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ORIGINAL PAPER

Peak flow assessment of El-Ham wadi in Hodna basin case study

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Abstract

Wadis of Algeria are subjected to a very irregular hydrological regime. The present study attempts to assess the peak flows in El-Ham wadi study area in the Hodna basin of Algeria by applying empirical (Giandotti, Possenti, Turazza, and Temez) and statistical techniques (Gradex). These methods are the most suitable for El-Ham valley due to the availability and accessibility of precipitation data. The annual maximum daily precipitation (*P*max,*d*) records are chosen for the applications. This leads, firstly, the estimation of the concentration time T_c using ANRH-Sogreah, Basso, and Giandotti formulas. The results can provide us with many insights. One can easily observe the rise in flood discharges over the different chosen return periods (10-year, 20-year, 50-year, 100-year, and 1000-year). The estimated concentration period equals to 21.5 h. The short-term precipitations at stations 050101, 050301, and 050703 are 91.2 mm, 121.7 mm, and 51.2 mm, respectively, for a 100-year return period. Centennial return period density shows high values at stations 050301 (5.67 mm/h), 2.43 mm/h at station 050703, and 4.25 mm/h at station F050101. Empirical analysis of flood discharges still repeats the same observations regarding flows with return periods with different flow rates (5581.86 m^3/s for a 100-year, also shown at Ain El Hadjel station). One should point out that these outcomes enhance the future research in the Hodna study area, particularly in study of flash floods which implies the knowledge of peak flow of several return periods.

Keywords Peak flow · Hodna · El-Ham wadi · Empirical formulas · Gradex · Precipitation

Introduction

Predicting and reporting extreme events, especially the risk of floods and droughts, are what every country cares about most. Flooding in arid regions is an extremely beneficial event as it is the main source of groundwater recharge along drainage basins where there is no human habitation or flood-prone urban areas (Şen 2018). But floods are the most dangerous natural disasters; they are governed by various factors such as precipitation characteristics, drainage geomorphological features, land use, and water management in river basins (Chang et al. 2013).

Floods occur when the water of streams or storm water drainage systems overflows drainage channel cross-sections and consequently invades urban areas (Konrad 2003). Impacts associated with such events depend on the geographical and climatic characteristics of the watersheds, as well as on anthropogenic factors.

Peak flow rate can be determined from empirical formulas taking into account watershed area characteristics and application experience gained over the years, synthetic formulas based on the concept of concentration time, and critical precipitation (precipitation forming the maximum peak flow rate) during a specific concentration period (Lencastre and Franco 2006; Miranda et al. 2018).

There are numerous methods and formulas that lead to different results when estimating peak flows for the same probability. Many scientific documents have been published

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over the years, for instance, a summary of regionalization simple techniques of hydrological events (Ouarda et al. 2001; Lencastre and Franco 2006), determination of flood discharge in small watersheds using five different models (Kang et al. 2013); estimating concentration time and peak flow values in large watersheds (Salimi et al. 2017); calculation of peak flows by different methods enabling the HEC-RAS roughness coefficient estimation (Miranda et al. 2018); study of rainfall-runoff relationship in watersheds by applying the Only Corresponding Competitor (OCC) stochastic method (Oulad Naoui et al. 2018); determination of flood characteristics by considering the average of flow values derived from empirical, hydrometeorological, and statistical techniques (Salhi et al. 2019); analyzing problems related to the determination of flows discharge in ungauged catchments (Młyński 2020); in addition to the case study of Lousada and Loures (2020) aims to characterize the flow and obtain water heights due to a flood based on three different models.

Algeria is one of the many Mediterranean countries facing the flooding phenomenon in arid and semi-arid regions. The Algerian Valleys are characterized by a very irregular hydrological regime. More recently, various parts of Algeria are marked by some degree of human and property damage including Adrar (October 2004, January 2009, August 2013), Ghardaïa (October 2008, January 2009), Biskra (September 2009), Bechar (October 2008), El Bayadh (October 2011), Tamanrasset (March 2005), Tindouf (October 2015), and M'sila (September 2007, June 2015, May & September 2021) (Hachemi and Benkhaled 2016; ANRH, 2020).

The aim of this study is, then, to evaluate the peak flood discharge through the application of empirical and statistical analysis of flood for different return periods (10-year, 20-year, 50-year, 100-year, and 1000-year) in El-Ham wadi of the Hodna basin in central Algeria. This work was conducted, at the first place, not only to yield discharge data of the Hodna basin, which were estimated previously by Hasbaia et al. (2012), but to gather more data of this basin needed for further researches, due to the paucity and insufficiency of Hodna basin flow discharges data, particularly in study of flash floods which implies the knowledge of peak flow of several return periods.

Study area

The Hodna basin consists of eight sub-basins, named El-Ham, K'sob, Barika, Boussaada, M'sif, El Leham, Lougman, and Soubella, according to Hasbaia et al. (2012; 2015). The Hodna basin itself is approximately 250 km southeast of the capital city of Algeria with a basin area of 26,000 km^2. Chott El Hodna is located in the center of this basin (Hasbaia et al. 2017; Boudjemline and Semar 2018; Djoukbala et al. 2018; Ferhati et al. 2021; Zeroual et al. 2021).

The El-Ham valley, with an area of 6165.68 km^2 is located in the north-west of the Hodna basin, which occupies most of this section. The sub-basin is geographically located between 35°15′ and 36°15′ north latitude and between 3° and 4°15′ east longitude (Fig. 1).

The main hydro-morphometric characteristics according to Djoukbala et al. (2018) of the investigated sub-basin are shown in Table 1.

Material and method

Hill floods have devastating effects on the physical environment and infrastructure. In most of the southern Mediterranean basins, the identification of these floods is complicated by the lack of reliable and sufficient data (Salhi et al. 2019). Therefore, the first flood discharge analyses are based on different techniques prior to hydraulic modeling to identify flood zones.

The methodology used to determine the hydrological distribution that best represents the maximum precipitation data and maximum peak flow rates associated with different return periods is presented below.

Selection of precipitation stations

The sample consists of 46 years (1966–2011) precipitation data for each gauge station from the National Agency for Hydraulic Resources (ANRH, 2020). Annual Maximum Daily Precipitation data (Pmax,d) records were collected from 8 precipitation measuring stations 050101, 050102, 050301, 050401, 050402, 050502, 050601, and 050703 distributed throughout the El-Ham wadi sub-basin located in Ain Nessissa, Challalat El Adaoura, Ain El Hadjel, Sidi Aissa, Dirah center, Meida, Sidi Ameur, and Rocad Sud.

Frequency analysis

Out of eight stations, three main stations of El-Ham wadi are selected (050101, 050301, and 050703 stations), the series of annual maximum precipitation values adjusted for 24 h by Gumbel probability distribution function (PDF) leading to the return periods 2-year, 10-year, 20-year, 50-year, 100-year, and 1000-year.

The short-term precipitations Ptc (T) is used for the flood estimation. The calculation of Ptc (T) can be achieved by using the Body formula (Eqs. 1 and 2) as

$$\mathrm{Ptc}(T) = P\mathrm{max}, d(T).(\frac{t}{24})^{b} \tag{1}$$

where: Ptc (T) is the short-term rainfall for a given return period T (mm);

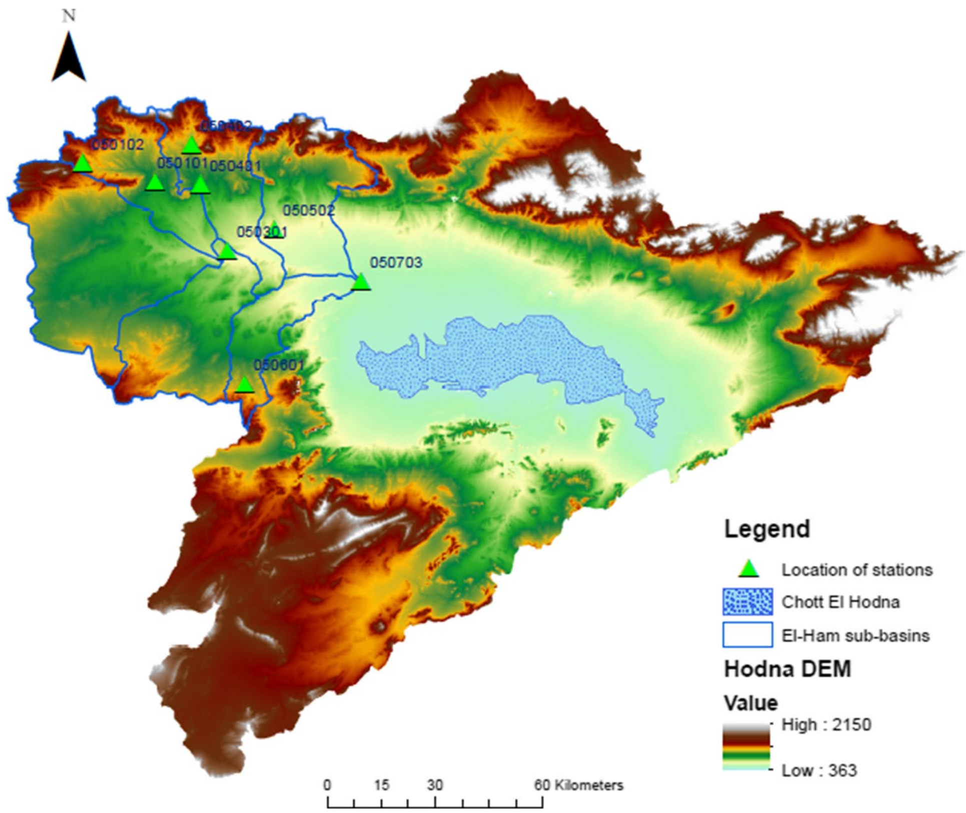

Fig. 1 Location of El-Ham wadi in Hodna basin (elevation map realized using ArcGIS)

Table 1 Main morphometric properties of El-Ham wadi sub-basin

Parameter	Symbol	Unit	Value
Basin area	A	km^2	6165.68
Maximum elevation	$H_{\max}$	m	1823
Minimum elevation	$H_{\min}$	m	441
Average elevation	H_m	m	747.81
Average slope	S	%	6.04
Main water course length	L	km	112

Pmax,d (T) is the maximum daily precipitation for a given return period T (mm);

t is duration of precipitation (hours);

b is coefficient calculated using the following equation (Eq. 2):

$$b = 1 + \frac{Ln\left(\frac{P\max,d(m)}{24}\right) - \mathrm{Ln}(25)}{\mathrm{Ln}(24) - \mathrm{Ln}(0.5)} \tag{2}$$

where Pmax,d (m) is the average maximum daily precipitation (mm).

In this study, we have determined the rainfall intensity corresponding to different return periods for the concentration time using the following formula (Eq. 3):

$$\mathrm{Itc}(T) = \frac{\mathrm{Ptc}(T)}{t} \tag{3}$$

where Itc (T) is the rainfall intensity for duration equals to the time of concentration of a given return period T and t is duration of precipitation (hours).

Once the data are fitted with a Gumbel PDF (as it is the most adequate PDF), it is possible to construct the corresponding intensity duration frequency (IDF) curves, which are the base of every rainfall runoff model in flooding studies. Their elaboration presents the first necessity in the planning, management, and prediction of rainfall risk. This leads, firstly, the estimation of the concentration time T_c using ANRH-Sogreah, Basso, and Giandotti formulas. To build the IDF curves, it is necessary first to identify for each event the time series and the rainfall maximum intensity corresponding to the different cumulative durations at 1, 5, 7, 10, 13, 15, 17, 20, 22, and 24 h. This intensity is determined based on the short-term rainfalls Ptc. Starting from the previous sample of maximum daily precipitation values, one can assign to each of these values an empirical frequency of non-exceedence.

Design flood estimation formulas

Following the goal of estimating peak flow rates (design flood) using maximum daily precipitation data for different return periods, the formulas in Table 2 of Eqs. 4, 5, 6, 7, 8, 9, and 10 are useful.

Results and discussion

Concentration time is estimated after application of Basso, Giandotti, and ANRH-Sogreah formulas. The selected formulas find wide application in the technical literature due to the limited amount of information they need to estimate the time of concentration at the basin scale (Grimaldi et al. 2012). The average concentration time evaluated for the El-Ham wadi sub-basin is 21.5 h, which is used to estimate the above-mentioned methods.

Throughout the adjustment graphs through Gumbel's distribution law (Figs. 2, 3, and 4) for the three stations, it has been noticed that the Gumbel model is clearly adequate, and it is clearly sufficient in the tuning plots made by means of the Gumbel PDF law for the three stations.

The main results of maximum daily precipitation for different return periods are presented in Table 3.

Once the maximum daily precipitation $P\max,d$ (T) amounts are determined, it is then possible to proceed for the short-term rainfall Ptc (T) and the rainfall intensity Itc

Table 2 Peak flow assessment formulations

Methods	Formulas or mode of application	Details
Giandotti	$Q_p = \frac{C.A.(Hm-H\min)^{0.5}}{4.(A)^{0.5}+1,5.L}.\text{Ptc}\%(4)$	C: coefficient ranges between 66 and 166; A: basin area (km^2); H_m: Average elevation (m); $H_{\min}$: minimal elevation (m); L: length of the main water course (km); Ptc: short-term rainfall (mm)
Possenti	$Q_{p\%} = \frac{\mu.P\max,d.A}{L}(5)$	μ: coefficient ranges between 700 and 800; $P\max,d$: maximum daily precipitation of a given return period; A: basin area (km^2); L: length of the main water course (km)
Turazza	$Q_p = \frac{Cr.H.A}{3,6.Tc}(6)$	Cr: runoff coefficient ranges between 0.4 and 0.65 (for the study area); H: maximum precipitation of duration equals to the concentration time (mm); A: basin area (km^2); Tc: concentration time (h)
Temez	$Q_p = \text{C.I.}\frac{A_b}{3}(7)$	C: runoff coefficient ranges between 0.4 and 0.65 (for the study area); I: rainfall intensity for a duration equals to the concentration time of a given return period (mm/h); A: basin area (km^2)
Gradex	$F(x) = \frac{r-0,5}{N}(8)$ $U = -\text{Ln}(-\text{Ln}(F(x))\ (9)$ $P\max, d(T) = U.Gp(T) + P\max, d(i)\ (10)$	$F(x)$: Hazen non-exceedance probability equation r: range number; N: total sample; U: reduced variable of Gumbel; $P\max,d$: maximum daily precipitation (mm); Gp (T): precipitation Gradex (mm)

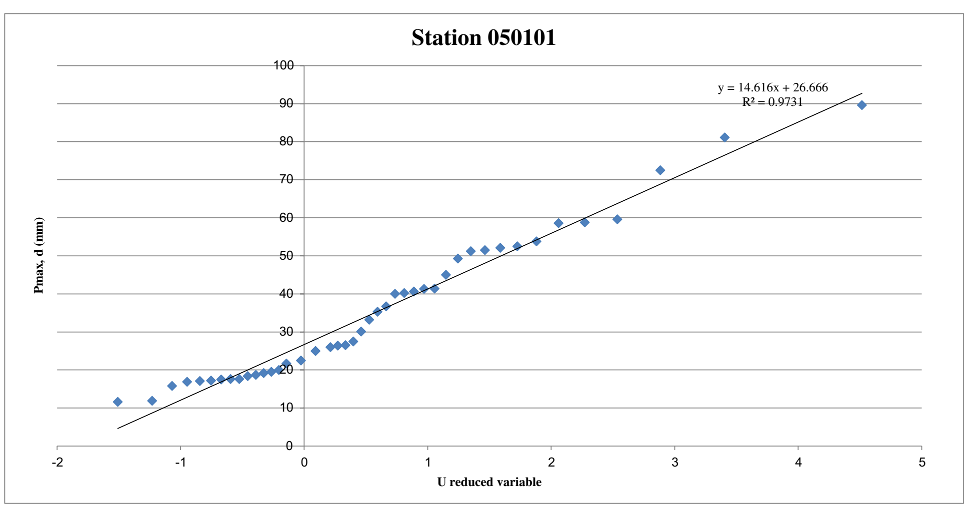

Fig. 2 Adjustment of maximum daily precipitation through Gumbel's law of Ain Nessissa (050301) station

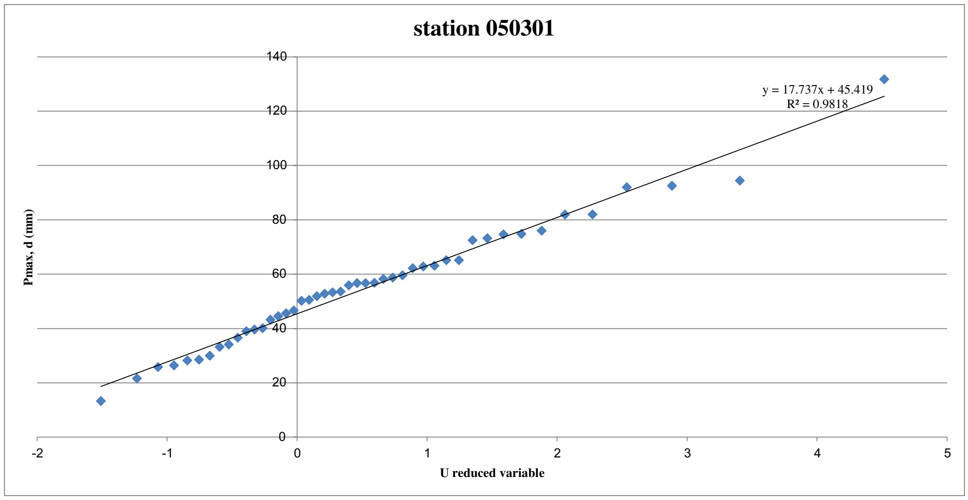

Fig. 3 Adjustment of maximum daily precipitation through Gumbel's law of Ain El Hadjel (050301) station

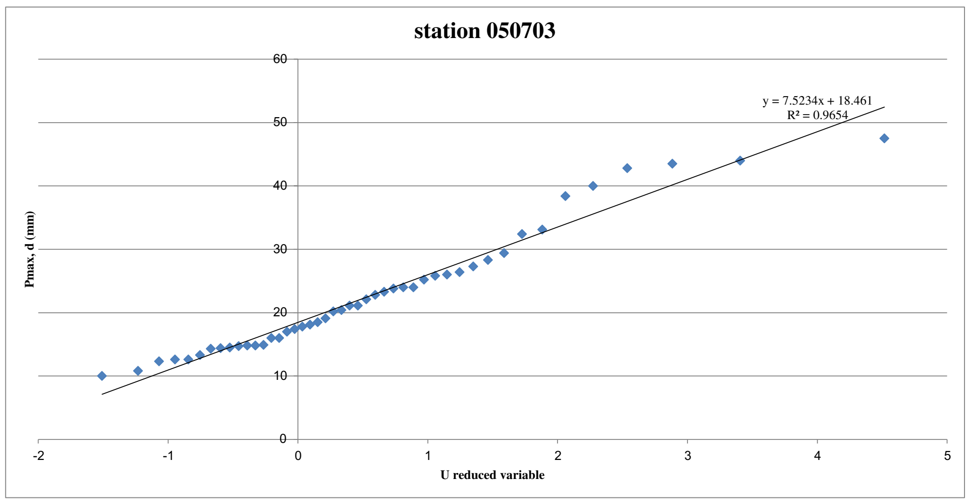

Fig. 4 Adjustment of maximum daily precipitation through Gumbel's law of Rocad Sud (050703) station

(*T*) calculations using the previously mentioned equations (see Tables 4, 5, 6, and 7). The intensity–duration–frequency (IDF) curves are depicted in Figs. 5, 6, 7, 8, 9, and 10. Rainfall IDF curves are derived from the statistical analysis of single storm rainfall records over a period of time, and they are used to capture important characteristics of point rainfall at any desired shorter duration. In other word, it is defined as the calculation of average design rainfall intensity for a given exceedance probability over a range of duration (Subyani and Al-Amri 2015).

For a 100-year return period and concentration time equals to 21.5 h, the Ptc (T) in the stations 050101, 050301, and 050703 are 91.2 mm, 121.7 mm, and 51.2 mm, respectively. On the other hand, 100-year return period intensity in these stations implies high values at the station 050301

Table 3 Annual maximum daily precipitation (for period 1966–2011) of El-Ham wadi sub- basin for different return periods at 3 gauging stations

	Return period T						
		2 years	10 years	20 years	50 years	100 years	1000 years
	Frequency	0.5	0.9	0.95	0.98	0.99	0.999
	Reduced variable of Gumbel	0.37	2.3	2.9	3.9	4.6	6.9
*P*max,*d* (mm)	050101	32.0	59.6	70.1	83.7	93.9	127.6
	050301	51.9	85.3	98.1	114.6	127.0	167.9
	050703	21.2	35.4	40.8	47.8	53.1	70.4

Table 4 Average maximum daily precipitation and coefficient b values

Station code	Average *P*max,*d* (mm)	Coefficient *b*
050101	34.4	0.26
050301	55.6	0.39
050703	22.8	0.16

(5.67 mm/h) with 2.4 mm/h in the station 050703 and 4.3 mm/h in the station 050101.

Evaluation of flood discharges after statistical and hydro-meteorological technique (Gradex method) shows continuously increasing flows towards the return period in the El-Ham wadi sub-basin (see Table 8). The maximum flood discharge at Ain El Hadjel station is 5868.1 m^3/s for 100-year. Empirical analysis of flood discharges in Table 9 repeats the same observations regarding return-periods with different discharges (also shown at Ain El Hadjel station at 5581.9 m^3/s for 100-year).

Conclusion

Floods in arid areas are an anomalous and infrequently recurring phenomenon, which is more important not because of the extreme and highly variable hydrological regime, but because of human settlement in flood-prone areas. Modeling that can provide a holistic understanding of technology at a basic level is a great necessity (Oulad Naoui et al. 2018). Precipitation-runoff models are standard tools for hydrological analysis. These models are used for applications such as water resource studies and flood forecasting.

The aim of this study is to evaluate the design discharges in the El-Ham wadi sub-basin by applying empirical formulas (Giandotti, Possenti, Turazza, and Temez) and statistical techniques (Gradex method). These methods are most suitable for the study area due to the availability and accessibility of precipitation data. In this case, maximum daily records are adapted for application. Concentration time is also determined using ANRH-Sogreah, Basso, and Giandotti formulas.

The results show an increase in peak discharges at a set of return periods (10-year, 20-year, 50-year, 100-year, and 1000-year). The maximum peak discharge is clearly visible at Ain El Hadjel station 050301.

To provide better flood protection, the mean peak discharge values are recommended for consideration as reference values for the lower basin of the El-Ham valley in the large Hodna basin. Therefore, preventive measures should be considered and implemented to avoid devastating effects.

One should point out that these outcomes enhance the future research in the Hodna study area, particularly in study

Table 5 Determination of short-term precipitation and rainfall intensity for 10-year, 20-year, 50-year, 100-year, and 1000-year return periods (station 050101)

Return period *T*	2		10		20		50		100		1000	
Frequency	0.5		0.9		0.95		0.98		0.99		0.999	
Time (hours)	Ptc (mm)	I (mm/h)	Ptc (mm)	I (mm/h)	Ptc (mm)	I (mm/h)	Ptc (mm)	I (mm/h)	Ptc (mm)	I (mm/h)	Ptc (mm)	I (mm/h)
1	13.9	13.9	25.9	25.9	30.5	30.5	36.4	36.4	40.8	40.8	55.5	55.5
5	21.2	4.3	39.5	7.9	46.5	9.3	55.5	11.1	62.3	12.5	84.6	16.9
7	23.2	3.3	43.1	6.2	50.8	7.3	60.6	8.7	68.0	9.7	92.4	13.2
10	25.5	2.6	47.4	4.7	55.7	5.6	66.5	6.7	74.7	7.5	101.5	10.2
13	27.3	2.1	50.7	3.9	59.7	4.6	71.3	5.5	80.0	6.2	108.7	8.4
15	28.3	1.9	52.7	3.5	62.0	4.1	74.0	4.9	83.0	5.5	112.8	7.5
17	29.3	1.7	54.4	3.2	64.0	3.8	76.5	4.5	85.8	5.1	116.6	6.9
20	30.5	1.5	56.8	2.8	66.8	3.3	79.8	4.0	89.5	4.5	121.7	6.1
21.5	31.1	1.5	57.8	2.7	68.1	3.2	81.3	3.8	91.2	4.3	123.9	5.8
22	31.3	1.4	58.2	2.7	68.5	3.1	81.8	3.7	91.8	4.2	124.7	5.7
24	32.0	1.3	59.6	2.5	70.1	2.9	83.7	3.5	93.9	3.9	127.6	5.3

Table 6 Determination of short-term precipitation and rainfall intensity for 10-year, 20-year, 50-year, 100-year, and 1000-year return periods (station 050301)

Return period T	2		10		20		50		100		1000	
Frequency	0.5		0.9		0.95		0.98		0.99		0.999	
Time (hours)	Ptc (mm)	I (mm/h)	Ptc (mm)	I (mm/h)	Ptc (mm)	I (mm/h)	Ptc (mm)	I (mm/h)	Ptc (mm)	I (mm/h)	Ptc (mm)	I (mm/h)
1	15.3	15.3	25.1	25.1	28.9	28.9	33.7	33.7	37.4	37.4	49.4	49.4
5	28.4	5.7	46.7	9.3	53.6	10.7	62.7	12.5	69.4	13.9	91.8	18.4
7	32.3	4.6	53.1	7.6	61.1	8.7	71.3	10.2	79.0	11.3	104.5	14.9
10	37.1	3.7	60.9	6.1	70.0	7.0	81.8	8.2	90.7	9.1	119.9	12.0
13	41.0	3.2	67.4	5.2	77.5	6.0	90.5	7.0	100.3	7.7	132.6	10.2
15	43.3	2.9	71.2	4.8	81.9	5.5	95.7	6.4	106.0	7.1	140.1	9.3
17	45.5	2.7	74.7	4.4	85.9	5.1	100.4	5.9	111.2	6.5	147.1	8.7
20	48.4	2.4	79.6	4.0	91.5	4.6	106.9	5.3	118.4	5.9	156.6	7.8
21.5	49.7	2.3	81.7	3.8	94.0	4.4	109.8	5.1	121.7	5.7	160.9	7.5
22	50.2	2.3	82.5	3.8	94.9	4.3	110.9	5.0	122.8	5.6	162.4	7.4
24	51.9	2.2	85.3	3.6	98.1	4.1	114.6	4.8	127.0	5.3	167.9	7.0

Table 7 Determination of short-term precipitation and rainfall intensity for 10-year, 20-year, 50-year, 100-year, and 1000-year return periods (station 050703)

Return period T	2		10		20		50		100		1000	
Frequency	0.5		0.9		0.95		0.98		0.99		0.999	
Time (hours)	Ptc (mm)	I (mm/h)	Ptc (mm)	I (mm/h)	Ptc (mm)	I (mm/h)	Ptc (mm)	I (mm/h)	Ptc (mm)	I (mm/h)	Ptc (mm)	I (mm/h)
1	13.0	13.0	21.6	21.6	24.9	24.9	29.2	29.2	32.4	32.4	43.0	43.0
5	16.6	3.3	27.8	5.6	32.0	6.4	37.5	7.5	41.6	8.3	55.2	11.1
7	17.5	2.5	29.2	4.2	33.7	4.8	39.5	5.6	43.8	6.3	58.2	8.3
10	18.5	1.9	30.9	3.1	35.6	3.6	41.8	4.2	46.3	4.6	61.5	6.2
13	19.3	1.5	32.2	2.5	37.1	2.9	43.5	3.3	48.3	3.7	64.1	4.9
15	19.7	1.3	32.9	2.2	37.9	2.5	44.5	3.0	49.3	3.3	65.5	4.4
17	20.1	1.2	33.6	2.0	38.7	2.3	45.3	2.7	50.3	3.0	66.8	3.9
20	20.6	1.0	34.4	1.7	39.7	2.0	46.5	2.3	51.6	2.6	68.5	3.4
21.5	20.9	1.0	34.8	1.6	40.1	1.9	47.0	2.2	52.2	2.4	69.2	3.2
22	20.9	1.0	34.9	1.6	40.3	1.8	47.2	2.1	52.4	2.4	69.5	3.2
24	21.2	0.9	35.4	1.5	40.8	1.7	47.8	2.0	53.1	2.2	70.4	2.9

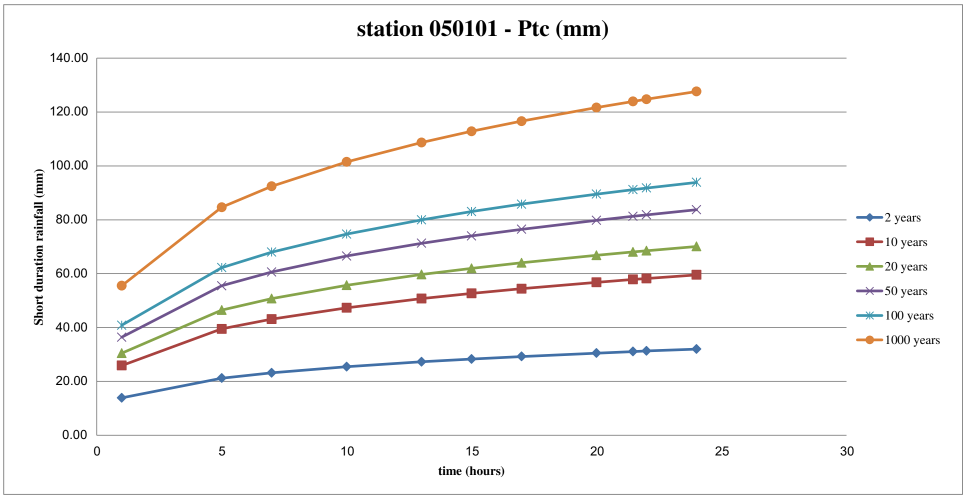

Fig. 5 Short-term rainfall Ptc (mm) curves for different return periods of station 050101

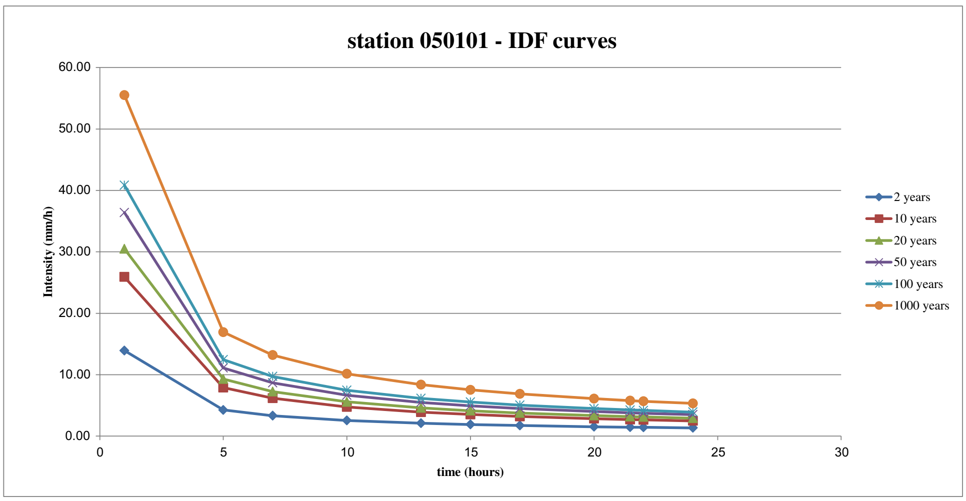

Fig. 6 IDF curves for different return periods of station 050101

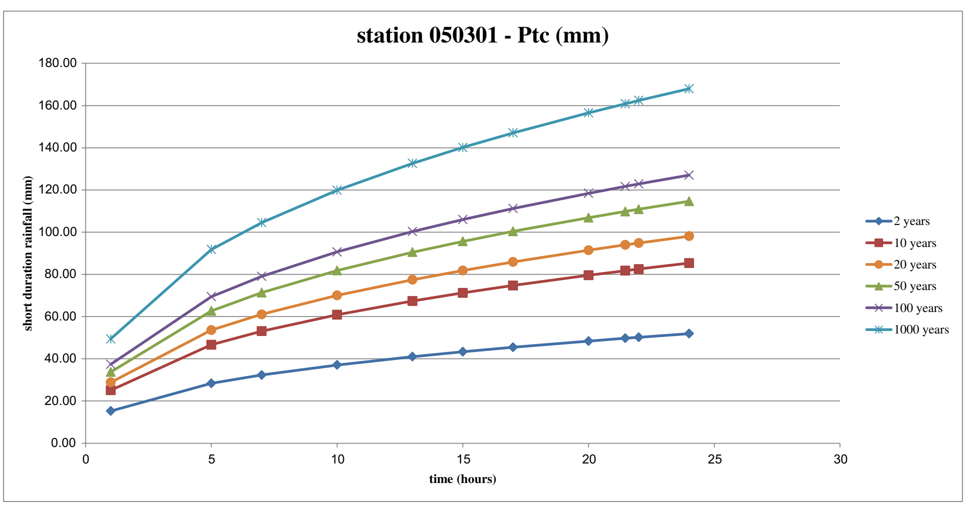

Fig. 7 Short-term rainfall Ptc (mm) curves for different return periods of station 050301

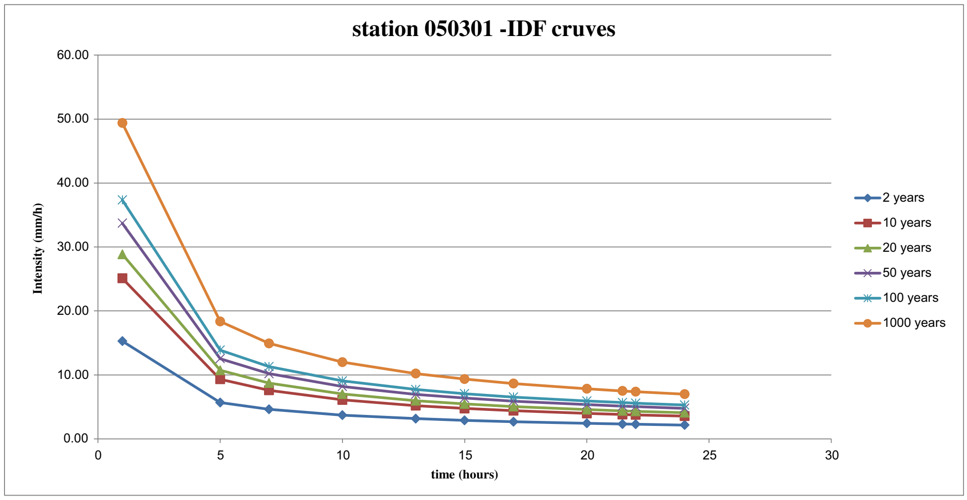

Fig. 8 IDF curves for different return periods of station 050301

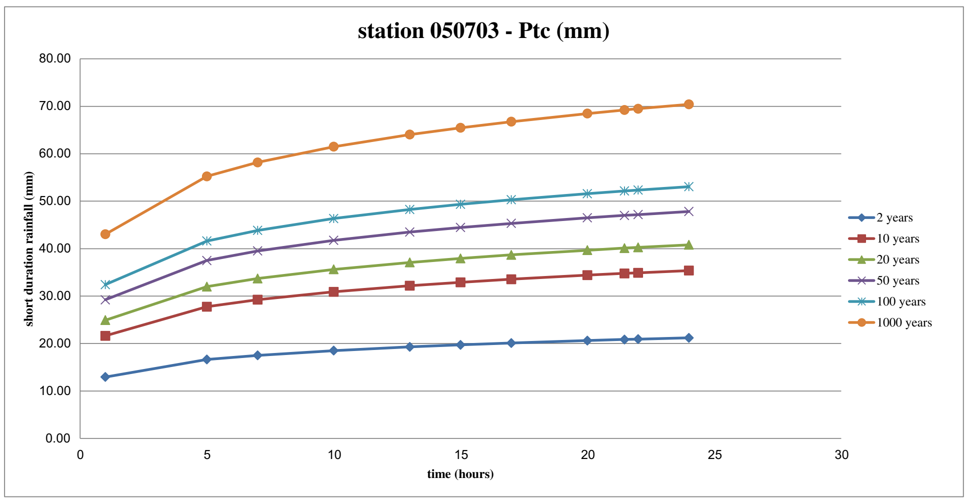

Fig. 9 Short-term rainfall Ptc (mm) curves for different return periods of station 050703

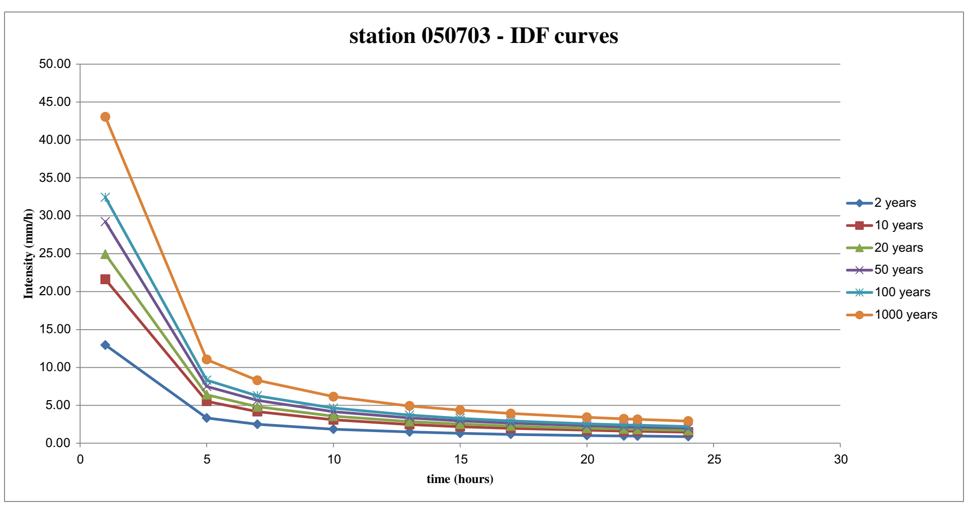

Fig. 10 IDF curves for different return periods of station 050703

Table 8 Results of flood discharges assessment using the Gradex method for the three stations 050101, 050301, and 050703

Return period *T*	Station code	Precipitation amount (mm)	*P*max,*d* (mm)	Reduced variable	Discharge amount (m^3/s)	Peak flow (m^3/s)
10 years RP	050101	14.6	59.6	2.3	1043.0	2373.9
	050301	17.7	85.3	2.3	1265.8	2893.8
	050703	7.5	35.4	2.3	536.9	1226.7
20 years RP	050101	14.6	70.1	3.0	1043.0	3124.8
	050301	17.7	98.1	3.0	1265.8	3804.9
	050703	7.5	40.8	3.0	536.9	1613.1
50 years RP	050101	14.6	83.7	3.9	1043.0	4096.5
	050301	17.7	114.6	3.9	1265.8	4984.3
	050703	7.5	47.8	3.9	536.9	2113.4
100 years RP	050101	14.6	93.9	4.6	1043.0	4824.8
	050301	17.7	127.0	4.6	1265.8	5868.1
	050703	7.5	53.1	4.6	536.9	2488.2
1000 years RP	050101	14.6	127.6	6.9	1043.0	7231.1
	050301	17.7	167.9	6.9	1265.8	8788.3
	050703	7.5	70.4	6.9	536.9	3726.9

Table 9 Results of flood discharge assessment through comparative empirical analysis for different return periods (10-year, 20-year, 50-year, 100-year, and 1000-year)

		Peak flow (m^3/s)				
	Station code	Giandotti	Possenti	Turazza	Temez	Average value
10-year RP	050101	2073.2	2295.1	1901.3	2205.4	2118.7
	050301	2929.6	3288.4	2724.1	3131.1	3018.3
	050703	1246.8	1363.8	1129.8	1332.5	1268.2
20-year RP	050101	2439.4	2700.5	2516.8	2919.4	2644.0
	050301	3368.0	3780.4	3523.2	4049.5	3680.3
	050703	1437.6	1572.5	1465.5	1728.5	1551.0
50-year RP	050101	2913.4	3225.3	3673.8	4261.5	3518.5
	050301	3935.3	4417.2	5031.5	5783.2	4791.8
	050703	1684.5	1842.7	2098.9	2475.5	2025.4
100-year RP	050101	3268.7	3618.6	4496.5	5215.8	4149.9
	050301	4360.5	4894.5	6082.0	6990.5	5581.9
	050703	1869.6	2045.1	2541.3	2997.2	2363.3
1000-year RP	050101	4442.4	4918.0	6620.5	7679.6	5915.1
	050301	5765.4	6471.4	8711.6	10013.0	7740.3
	050703	2481.0	2714.0	3653.4	4308.9	3289.3

of flash floods which implies the knowledge of peak flow of several return periods. Hydraulic modeling can be performed using HEC-RAS software, which helps to reveal the overflow extension specifically for the 100-year and 1000-year return periods.

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Code availability Not applicable

Declarations

Consent to participate The authors voluntarily agree to participate in this research study. The authors had the purpose and nature of the study explained to them in writing and they have opportunity to ask questions about the study.

Consent for publication The authors warrant that the work has not been published before in any form except as a preprint, that the work is not being currently submitted to and is not under consideration by another publisher, and that the persons listed above are listed in the proper order. The authors also warrant that the work does not libel anyone, infringe anyone's copyright, or otherwise violate anyone's statutory or common law rights.

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