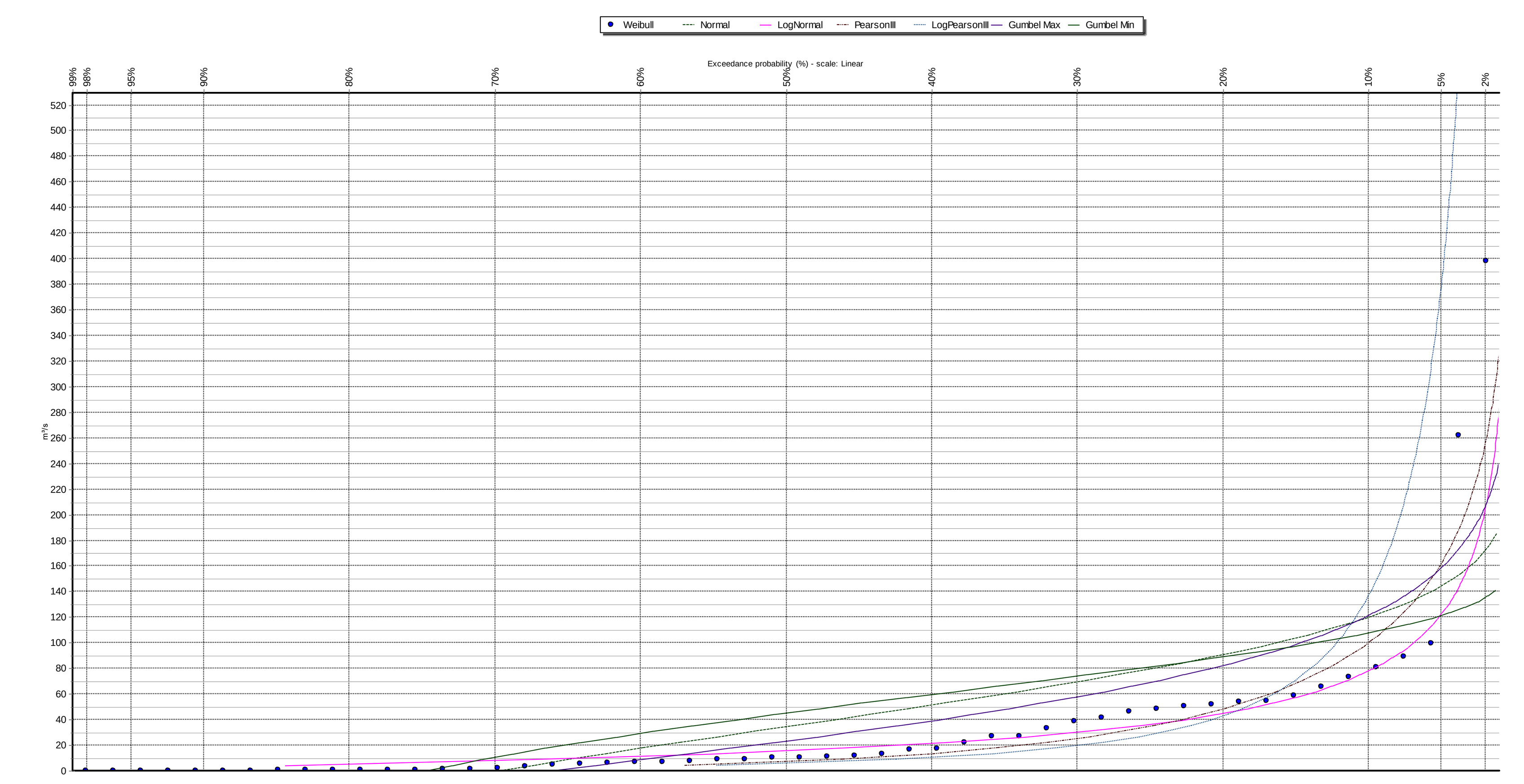

Figure 3. Cumulative distribution function (Casimcea station)

As we can see Log Pearson III it was accepted but the values for different return period presented in table 3 are very high compared to those obtained using Hazen empirical formula (Hazen, 1930) and also with the annual maximum peak discharge data that we use.

Table 3. The return period for Log Pearson III distribution

STATIONS	CASIMCEA CASIMCEA RIVER					CHEIA CASIMCEA RIVER					PANTELIMONU CARTAL TRIBUTARY					PANTELIMONU RAMNIC TRIBUTARY				
T(Max)=	**200 y**	**100 y**	**50 y**	**25 y**	**10 y**	**200 y**	**100 y**	**50 y**	**25 y**	**10 y**	**200 y**	**100 y**	**50 y**	**25 y**	**10 y**	**200 y**	**100 y**	**50 y**	**25 y**	**10 y**
Log Pearson III	6624.2	2964.4	1269.6	513.3	136.3	4975.2	2635.8	1359.4	676.8	248.8	7432.8	3449.0	1540.7	654.7	188.9	10132.5	3913.1	1464.8	526.2	124.0
Hazen	-	395.3	324.6	167.6	75.6	-	-	379.9	350.3	270.6	-	484.6	395.1	312.5	156.8	-	130.6	121.8	111.7	60.7

We could conclude the PDF tested (Log Normal, Pearson III, Log Pearson III and Gumbel) not provide the real results for Casimcea River and its tributaries and it is necessary to test other function.

References:

[1] AL-Mashidani et al., 1978,
[2] Hosking and Wallis, 1997
[3] IACWD, 1982;
[4] Sing, 1998
[5] http://www.hydrognomon.org/
[6] https://easyfit.soft32.com