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Evaluation Of Flows From The Rainfall For A Forecast Of Floods In The Bafing River Watershed At Mamou In The Republic Of Guinea

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Abstract – The purpose of this research is to transform the series of rainfall observations from the Mamou meteorological station in the Republic of Guinea into flows for flood forecasting in the watershed of the Bafing River. We used the rational method for this transformation of rains into flows. After this transformation, we made a graphical representation of the cumulative annual flows over the 42 years of observations (1971-2012), in order to know the year in which there was the maximum flow that we consider to be the year of flooding of the watershed. Then, determine the period at which this flood flow can be repeated on the bed of the stream. According to our calculations, we have used two years for the analysis of flood phenomena on the Bafing River. This choice fell on the years 1976 and 2009 when the maximum flows are respectively 33,594.8 m^3/s and 32,599.4 m^3/s. The analyzes around these two years show that the flood was observed in 2020 for the year 1976 and it will take place in 2031 for the forecast from 2009. The graph representing the two flood periods has been presented, the flow was maximum in September in 1976 and maximum in August in 2009, with the respective values of 6628.6 m^3/s and 11394.6 m^3/s.

Keywords – Assessment, flows, rainfall, forecast, floods, Bafing, Guinea.

I. INTRODUCTION

Predicting flood risks is a crucial part of flood risk assessment, management of flood risk plans, and design of flood protection measures [1]. In the European Union (EU), a standard of flood mapping procedure has been established by the European Flood Directive (2007/60 / EC) [2], which explicitly specifies what types of floods, parameters of flood Floods and flood frequencies should be taken into account when assessing flood risk. Due to the increasing number of natural disasters, there is growing interest in the EU regarding floods resulting directly from heavy rains, commonly referred to as storm floods [3]. In addition, due to a highly interconnected rain-runoff process, as well as the rapid advancement in computational technology and the availability of high-resolution topographic data [4], storm floods are now simulated using integrated hydrologico-hydraulic methods [3,5–8]. However, a reliable flood prediction in small ungauged watersheds remains difficult due to the lack of field observations needed to calibrate the models [9–12]. There are two main approaches for the assessment of floods in ungauged watersheds: and the continuous simulation method [13]. The event-based methods simulate the precipitation runoff transformation of a design rainfall hyetograph of a given duration and return period [14], while the continuous simulation methods are based on a similar transformation of 'a long (synthetic) time series rainfall and subsequent analysis of the flood results to obtain a hydrograph of a return period [15]. Event methods are more widely adopted and applied in practical engineering because of their simplicity, the availability of data on rain events and the time required to perform the simulations. However, in event-based approaches, one of the main sources of uncertainty is hydrological data [11,13,15]. In particular, precipitation input data, generally defined as a hyetograph - a temporal distribution of precipitation intensities - directly affects runoff and water depths, water velocities and corresponding flow rates [16,17]. It is with this in mind that we have proposed the theme entitled: Evaluation of flows from rains for a flood forecast in the watershed of the Bafing River at Mamou in the Republic of Guinea.

II. Materials and Method

2.1. Materials

To carry out this research, we used meteorological data from the Mamou meteorological station for a 42-year observation series (1971-2012) and statistical calculations from advanced Excel software. These data are reported in Table 1.

Table 1: Precipitation of the Mamou meteorological station (1971-2012) in mm/h

Yea/Mont	Jan	Feb	Mar	Apr	Mai	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Sum ann
1971	0,0	0,0	10,7	156,3	107,5	231,4	229,8	421,5	317,2	115,2	107,1	42,9	1739,6
1972	0,0	0,0	25,4	85,7	125,3	255,7	234,1	282,4	227,1	281,2	17,8	0,0	1534,7
1973	0,0	0,0	0,0	105,0	261,3	115,6	248,0	411,7	370,6	230,8	54,6	0,0	1797,6
1974	0,0	0,0	0,0	23,6	112,6	239,6	390,5	476,9	301,8	152,5	43,8	0,0	1741,3
1975	0,0	0,0	26,5	102,7	109,8	117,1	390,3	357,9	442,5	218,4	30,8	0,0	1796,0
1976	0,0	41,7	13,3	162,3	197,4	294,6	214,6	354,1	438,4	377,4	90,9	0,0	2184,7
1977	0,8	0,0	15,4	31,5	150,4	173,1	404,6	359,2	324,9	182,0	3,1	12,9	1657,9
1978	25,0	3,1	48,4	111,9	150,5	12,9	423,6	393,1	294,8	246,2	0,8	0,0	1710,3
1979	0,0	0,0	21,2	61,7	154,1	285,6	307,4	394,6	210,1	147,0	23,5	0,0	1605,2
1980	0,0	8,2	0,0	78,7	135,6	117,3	269,4	358,7	286,9	144,0	87,6	0,0	1486,4
1981	0,0	9,5	98,6	46,5	203,1	206,5	332,2	400,2	350,5	186,7	0,0	0,0	1833,8
1982	0,0	0,0	41,8	89,6	87,4	134,8	304,4	359,4	268,8	236,3	62,8	0,0	1585,3
1983	0,0	2,3	6,2	27,2	205,6	273,4	295,3	426,4	266,1	226,4	38,3	0,0	1767,2
1984	0,0	0,0	72,3	64,9	132,6	290,6	430,4	323,6	333,7	215,3	56,8	0,0	1920,2
1985	5,2	6,3	4,0	56,5	78,0	153,9	302,6	614,2	223,9	155,9	22,5	0,0	1623,0
1986	0,0	9,8	0,0	60,9	129,2	117,4	285,6	491,6	359,3	135,5	52,2	0,0	1641,5
1987	0,0	0,0	0,1	19,8	204,8	189,1	195,9	360,4	338,4	165,0	0,3	7,1	1480,9
1988	0,0	0,0	0,6	41,5	137,5	207,5	369,6	331,6	264,4	118,5	84,4	0,0	1555,6
1989	0,0	3,3	19,0	81,7	169,1	185,3	290,7	410,9	304,2	84,5	45,8	0,0	1594,5
1990	0,0	0,0	0,0	47,1	139,6	170,5	283,3	378,2	398,2	194,8	45,2	12,8	1669,7
1991	2,9	10,0	9,4	42,6	40,3	269,8	232,5	444,6	169,5	223,4	2,4	1,3	1448,7
1992	0,0	19,0	0,0	47,6	155,1	141,5	359,9	424,1	316,0	254,8	18,0	0,0	1736,0
1993	0,0	6,2	5,1	60,3	158,7	228,0	323,6	279,5	259,5	163,4	105,8	0,0	1590,1
1994	0,0	0,0	2,2	18,9	206,2	267,5	387,2	370,6	557,7	197,5	31,0	0,0	2038,8
1995	0,0	0,1	73,7	57,2	102,2	118,8	287,0	528,1	235,4	304,6	9,9	6,0	1723,0
1996	7,9	0,8	16,4	90,5	184,5	242,6	356,6	497,0	454,4	153,8	2,9	0,0	2007,4
1997	0,0	0,0	0,0	104,3	182,7	193,4	235,2	296,0	335,9	223,7	30,2	0,2	1601,6
1998	0,8	9,4	29,9	55,2	138,6	242,2	327,7	462,9	356,0	314,3	0,0	0,0	1937,0
1999	0,1	0,0	14,3	88,4	180,7	270,5	322,0	463,5	422,4	283,7	38,4	0,0	2084,0
2000	70,5	0,3	1,4	79,8	134,2	146,0	401,9	329,5	320,4	324,3	144,6	0,0	1952,9
2001	0,0	0,0	0,0	92,2	90,5	269,3	328,7	421,5	394,9	160,9	39,7	0,0	1797,7
2002	1,8	0,0	2,0	60,1	127,0	214,5	335,3	226,3	213,1	206,9	36,6	0,0	1423,6

2003	0,0	0,0	12,6	50,7	239,6	211,4	227,6	365,4	474,0	176,3	8,7	0,0	1766,3
2004	0,0	0,1	31,8	111,0	46,0	204,0	326,5	410,3	277,5	115,8	154,2	0,0	1677,2
2005	1,4	3,4	52,2	69,9	163,2	227,4	200,3	441,4	318,4	79,8	4,4	0,0	1561,8
2006	8,5	0,5	20,9	263,8	172,6	172,6	334,6	280,4	396,4	214,4	9,7	0,0	1874,4
2007	0,0	0,4	0,0	11,1	114,9	129,2	403,2	462,2	318,3	196,5	43,7	3,8	1683,3
2008	0,0	29,3	56,8	125,7	133,1	208,0	391,7	382,7	259,4	144,8	0,0	12,7	1744,2
2009	0,0	0,0	23,2	59,7	121,9	235,6	315,0	729,3	328,5	260,8	33,7	0,0	2107,7
2010	0,0	7,7	1,4	190,2	101,2	223,1	326,6	359,7	500,3	292,8	16,5	13,6	2033,1
2011	17,7	0,0	61,4	78,9	143,6	308,0	215,8	350,4	416,7	125,8	71,1	0,0	1789,4
2012	0	0	19,1	119,6	147,8	260,2	315,3	518,5	323,2	279,9	96,3	0,0	2079,9

2.2. Method

For the transformation of rainfall into flow, we used the rational method for this study. This method is expressed by the relation [18-24]:

$$Q = K.C.I.A \quad (1)$$

Or:

Q : est le débit en m^3/s ;

K : is the conversion factor, taken equal to 0.0028 ;
C : is the runoff coefficient between 0 and 1 ;
I : is the intensity of precipitation in mm/h;
A : is the area of the watershed, for this specific case, it is equal to 15.000 km^2.

2.2.1. Determination of the probability of exceeding

The extreme hydrological events that can cause problems are of different types (flood, snowstorm or ice storm, etc.). It is the value of the flow that can cause flooding or an overflow of the capacity of a spillway. This probability P of overshoot is determined by the Weibull formula [25-27]:

$$P(X \geq X_m) = \frac{m}{N+1} \quad (2)$$

2.2.2. Determination of the flood return period

The return period T of an event is the inverse of the probability of exceeding P.

$$T = \frac{1}{P} \quad (3)$$

III. RESULTS AND DISCUSSION

By applying relation (1) to the meteorological data in Table 1, we obtain the monthly flow rates of the stream which are recorded in Table 2.

Table 2: Monthly flows of the observation series on the Bafing River (1971-2012) in m3/s

Year/Mont	Qjan	Qfev	Qmar	Qav	Qmai	Qjun	Qjul	Qaug	Qsep	Qoct	Qnov	Qdec	Sn
1971	0	0	167,2	2363,3	1679,6	3498,8	3590,4	6585,5	4796,1	1799,9	1619,4	670,3	26770,5
1972	0	0	396,8	1295,8	1957,7	3866,2	3657,6	4412,2	3433,8	4393,5	269,1	0	23682,7
1973	0	0	0	1587,6	4082,6	1747,9	3874,8	6432,4	5603,5	3606	825,6	0	27760,4
1974	0	0	0	356,8	1759,3	3622,8	6101,2	7451,1	4563,2	2382,7	662,3	0	26899,4

1975	0	0	414	1552,8	1715,5	1770,6	6098	5591,8	6690,6	3412,3	465,7	0	27711,3
1976	0	609,5	207,8	2454	3084,2	4454,4	3352,9	5532,5	6628,6	5896,5	1374,4	0	33594,8
1977	12,5	0	240,6	476,3	2349,8	2617,3	6321,5	5612,1	4912,5	2843,6	46,9	201,5	25634,6
1978	390,6	45,3	756,2	1691,9	2351,4	195	6618,3	6141,8	4457,4	3846,6	12,1	0	26506,6
1979	0	0	331,2	932,9	2407,7	4318,3	4802,8	6165,2	3176,7	2296,7	355,3	0	24786,8
1980	0	119,9	0	1189,9	2118,6	1773,6	4209,1	5604,3	4337,9	2249,9	1324,5	0	22927,7
1981	0	138,9	1540,5	703,1	3173,2	3122,3	5190,3	6252,7	5299,6	2917	0	0	28337,6
1982	0	0	653,1	1354,8	1365,5	2038,2	4755,9	5615,3	4064,3	3692	949,5	0	24488,6
1983	0	33,6	96,9	411,3	3212,3	4133,8	4613,8	6662,1	4023,4	3537,3	579,1	0	27303,6
1984	0	0	1129,6	981,3	2071,7	4393,9	6724,6	5055,9	5045,5	3363,8	858,8	0	29625,1
1985	81,2	92,1	62,5	854,3	1218,7	2327	4727,8	9596,3	3385,4	2435,8	340,2	0	25121,3
1986	0	143,2	0	920,8	2018,6	1775,1	4462,2	7680,8	5432,6	2117,1	789,3	0	25339,7
1987	0	0	1,6	299,4	3199,8	2859,2	3060,7	5630,9	5116,6	2578	4,5	110,9	22861,6
1988	0	0	9,4	627,5	2148,3	3137,4	5774,6	5180,9	3997,7	1851,4	1276,1	0	24003,3
1989	0	48,2	296,9	1235,3	2642	2801,7	4541,9	6419,9	4599,5	1320,2	692,5	0	24598,1
1990	0	0	0	712,2	2181,1	2578	4426,3	5909	6020,8	3043,6	683,4	200	25754,4
1991	45,3	146,2	146,9	644,1	629,6	4079,4	3632,6	6946,4	2562,8	3490,4	36,3	20,3	22380,3
1992	0	277,7	0	719,7	2423,3	2139,5	5623,1	6626,1	4777,9	3981	272,2	0	26840,5
1993	0	90,6	79,7	911,7	2479,5	3447,4	5055,9	4366,9	3923,6	2553	1599,7	0	24508
1994	0	0	34,4	285,8	3221,7	4044,6	6049,6	5790,3	8432,4	3085,7	468,7	0	31413,2
1995	0	1,5	1151,5	864,9	1596,8	1796,3	4484,1	8251	3559,2	4759,1	149,7	93,7	26707,8
1996	123,4	11,7	256,2	1368,4	2882,6	3668,1	5571,5	7765,1	6870,5	2403	43,8	0	30964,3
1997	0	0	0	1577	2854,5	2924,2	3674,8	4624,7	5078,8	3495,1	456,6	3,1	24688,8
1998	12,5	137,4	467,2	834,6	2165,5	3662,1	5120	7232,3	5382,7	4910,6	0	0	29924,9

1999	1,6	0	223,4	1336,6	2823,3	4090	5030,9	7241,7	6386,7	4432,5	580,6	0	32147,3
2000	1101,5	4,4	21,9	1206,6	2096,7	2207,5	6279,3	5148,1	4844,4	5066,9	2186,4	0	30163,7
2001	0	0	0	1394,1	1414	4071,8	5135,6	6585,5	5970,9	2513,9	600,3	0	27686,1
2002	28,1	0	31,2	908,7	1984,2	3243,2	5238,7	3535,7	3222,1	3232,6	553,4	0	21977,9
2003	0	0	196,9	766,6	3743,5	3196,4	3556	5709	7166,9	2754,5	131,5	0	27221,3
2004	0	1,5	496,8	1678,3	718,7	3084,5	5101,2	6410,5	4195,8	1809,3	2331,5	0	25828,1
2005	21,9	49,7	815,6	1056,9	2549,8	3438,3	3129,5	6896,4	4814,2	1246,8	66,5	0	24085,6
2006	132,8	7,3	326,5	3988,7	2696,7	2609,7	5227,8	4381	5993,6	3349,8	146,7	0	28860,6
2007	0	5,8	0	167,8	1795,2	1953,5	6299,6	7221,4	4812,7	3070,1	660,7	59,4	26046,2
2008	0	428,2	887,4	1900,6	2079,6	3145	6119,9	5979,3	3922,1	2262,4	0	198,4	26922,9
2009	0	0	362,5	902,7	1904,6	3562,3	4921,6	11394,6	4966,9	4074,7	509,5	0	32599,4
2010	0	112,5	21,9	2875,8	1581,1	3373,3	5102,8	5620	7564,5	4574,7	249,5	212,5	31288,6
2011	276,5	0	959,3	1193	2243,6	4657	3371,7	5474,6	6300,5	1965,5	1075	0	27516,7
2012	0	0	298,4	1808,4	2309,2	3934,2	4926,2	8101	4886,8	4373,2	1456,1	0	32093,5

The relation (2) applied to the different values of the cumulative flows classified in decreasing order of magnitude made it possible to determine the probabilities of exceeding are reported in Table 3.

Table 3: Cumulative annual flows in decreasing order and the probability of exceeding

Rank	Debits [m^3/s]	Probability	Rank	Debits [m^3/s]	Probability
1976	33594,8	0,02325581	1971	26770,5	0,51162791
2009	32599,4	0,04651163	1995	26707,8	0,53488372
1999	32147,3	0,06976744	1978	26506,6	0,55813953
2012	32093,5	0,09302326	2007	26046,2	0,58139535
1994	31413,2	0,11627907	2004	25828,1	0,60465116
2010	31288,6	0,13953488	1990	25754,4	0,62790698
1996	30964,3	0,1627907	1977	25634,6	0,65116279
2000	30163,7	0,18604651	1986	25339,7	0,6744186
1998	29924,9	0,20930233	1985	25121,3	0,69767442
1984	29625,1	0,23255814	1979	24786,8	0,72093023
2006	28860,6	0,25581395	1997	24688,8	0,74418605
1981	28337,6	0,27906977	1989	24598,1	0,76744186
1973	27760,4	0,30232558	1993	24508	0,79069767
1975	27711,3	0,3255814	1982	24488,6	0,81395349
2001	27686,1	0,34883721	2005	24085,6	0,8372093

2011	27516,7	0,37209302	1988	24003,3	0,86046512
1983	27303,6	0,39534884	1972	23682,7	0,88372093
2003	27221,3	0,41860465	1980	22927,7	0,90697674
2008	26922,9	0,44186047	1987	22861,6	0,93023256
1974	26899,4	0,46511628	1991	22380,3	0,95348837
1992	26840,5	0,48837209	2002	21977,9	0,97674419

Figure 1 illustrates the graphical representation of the annual cumulative discharges of the 42-year observation series based on the data in Table 2. According to this figure, we see that the greatest floods took place in 1976 and 2009 with the respective values of 33,594.8 m^3/s and 32,599.4 m^3/s.

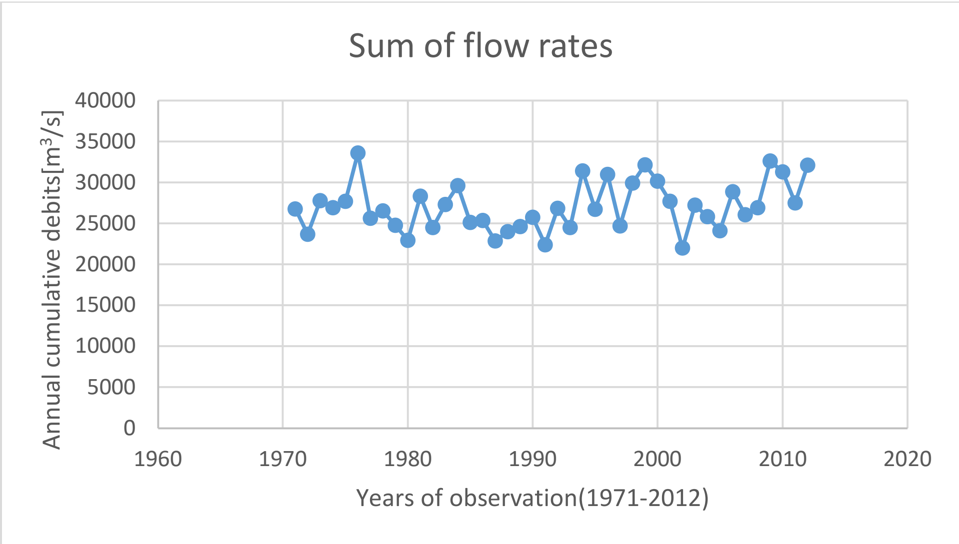

Figure 1: Interannual cumulative flow curves of the observation series

According to the results of Table 3, we have retained the first two years of floods for our analysis of flood forecasting on the Bafing River, that is to say the years 1976 and 2009. The values of the monthly flows of these two years are reported in Table 4.

Table 4: Monthly flows for the first two flood periods (1976-2009)

Year/Month	Qjan	Qfev	Qmar	Qav	Qmai	Qjun	Qjul	Qaug	Qsep	Qoct	Qnov	Qdec
1976	0	609,5	207,8	2454	3084,2	4454,4	3352,9	5532,5	6628,6	5896,5	1374,4	0
2009	0	0	362,5	902,7	1904,6	3562,3	4921,6	11394,6	4966,9	4074,7	509,5	0

Figure 2 shows the graph of the monthly flows for the two periods selected for the analyzes of flood phenomena on the Bafing River at Mamou in the Republic of Guinea from the data in Table 4, in order to predict the return of floods on this river. We find that the flow was maximum in September in 1976 and maximum in August in 2009, with the respective values of 6628.6 m^3/s and 11394.6 m^3/s.

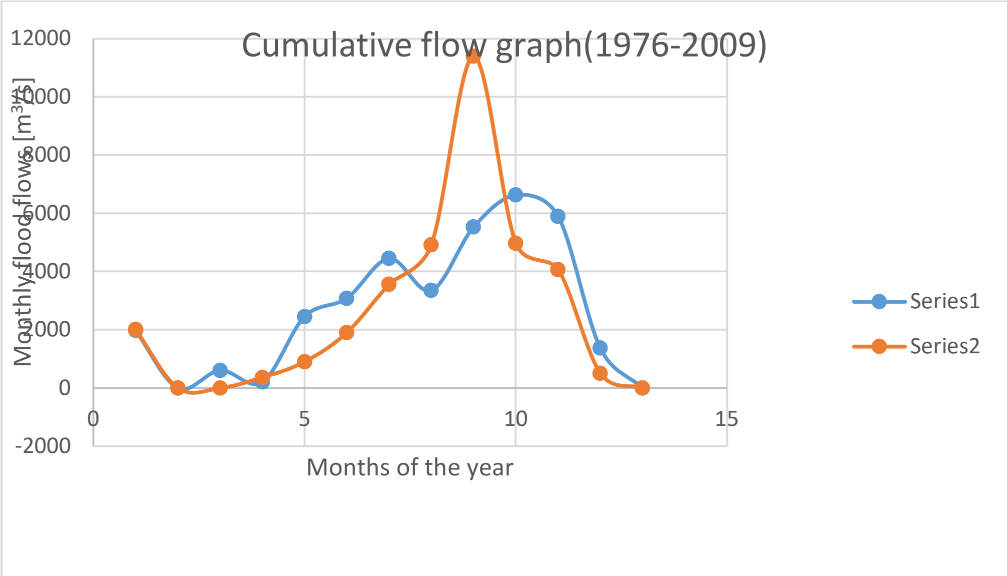

Figure 2: Curves of monthly flood discharges

From relation (3), we successively calculated the two periods of flood return on the catchment area of the Bafing river. This calculation allowed us to find respectively T = 44 years and T = 22 years for the years 1976 and 2009. This determination shows us that the flood was observed in 2020 for the year 1976 and it will take place in 2031 for the year 2009.

IV. Conclusion

This research allowed us to determine the flows from rainfall data collected from the National Meteorological Directorate of the Republic of Guinea for forty-two years (42 years) of observations. During this research, we retained the first two years of flooding in order to make a forecast on the possible return of a new flood on the site of the Bafing river basin. Next, we have shown the graph of the two flood periods whose maximum monthly flows are observed in September and August with respective values of 6628.6 m^3/s and 11394.6 m^3/s. The analyzes around these two years show that the flood was observed in 2020 for the year 1976 and it will take place in 2031 for the forecast from 2009. In perspective of this study, we intend to expand this research on the watershed. of the Niger river.

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