AN APPRAISAL OF FLOOD OCCURRENCE AND VARABILITY IN STREAMFLOWS OF NULLAH DEG, NORTH EAST PUNJAB, PAKISTAN

[*]Muhammad Faisal[1], Ghulam Nabi[2], Tanveer Abbas[1], Muhammad Yaseen[3], Muhammad Waseem Boota[1]

[1] Student Centre of Excellence in Water Resources Engineering, University Of Engineering and Technology, Lahore, Pakistan

[2] Assistant Professor Centre of Excellence in Water Resources Engineering, University Of Engineering and Technology Lahore

[3] Lecturer Centre for Integrated and Mountain Research, University Of Punjab, Lahore, Pakistan

[*]Corresponding Author's email:engineerfaisi@gmail.com

ABSTRACT: *Floods are the number-one natural disaster in most of the countries of the world in terms of number of lives lost and property damage. They play overwhelming destruction and at some point caused untold torments like death toll, disturbance of human exercises, and harm to property, rural yields and health dangers. Flood frequency analysis of Nullah Deg was employed using the Gumbel distribution which is one of the probability distribution used to model stream flow. This was required by the need to secure lives and property at the downstream of the catchment zone. This distribution was however verified with Log-Pearson III distribution to establish the best fitting statistical measure for hydrological fluctuations using chi square test. Peak flow data from 1982-2014 of Nullah Deg was used for frequency analysis based on return periods of 2, 5, 10, 25, 50, 100, 200 and 1000 years. Gumbel probability distribution gave best result according to chi square test. From the trend line equation, R^2 gives a value of 0.573 which shows that Gumbel's distribution is suitable for predicting expected flow in the Nullah. For the given return periods following were the estimated flows using Gumbel distribution 403 m^3/s, 1026 m^3/s, 1344 m^3/s, 1591 m^3/s, 1824 m^3/s, 2056 m^3/s and 2602 m^3/s respectively. These values are useful for storm management in the area. Flow trends of Nullah Deg were checked using the discharge data of Monsoon seasons of high flow years from 2010-2014. Flow trend graphs showed that august was the highest peak flows month of Monsoon seasons. This study concluded that in Nullah Deg flood danger is always in the Monsoon season and month of august is more danger for floods. Finally frequency analysis and trend analysis were estimated and conclusions were commented.*

Keywords: Flood Frequency Analysis, Gumbel distribution, Log Pearson III distribution, Nullah Deg, Peak flow

INTRODUCTION

Flood is defined as, "overflowing by water of the typical confines of a stream or other waterway, or gathering of water by seepage over regions that are definitely not typically submerged." The assessment of peak flow of a design reoccurrence period is an essential task in various civil engineering projects such as those relating design of bridge openings and culverts, drainage systems, flood reprieve/protection structures, the valuation of flood danger and the determination of the 'finish-floor level' for both commercial and large-scale residential improvements .

[1] Studied that Frequency analysis is the technique for calculating the probability of occurrence of past and future events. The analysis of hydrological data requires that the data should be stationary, consistent and homogeneous. A time series of data is strictly stationary if its statistical properties (mean, variance) are unaffected by the choice of time origin. [2] Evaluated the flooding hazard of Kabul River under various flood conditions. Effect of sedimentation and backwater in proposed Kalabagh dam was also studied on River Kabul. The cross section data obtained with the help of Google Earth software. The water surface profile under various flood and geometry conditions was determined by using HEC-RAS software. It was concluded that under present condition the River Kabul is safe. The sedimentation and backwater effect of Kalabagh dam has insignificant effect on flooding at Nowshera..

[3] Attempted to evaluate various probability functions using 100 records representing the longest flood peak records in the United States. The Lognormal and Extreme value type-1(Gumble) probability functions were among those used and no Probability distribution gave consistently result.

[4] Used HEC-RAS model for floodplain delineation of the river reach from downstream of Darya Khan Bridge to Taunsa Barrage. He stated that HEC-RAS results with the use of Arc-GIS facilitated in the determining the inundation area.

[5] Conducted hydraulic analysis of 2010 flood of Kabul River from Amankot to Khairabad by Using Hydraulic Modeling. He concluded that HEC-RAS model provides realistic flood water level of the studied area.

Some parts of District Narowal, Sialkot and Tehsil Muridke has been the victim of severe flooding over the past many years with latest extreme in 2014 and are still at risk of it in future. Accurate estimates of magnitude and frequency of flood flows are needed for design and operation of water use and water control project. In spite of adopting the best and economically feasible structural methods for controlling floods. It is generally not possible to control them totally. Sustainable development regarding new urban planning and establishment of industrial area do require a guiding map to meet safety and protection. The main objective of the study was to assessment of peak flood at different recurrence interval using flood frequency methods.

[6] Carried out comparative study of various distributions such as, Gumble, Lognormal and Log Pearson Type III using 55 sets of data and found no single distribution to fit all the flood data set accurately.

STUDY AREA

Deg Nullah, the drain in Rachna Doab will be analyzed as study area in the present study. It is originated from Indian seized Kashmir, where it has two divisions named Divak river and Basentar river which chain to form Deg Nullah before diverting into Pakistan terrain near Lahri check post,

the north east of Zafarwal tehsil,distt. Narowal. Its ranges from 32°17'25" N ,74°48'11" E. to 32°10'21"N, 74°38'37"E Deg Nullah in its introductory reach in Pakistan is a straight twisted channel with wide and shallow cross area and steep slope. Bankful limit of the Nullah in this range is little and over spills and spreads over vast zones. Study reach was about 41 km from upstream near Kingra Moor to downstream near Wahly village.

METHODOLOGY

Data Collection

The data related to elevation of study reach, annually peak flow data and cross sections data of Nullah Deg was collected from Punjab Irrigation Department, Sialkot to meet the study objectives. Annual peak flow data of Nullah Deg for the present study is collected from years 1982 to 2014.

Flood Frequency Analysis

Frequency analysis was carried out to predict design floods for a site along the Nullah. Determination of the frequency of occurrence of extreme hydrologic events is very important in water resources planning and management. It gives the data about the event of flood occasions effectively. Frequency analysis was done by using excel sheets and applying Gumbel distribution and Log Pearson type III distribution to check the future flood events in Nullah Deg**.**

Gumbel's distribution

Gumbel distribution is applied to carry out the flood frequency analysis of Nullah Deg using 33 years annually peak flow data (1982-2014) .Formula for Gumbel distribution used to calculate the value of the variate X of a random hydrologic series was,

$X_t = \bar{X} + K\sigma n - 1$

Xt=Value of the Variate X of a random hydrologic series

X^{-}=Mean of the Variate

σn-1=Standard Deviation,

K=Frequency factor which depends upon the return Period T

To calculate K ,

$K = Yt - Yn/Sn$

Yt=[.834+2.303loglogT/(T1)

Yt=-[lnlnT/T-1]

Log-Pearson III Distribution

Log-Pearson III distribution is applied to carry out the flood frequency analysis of Nullah Deg using 33 years annually peak flow data (1982-2014) . Formulas for the Log-Pearson III given below,

XT=Antilog ZT

$ZT=z^{-} + Kz\sigma z$

$Cs=N\sum (Z-Z^{-}) \text{ ^3/ } [(N-1)(N-2)(\sigma z) \text{ ^3}]$

Flow trend analysis of Nullah Deg

High magnitude floods and behavior of stream flows in Nullah Deg were observed consistently from 2010 to 2014 **by** the time series analysis.

RESULTS AND DISCUSSION

Gumbel distribution and Log Pearson III was applied to carry out the flood frequency analysis of Nullah Deg using 33 years annually peak flow data (1982-2014) and it gave the results shown below

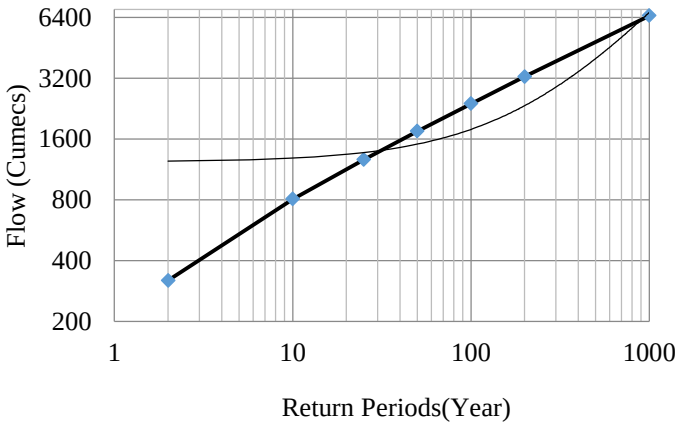

Figure 1 Log Pearson-iii Distribution Plot

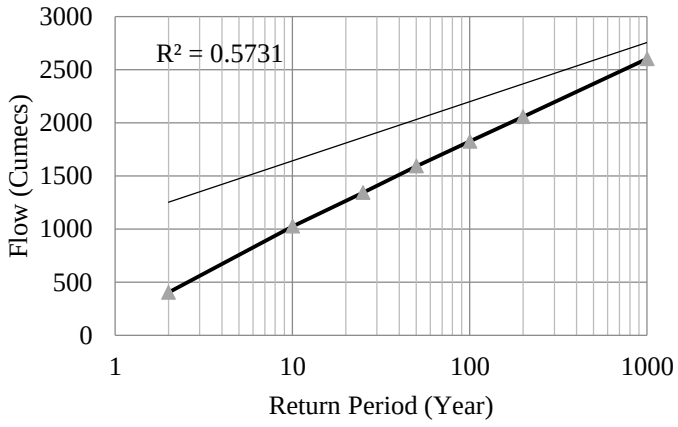

Figure 2 Gumbel Distribution Plot

Table 2 Comparison of Gumbel and Log Pearson-iii Results

Return Periods	2	10	25	50	100	200	1000
Gumbel Method	403	1026	1344	1591	1824	2056	2602
Log-Pearson Type-III	319	807	1265	1749	2394	3255	6522

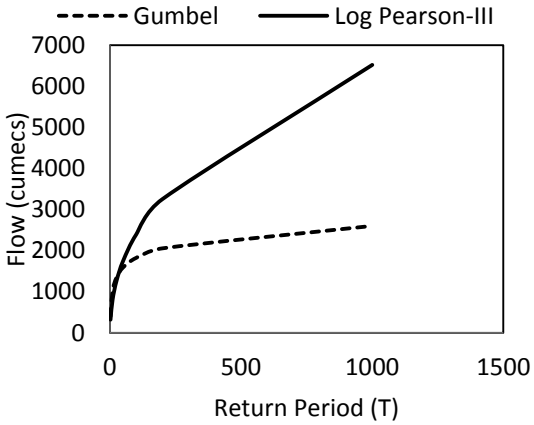

Fig 3 Comparison of Gumbel and Log Pearson-III

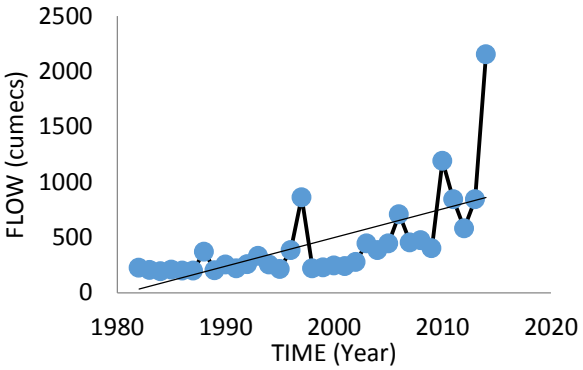

Figure 4 Annual Peak Flows

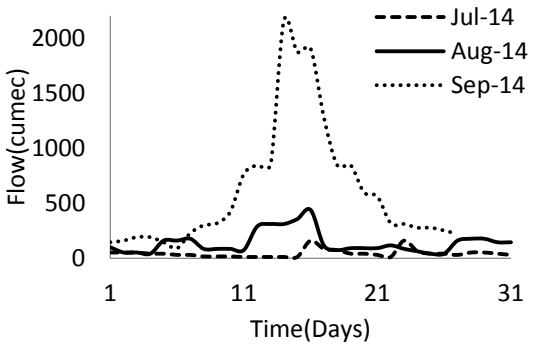

Figure 5 Monsoon Season 2014 Flow Trend

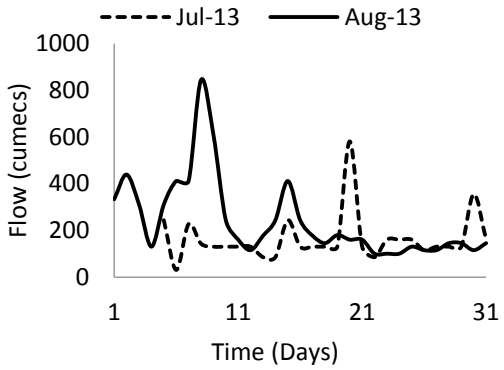

Figure 6 ***Monsoon Season 2013 Flow Trend***

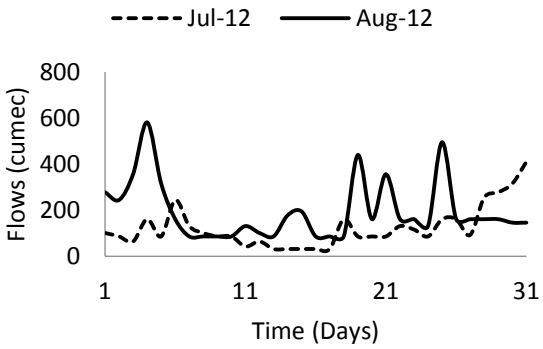

Figure 7 ***Monsoon Season 2012 Flow Trend***

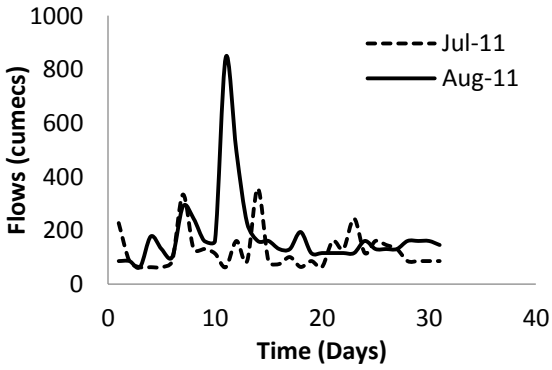

Figure 8 ***Monsoon Season 2011 Flow Trend***

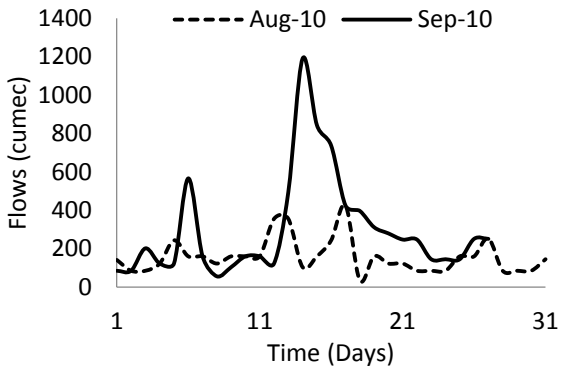

Figure 9 ***Monsoon Season 2010 Flow Trend***

Flow Trends Analysis Results

Figure.4 represents flow in the Nullah during the years 1982-1987 was normal. There was no significant change in the flows in the Nullah Deg, but during 1988 it has some high flows due to heavy rainfalls in Monsoon season which exceeds the Nullah capacity. Figure showing high flow in 1993 but less than the flood in 1988. Next two years again there was normal flows in the Nullah, in 1996 there was a high flood as Compare to previous floods but in 1997 all flood records were shattered and it has a very high flow, doubled than 1996 flood. From 1998-2002 it observed the drought year's means the flows were at its normal conditions. From the year 2003, the flows started increasing in every upcoming year due to heavy rains of monsoon seasons. From 2003-2009 there were high floods in every year but less than the 1997 flood. In 2010 Nullah observed the greater value of flood than in 1997 and during 2011-2013 there were significant floods but less than the 2010 flood.

In 2014(Fig.5) it has recorded a very high value of flood, doubled than the 2010 flood which causes innumerable miseries like loss of life, disruption of human activities, damage to property, agricultural crops and health hazards. According to the annually data figure, it is clear that last five years 2010-2014 have extreme and consistent floods in the Nullah Deg. Some more figures of yearly data from 2010-2014 are given below, showing the trend of flows in the monsoon season. From these figures it is noted that in the month of August every year, Nullah Deg observed high flows as compared to July or September of the monsoon season. But one thing is more interesting that whenever highest flood values occur, these values were in the month of September, like in 2010 and 2014.

In the monsoon season of 2013(Fig.6) there were eleven peak flow values, two were in the month of July and other nine were in the month of August. Nullah observed a flood from 1st of Aug to 9th of Aug and then flows were normal again but on 15th of Aug it again raised up but on next day it was again at its normal conditions. On 8th of Aug it observed highest flood of 844 cumec.so 2013 trend shows that maximum flows were in the month of August.

There were eight peak flow values in 2012 monsoon season (Fig.7), two were in the month of July and other six were in the month of August. From 30th of July to 5th of August Nullah observed high flood and it reached maximum value of 581 cumecs on 4th of August. From above figure it is concluded that in 2012 also there were high flows in the month of August.

In 2011 (Fig. 8) monsoon season there was only three peak flow values. But two of them were in the month of August on 11th and 12th .It observed highest flood on 11th of August having a magnitude of 844 cumec.so trend of 2011 also showing that high flows were in August.

In the monsoon season of 2010 (Fig. 9) Nullah observed a high magnitude of flood of 1190 cumecs in the month of September and overall in this season there were eleven peak flow values. There was flood from 13th to the 19th of the September. So the trends of 2010 showing that maximum peaks were in the September 2010.

CONCLUSION

Gumbel and Log-Pearson III distributions were applied for the flood frequency analysis of Nullah Deg. Results of both distributions compared to check the goodness of best fit, according to the chi square test Gumbel's distribution is giving best fit because Gumbel's value of Chi square test is 10.21 as compared to Log-Pearson III distribution value for Chi square is 11.06.Variability of Nullah Deg floods showing that the august month of the Monsoon season is most danger for flood in Nullah Deg

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