Available online at www.elixirpublishers.com (Elixir International Journal)

Agriculture

Elixir Agriculture 39 (2011) 4956-4959

ISSN: 2229-712X

Estimation and comparison of maximum instantaneous flood discharge using experimental method in small watersheds

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ARTICLE INFO

Article history:

Received: 1 August 2011;

Received in revised form: 22 September 2011;

Accepted: 29 September 2011;

Keywords

Maximum discharge,
Flood estimation,
Small watershed,
Curve number,
RMSE.

ABSTRACT

Flood discharge is one of important factors in designs and hydrological works. Because of non-facilities and non-hydrometric equipment in basins without statistics or with deficient statistics especially in small watersheds, estimation of maximum instantaneous flood discharge is one of main problems in watershed projects. In this stud with the aim of determination of acceptable method to estimate maximum instantaneous flood discharge in small watersheds, two methods one base to basin area and other based to physiographical feature and precipitation were studied. The results showed that among methods related to basin area, Horton method with residual sum of squares 2.8(RMSE=2.8) and among methods related to basin- physiographical feature and precipitation, curve number with RMSE=20.6 had least error .so, determined as the best methods. FHWA method because of having most amount of RMSE=5924.5 had the least efficiency for determination of peak discharge in this area.

Introduction

Nowadays due to imbalance environmental issues and degradation caused by human activities, there is many problems in order to floods harness and each year floods in addition to loss of life and financial losses, entered many Damages to the agricultural lands. Therefore, the need for research in matters related to flood control and predict has been done such as feeling and actions in this field. In further designing construction of water is very important such as Spillway, Hungarian wastewater, design of flood control and program engineering at the watershed, discharge maximum moment (15 and 8) Therefore, choosing appropriate methods, according to basin conditions and characteristics that a small watershed are digested normally or without water or they have defect statistics, is inevitable.

For this purpose, have been presented methods and mathematical equations that many of the most need important ones can make satisfy, including methods based on area - field, Methods based on basin Gita reticulum characteristics, characteristics basin, rainfall conditions, mentioned genetic and factor equations (9). Using these methods should be limited to conditions that made enough information for to investigate statistics and the exact analysis is not available and evaluate each of which of them according to the conditions of the watershed country that To what extent have the performance The first step in selecting appropriate methods, are according to watershed conditions and characteristics. In the next step, these methods are evaluated and ultimately method that more efficient in estimated to be maximum discharge, marked and is recommended its use in the watershed with similar characteristics.

About Flood estimation have been done many researches in Iran. Salajegheh (1373) evaluate Most floods discharge in small basins and then has calibration of the empirical equation coefficients. Jafar zadeh(1378) has assessed methods based on the watershed area in the north of Iran (2). Telvary (1382) efficiency of some experimental methods such as Kriger, Horton and Fuller to estimate maximum flood has evaluated in the Karkheh basin and reached the conclusion that fuller Method because of consideration quantitative morphological land characteristics, vegetation and climate, the most appropriate method for estimating discharge flood has been in most sub region studied (1). Also the graphic method scs were evaluated on 19 watershed in Three regions of Northern Alborz, Azarbaijan and Qazvin and has Good results in two regions of Azerbaijan and Qazvin (9). For estimating the flood discharge maximum by using of runoff curve number technique also has been much research, including study can Bonta (1997) pointed out that by using of derivative distributions method has action to determine the runoff curve number (10).

Objective Of this study evaluated several Method for estimating of flood discharge maximum in the areas selective and choose the best Method for estimating it In small basins. In this study, four Method based on field area,two Method Selected based on field Gita reticulum characteristics and precipitation and their efficiency was evaluated in four watershed until be choose best it's. to investigate the size of precipitation method Selected based on field Gita reticulum characteristics and precipitation This four a watershed were chosen from one regions until be investigated better Efficiency these methods .

Material and methods

The study area

Kan watershed is located in the North West of Tehran on the slopes of Alborz (approximately longitude: 51.2 to 51.31 and latitude 35.74 to 35.98). The study area has a cold, dry weather too cold. Air Climatology effective has originated from area of the Mediterranean Sea and Atlantic Ocean. Annual

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rainfall in the study area is changed from 400 to 900 mm per year. Annual average daily temperature (annual) varies from -2.17to 44 ° C.

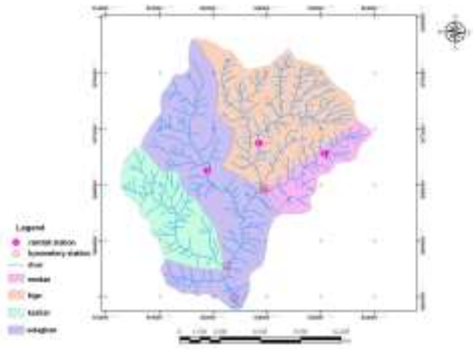

Figure 1 - Map kan Watershed

Methodology

In this study to determine the efficiency of selected methods, the study areas is divided into four areas below. Rainfall amounts of precipitation were taken from the nearest station. Then, using topographic maps 1:25000 were extracted physiographic features field. Physiographic characteristics of the following areas are presented in Table 1:

Rainfall in one field is divided into different sections, which in here pay to the rate of rainfall that becomes runoff. Estimating flood peak can be used several methods that their choice depends on the purpose of this study, statistics, specifications and important of plan. For this study has been used two series of methods to estimate flood levels based on field-based methods and physiographic properties and precipitation that explain any of the methods used are as follows:

Methods based on field level

1- Meier method

Mayer have provided the following equation for areas in the U.S. that has more than 70 square kilometers

$Q= 177.05 \ A^{۰/۵}$ (1)

Q=Maximum debit flood (m^3/s)

A= area(km^2)

2- mc elerit

Following equation have proposed based on the maximum recorded flood in the world :

$Q= (131000 \ A)/(107 + A)^{0.78}$ (2)

Q=Maximum debit flood (ft^3/s)

A= area (km^2)

3-Creager method

Creager, the following equation that is used for determining the most debit flood in large and small watershed, has provided:

$Q=46 \ CA\wedge(0.894A^{0.048})$ (3)

Q=Maximum debit flood (ft^3/s)

C= Creager coefficient, that, maximum value of C is equal to 200.

A= area (mil^2)

Creager coefficient field for the different return periods in the study area, are in Table 2. (Khalighi, 2005).

4- Horton method

Horton empirical relationship was presented as follows:

$Q= A71/2(T)^{0/25} \ /(A)^{-0/5}$ (4)

A= area (Km^2)

T= return period (year)

Q=Maximum debit flood (m^3/s)

Methods based on basin physiographic characteristics and precipitation

1- FWHA method

This method is presented for flood estimation in homogeneous watershed, small to medium with a focus on time 1 to 10 hours.

qp=quA.Q Logqu = C ۰ +C۱Logtc+ C ۲ $\log^2$tc) (5)

qp= Maximum debit flood(m^3/s)

A= area (Km^2)

Q= High precipitation surplus (cm)

Tc= time of concentration

2- curve number method

Calculation of maximum debit in the curve number method:

In the beginning to Calculation of maximum debit in the curve number method, obtains amount of runoff using following method:

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad (6)$$

$$S = \frac{25400}{CN} - 254 \qquad (7)$$

P is amount of rainfall during the 24 hour. Curve Number value (CN) is determined base on the soil profile, type of land productivity and previous soil moisture conditions that for the study area is the following:

Then, amoun of debit calculated base of following equation:

$$Q_{\max} = \frac{2.083A.Q}{t_p} \qquad (8)$$

That A is area (Km^2), Q runoff (cm) and t_p time to peak that obtains from following equation:

$$t_p = \sqrt{t_c} + 0.6t_c \qquad (9)$$

Cross-validation is applied to compare the prediction performance of the univariate and multivariate interpolation methods among one another.

Following Isaaks and Srivastava (1989), one scores were used: the RMSE computed as follows:

$$RMSE = \sum_{i=1}^{n} \sqrt{\frac{1}{n}(\hat{Z}(x_i) - Z(x_i))^2}, \qquad (10)$$

Where "n" corresponds to the number stations used in the study. Note, therefore, that these error measures are related to the spatial variability. Also the percentage of error in terms of RMSE was obtained. The RMSE is mainly a joint measure of bias in the mean and in the variance (spatial variance in our case), as obviously the square of individual difference between estimated and observed values put the emphasis on the errors in outliers or higher differences (Ashraf et al., 1997; Nalder and Wein, 1998). The RMSE errors give the possibility to analyze. The evaluation of these score provides the best method of evaluating the models giving the method variable.

Results

Using equation 1 and 2, show the greatest amount of flooding to areas of choice for Meier method and the Mmc Elerit is calculated. In the next stage, Using equation 10, the remaining sum of squares is calculated for both methods that is shown in Table 5.

We also calculated of flood and RMSE for Creager and Horton methods. This results show that the RMSE has declined too. The main reason that it can be seen as involving a return period of rainfall (table 6 and 7).

Using equation 5 and 8, the greatest amount of flooding to areas of choice for SCS and FWHA methods is calculated. There are many differences between the two methods. Probably because of this difference, is consider CN ratio.

Conclusion

Regarding to the sum of residual squares of area-based, error in Horton method is less than Krieger . in comparison with others watershed based method , because of return period and its interference in flood estimation Krieger has a significant difference. Krieger considered return period only in C coefficient whereas in Horton method it involved in all factors and this is the difference between them. Since that In Meier method and the Bride Ilirit , highest discharge determine upon surface area, hence with increasing in surface area estimated highest discharge has increased. Maximum errors (5438.3) was related to the solaghan sub basin in Bride ilirit method and minimum errors was in solaghan sub basin and Horton method in10-year return period (8/2RMSE =).

In Methods that are based on rainfall and physiographic characteristics, FHWA show the maximum error, while In selected areas lowest error rate is related to the SCS method. Since in SCS Method , correspondingly , flood discharge was calculate with its rainfall, thus the rate of error in comparison with methods based only on the surface area is reduced and maximum error is related to solaghan basin and minimum rate of error is related to keshar basin.

Yazdani (1385) evaluate several experimental approaches in the northern region of Azerbaijan, Iran, Alborz and 19 watershed basins and eventually conclude that if the information about the watershed and basin characteristics not available, the Horton method would be the best method for flood estimation. In all sub basin, evaluation of selected method showed that Horton method has a minimum error and maximum error is related to Krieger. obtained results showed that , among the methods based on surface area and among methods based on physiographic features and rainfall, Horton method and RMSE Were the best method and had the best performance respectively. FHWA method due to the highest RMSE has a low efficiency for peak discharge estimation in these area. Generally we can conclude that in basin that has not any data or has incomplete data, Horton method is the best method for estimate the instantaneous discharge .these results are concur with those of yazdani(1379).

References

Bonta J.V. 1997.Determination of Watershed Curve Number Using Derived Distribution. J. Irrig and Drain Eng.123 (1)28-36

Ghodsin, M., 1377. flood control and drainage engineering. authoring S.N.Gesh, Scientific Publishing Center works Tarbiat Modarres University.

Hawkins R.H. A.T. Hielmfelt and A.W.Zeranbergan .1985 . Runoff probability Storm Depth and Curve Numbers. J. Irrig and Drain Eng.111 (4):330-340

Hawkins R.H. and D.E.Woodward .1998.Local Source for Runoff Curve Numbers.11th Annual Symposium of the Arizona Hydrological society 214-219

Hotchkiss, R.H. and D.E. Mc Callum. 1995. Peak Discharge from SmallAgricultural Watershed, J. Hydraulic Eng. 121(1):36-48.

Jafarzadeh, Ali, 1378. Comparison of different methods to estimate maximum flood Dubai, Watershed Management MSc thesis, Department of Natural Resources, Tarbiat Modarres University, Tehran.

Khalighi Sigaroody, Shahram, 1375. Zoning district Creager factor in Iran, Watershed Management MSc thesis, Department of Natural Resources, Tehran University.

Khalili, Ali, 1362. Country's water master plan, identifying climate of Iran. Fundamental review of rainfall in Iran, volume 1, 2, Jamab Consulting Engineers.

Mahdavi, M., 1378. Applied Hydrology. Second edition, volume 2, Tehran University Press.

Mutreja, K.N. 1986. Applied Hydrology. TATA Mc GrawHill Publishing Company Ltd.New Dehli.1-257.

Najmaee, M., 1369. Hydrology Engineering, volume 1 and 2, Science and Technology University Press, 610 pp.

Salajegheh, Ali, 1373. Estimated peak flood in small areas, Watershed Management MSc thesis, Department of Natural Resources, Tehran University.

Silviera , L.F., Charbonnier and L. Genta. 2000. The Antecedent Soil Moisture Condition.Hydrological Sciences Journal. 45(3): 3-12.

Telvari, Abdolrasoul, 1382. Calibration and comparison of some methods used to estimate the maximum discharge in the watershed Karkheh, Ministry of Agriculture, Soil Conservation and Watershed Management Research Institute, Tehran.

USDA- Soil Conservation Service. 1975., Urban Hydrology for Small Watersheds.Technical Release No. 55, chapter 5, Washington, D.C., 85pp.

USDA- Natural Resources Conservation Service. 1998., Hydrology Calculation for Storm Runoff Discharge and Curve Number for Watershed, Report No: 5, 7pp.

Viessman, W.G. and L. Lewis. 1996. Introduction to Hydrology. 4th Ed. USA, 704 pp.

Yazdani, M., 1379. determine the maximum flood Dubai SCS graphics technique in small drainage basins. Watershed Management MSc thesis, Department of Natural Resources, Tarbiat Modarres University, Tehran.

Table1. Chariacstics of subbasin

subbasin	longitude	latitude	Main channel length(Km)	Area(Km^2)	Maximum height field(m)	Minimum height field(m)
Rendan	525644	3967570	12.3	68.35	3400	1800
Kiga	525734	3967681	9.7	21.65	3700	1800
Keshar	522949	3962128	12.48	34.61	3200	1600
solaghan	523587	3967681	20.8	20.46	3700	1400

Table 2. Creager coefficient field for the different return periods in the study area

return period(year)	2	5	10	25	50	100
Amount of coefficient C	1.23	2	2.58	3.38	4.03	4.72

Table3. Amount of C Cofficients

I_a/p	C_0	C_1	C_2
0.1	2.553	-0.61512	-0.16403
0.3	2.465	-0.62257	-0.11657
0.35	2.418	-0.61594	-0.0882
0.4	2.364	-0.5987	-0.05621
0.45	2.292	-0.57005	-0.02281
0.5	2.202	-0.51599	-0.01259

Table 4. Values CN subbasin

SUBBASIN	CN
Rendan	85
Kiga	85
Keshar	82
solaghan	85

Table 5. Amount RMSE for maximum debit flood in methods base on area of basin

SUBBASIN	mayer	Mc berid
Rendan	1591.7	2346
Kiga	894.9	828
Keshar	1132.9	1285.2
solaghan	2764.4	5438

Table 6. Amount RMSE for Horton method base of return period(year)

SUBBASIN	2	5	10	25	50	100
Rendan	3.4	3.9	5.7	9.6	13.4	18.1
Kiga	12.5	17.5	22.2	29.8	36.9	45.3
Keshar	7.4	11.4	15.1	21.2	26.8	33.4
solaghan	4.7	3.5	2.8	3.3	4.9	7.4

Table 7. Amount RMSE for Creager method base of return period(year)

SUBBASIN	2	5	10	25	50	100
Rendan	9.9	22.9	33	46.8	58.1	70.1
Kiga	3.5	8.6	12	19.2	24.3	29.8
Keshar	5.4	13.7	20	28.8	36	43.6
solaghan	31.4	57.4	77	104.1	126.1	149.5

Table 8. Amount RMSE for SCS and FWHA methods

SUBBASIN	SCS	FHWA
Rendan	62.4	5924
Kiga	21.2	273
Keshar	20.6	2936
solaghan	70.5	9499