Design discharge for ungauged site in pakistan biology essay

Science, Biology

Introduction

Hydrology describes the main input variable relevant for hydropower plants, namely the occurrence of river flow. The historical, hydrological series which represents variations in river flow throughout the year and between years is utilized to estimate the economic benefit connected to electric power production from the available river flow. Also recognizing that water as such is a very important natural resource, the description of river flow is of great importance for all human activities in the project area. Northern Pakistan is blessed by numerous mountainous areas rivers that have great potential in water resources and hydropower production. Since these mountainous areas are covered by snow, glacial lakes, and glaciers, numerous streams originate from these mountains and carry appreciable glaciers melt water that is ultimately used for the sustainable development of the country. Design discharge estimation has prime importance in many water resource planning and management tasks such as design of hydraulic structures, flood insurance studies, flood plain management and river ecological studies. At site flood frequency analysis is the most direct method of estimating design floods which requires a reasonably long period of recorded stream flow data at the site of interest. The development of a these method generally requires recorded flood data from a large number of gauged catchments in a region, which is often available in many of the developed countries of the world. However, in many instances, in developing and undeveloped countries like Pakistan, owing to lack of funds, unqualified personnel, low density of gauging stations, and the operation and maintenance of the stream gauging networks are difficult. Many annual flood series are too short to allow for a reliable estimation of extreme events or there is no flow record available at the site of interest. So, recorded stream flow data with sufficient spatial and temporal coverage and acceptable quality at site of interest is generally scarce. Under these circumstances, different regional methods have been frequently adopted to derive design flood, which in essence attempts to transfer flood characteristics information from gauged to ungauged catchments. For the planning and designing of hydraulic structure (Dams, Barrages Headwords etc) large data is required but in many cases where limited stream flow data is available for analysis, data is generated at the desired location by using different techniques. One straightforward method for obtaining daily streamflow at ungauged sites from gauged sites is the drainage area ratio (AR) method (Stedinger et al., 1993). The standard implementation of the AR method generally involves only one source site (Mohamoud, 2008). Such application actually assumes that a gauged site shares the same physiographical and hydrological characteristics as the target ungauged site except for a scaling factor representing the size of the drainage basin. In reality there are several other factors, in addition to the drainage area, that have a significant influence on a catchment’s unique runoff characteristics. Thus, the risk of introducing systematic errors in the streamflow estimation process at an ungauged site using the single source site area ratio (SAR) approach is high(chang, 2012)Another highly promising and extensively used technique for the estimation of daily stream flows at ungauged sites is associated with the use of flow duration curves. A flow duration curve (FDC) gives a summary of flow variability at a site and is interpreted as a relationship between any discharge value and the percentage of time that this discharge is equaled or exceeded (Vogel and Fennessey, 1994). Many RFFA methods have been developed and tested for different countries in the world e. g. (Cunnane, 1988; Hosking and Wallis 1993; Zrinji and Burn, 1994; Bates et al., 1998; Pandey and Nguyen, 1999; Ouarda et al., 2001; Merz and Blöschl, 2005; Micevski and Kuczera, 2009; Gaume et al., 2010). Some of the most commonly adopted RFFA methods in practice include the index flood method (Dalrymple, 1960; Hosking and Wallis, 1993), rational method (Mulvany, 1851; I. E. Aust., 2001) and various regression-based methods (e. g. Thomas and Benson, 1970; Stedinger and Tasker, 1985; Griffis and Stedinger, 2007; Haddad and Rahman, 2012). The primary source of information about stochastic properties of hydrological processes is the time series of data. An investigation of a trend in hydrological time series is mainly focused on the detection of the trend in the mean value. To that end, standard statistical techniques are used, based essentially on the theory of hypothesis testing. A trend in the variance or in the auto-correlation function is analyzed in different research (Strupczewski et al., 2001). In this paper, keeping in mind limited length of hydrological data at proposed site and hence need of parameter parsimony, statistical analysis has been carried out to establish similarities and rainfall trend between gauged and un gauged water shed. Subject to trend modeling to establish symmetry between gaged and ungagged station mainly focused is done on the detection of trend in the mean values. Furthermore, this study illustrate prediction of relation for the mean annual flood and design discharge for ungauged region of Pakistan which has been carried out by using two readily obtainable predictor variables (catchment area and design rainfall intensity), and which can be utilized along with the developed growth curve to estimate design floods for the ungauged catchments in study regions with reasonable accuracy. In this paper, we followed the idea of transferring hydrological information assuming no regions nor pooling groups, and by using rainfall factor, drainage area factor and their dimensionless ratios as statistical variables to be transferred to the ungauged sites. In particular, we select the mean rainfall ratio factor and catchment area of the record. Regionalizing these factors allows one to reconstruct the whole flood frequency curve and select the design discharge for the proposed ungagged site. The choice of the factors as hydrological signatures in this regional framework can be interpreted in an USGS rural regression equation for the ungagged site, considering the direct ratio of respective drainage area as the scale factor, as the descriptors of selection of design discharge from one gaged basin to another ungagged basin with similar hydrological characteristic. A similar approach considering some hydrological parameter as well has been applied in this study to the annual stream flow of a gagged site to select the design discharge for proposed ungagged site in Pakistan.

Study Area

Neelum Jhelum Hydropower Project to be located in the vicinity of Mozaffarabad in Azad Kashmir is a run of the river project for hydropower generation, an important hydropower project under " WAPDA Vision Program 2025". The project involves construction of a gravity dam, spillway, debris flow channel, power intake followed by sedimentation basin and headrace tunnel to the power house. It envisages the diversion of Neelum river water to Jhelum river water through a tunnel. The intake of tunnel (13 Km long) is at Nauseri 41 Km East of Mozaffarabad. This tunnel passes beneath the upper leg of Jhelum River near Janderbain and finally out -falls into lower leg of Jhelum River at Majhoi. As describe, Janderbain is located in the vicinity of Jhelum River and it is right bank tributary of Jhelum River. The length of Janderbain catchment is 11989m and watershed area is about 54 sq. km. The bed slope of study area is 0. 05." The climate of the Study area is sub-mountainous area and it is fairly hot in summer and cold in winter. June and July are the hottest months and the temperature rises to more than 101 'F (38. 3'C). The temperature during winter seldom falls below the freezing point. The river in the valley flows between elevations 1900 and 3300 f. a. s. 1. (580 and 1000 m) and the climate in the area is comparatively warm. The surrounding mountains rise to more than 5000 ft (1500 m) above the valley floor and have a cool and brazen climate." To carry out the study, two meteorological stations, i. e. Muzaffarabad and Garhi Dupatta are selected having same metrological and geological conditions. Most important is Muzaffarabad which has both an automatic rainfall recorder (pluviograph) and a Class A evaporation pan in addition to the standard meteorological equipment (daily raingauge, maximin. temperature, wet and dry bulb, anemometer and barometer). Rainfall records are probably longest from Muzaffarabad (reported to have records from prior to independence in 1947) and from Garhi Dupatta in the Jhelum catchment. Fig. Study area Neelum Jhelum hydroelectric project Pakistan

Methodology:

Source site selection

For the present study, the proposed site has no installed gauging station for the measurement of rainfall or flow. So the following data required for hydrological analysis to select design discharge for proposed site was collected from the nearby site having same metrological and geological conditions i. e. Mozaffarabad(upstream side) & Ghari Dopatta(downstream side)Annul flood peaks data of Mozaffarabad from 1970-2008Annual rainfall data of Mozaffarabad and GhariDopatta from 1970-2006Catchment characteristicsThe data analysis includes statistical analysis of 36years rainfall data of Mozaffarabad & Ghari Dopatta to establish correlation, symmetry and trend between gauged and un gauged . Then rainfall analysis at gauged site leads estimation of design discharge of different return period of time at unguaged site through hydrological information transfer and data synthesizing of Mozaffarabad station . This section is carried out by different empirical relations of flood frequency analysis to calculate peak flow for different return period of time for the purposed site. The verification and comparison of the proposed methodology is carried out by estimation of design discharge by SCS cure no method using the 36 years rainfall data of Ghari Dopatta station .

Investigation of trend of annual rainfall series of proposed gauged stations

As describe, two nearby stations (Mozaffarabad and Ghari Dopatta) were utilized for hydrological analysis as there was no rainfall gauge station at the proposed site. Daily 36 years rainfall data collected from station Mozaffarabad and Ghari Dopatta was processed. Processing of data included the arrangement of rainfall data of the both of station on daily, monthly, annually sum, and average rainfall, maximum rainfall, and on minimum basis. By the comparison of arranged rainfall data of both stations a rainfall factor is determined on the basis of average annual rainfall.

Interpolation of source site hydrological data for proposed site

After the preliminary analysis of rainfall of both rain gauge stations, the selection of design discharge for the proposed ungauged station was carried out using frequency analysis method by regression base interpolation of data for ungauged station. To carry out the estimation of design discharge by frequency analysis distribution technique, firstly, for estimation of peak flows for Janderbain, 38 years flow data collected at Mozaffarabad station has been interpolated by multiplying area factor(source site area ratio method i. e. RA= Au/Au-1) and rainfall factor estimated on basis of statistical analysis of 36 years rainfall data of both gauged stations. Where, is the synthesize discharge for proposed in m3/s, is the measured source site discharge m3/s and is the mean annual rainfall ratio factor (dimensionless)derived from statistical analysis of rainfall data of both gauged stations. Secondly, 38 years annual peak flow Janderbain has been used to determine the frequencies for various return periods to select the design discharge for the using frequency analysis distribution technique. The mostly used frequency analysis distribution technique in Pakistan i. e. Gumbel and log Pearson Type-III distribution method were selected for selection of design discharge as described below; Log Pearson EqutionX = Max. annual daily runoff, = average of the logarithms of X, SZ = standard deviation of the logarithms, K = a frequency factor, (a function of the skewness coefficient and return period and can be found using the frequency factor tableGamble EquationWhere; XT = value of the variant X of random hydrological series with a return period T, = mean of the value, σn-1= standard deviation of the variant X, K = frequency factor which depend upon the return period T and the assumed frequency distribution, expressed as: Where, YT = Reduce variant, a function of T and , Yn = Reduce mean, a function of sample size N , Sn = Reduce standard derivation, a function of sample size

Evaluation and Comparison of the result by SCS CN method

Another most effective method for computation of peak flow, SCS curve no. method has been used for the assessment of rainfall trend analysis and the proposed relation of determine the peak flow for Janderbain. For this section, annual 36 years daily rainfall data of second source site i. e. Ghari dopatta was arranged on maximum annual basis and by frequency analysis and Weibull's plotting formula:(, where i= 1, 2, 3,……, n and is the probability of annual maximum rainfall data of Source site i. e. Ghari doptta) the precipitations for various return periods been determined. Then the estimation of peak flow from precipitation of different return period of time has been calculated by the following relation of SCS curve no. methodWheretc = Time of concentration calculated by Kirpich equation for time of concentration , qb= Peak flows, A= cross sectional AreaQ: Run off (mm), S: Losses (mm) and P: Maximum precipitation in 24 h (mm).

Selection of Design Discharge

By comparisons of results of peak flow by flood frequency analysis and SCS curve no. method, the design discharge for design of Janderbain for further processing has been selected.

Results

In the previous chapters, theoretical and computation work has been describe for statistical analysis to describe the rainfall trend symmetry overall the region, transferring of hydrological information, estimation of design discharge, and finally evaluation and comparison of the results by computation of design discharge by empirical relation. In this chapter the detail results of analysis and calibration has been discussed. Keeping in mind limited length of hydrological data at proposed site and hence need of parameter parsimony. Subject to trend modeling to establish symmetry between gauge and un gauge station are mainly focused on the detection of trend in the mean values. The collected 36 years (1970-2006) daily rainfall data of Mozaffarabad and Ghari Dopatta gauging stations was used for rainfall analysis and for computation of peak flow to select the design discharge for the proposed site. The annual distribution of rainfall over both the stations i. e. Mozaffarabad & Ghari Dopatta is shown in Figs. 4. 5 & 4. 6 respectively. Figure Annual distribution of rainfall over the Mozaffarabad (1970-2006)Figure Annual distribution of rainfall over the Ghari Dopatta (1970-2006)Figure Comparison of annual distribution of rainfallThe data obtained was on daily basis and in mm depth. This daily 36 years rainfall data has been processed to calculate the average rainfall on daily basis, monthly basis and on annual basis. The average daily rainfall over the Mozaffarabad gauge station is 3. 96 mm average monthly rainfall is 120. 5 mm and annual rainfall is 1446. 4 mm whereas the average daily rainfall of Ghari Dopatta is 3. 57 mm, monthly average is 107. 35 mm and average annual rainfall is 1288. 25 mm as depicted in Table 4. 1. Table 4. 1Average daily, monthly & annual rainfall of Mozaffarabad and Ghari DopattaAverage Rainfall (mm)Gauge stationDaily Avg. Monthly Avg. Annual Avg. Mozaffarabad3. 96120. 51446. 4Gharidopatta3. 57107. 351288. 25On the basis of processed rainfall data of 36 years(figs. 4. 4& 4. 5) of both gauge stations results that the maximum daily, monthly and annually precipitation observed of Mozaffarabad station was 200. 5mm , 732. 3mm (July , 1988), 2153 mm(2006) respectively. Similarly observed maximum daily, monthly and annually precipitation data of Ghari Dopatta station was 153. 7mm, 516. 8 (July, 1988) and 1979. 3 mm (1971) respectively as shown in Table 4. 2. Table 4. 2Maximum daily, monthly & annual rainfall of Mozaffarabad And Ghari dopattaMax. Rainfall (mm)Gauge stationDaily Avg.(mm)Monthly Avg. (mm)Annual Avg. (mm)Mozaffarabad200. 5mm732. 3mm (July , 1988)2153 mm(2006)Gharidopatta153. 7mm516. 8 (July, 1988)1979. 3 mm (1971Fig Average daily rainfall of MozaffarabadFig Average daily rainfall of Ghari dopattaFigComparison of Average daily rainfall ofBy the analysis of 36 years rainfall data of both stations, it was noted that distributions of rainfall over both rainfall stations are bi-modular. One peak was observed in first three months of years and another peak was observed in Aug, Sep. The monthly temporal distribution trend of rainfall data over the both catchments observed was as depicted in Figs. 4. 6 & 4. 7. Figure 4. 7Monthly distribution of Rainfall trend over the MozaffarabadFigure 4. 8Monthly distribution of Rainfall trend over the Ghari Dopatta

Conclusion of statistical analysis:

By the analysis of 36 years rainfall data of both stations, it is noted that distributions of rainfall over both rainfall stations are bi-modular. One peak was observed in first three months of years and another peak was observed in Aug, SepBy computing the Pearson coefficient of skew ness (Cs), we obtained the results as Cs(GD) = - 0. 014, and Cs(MZ) = 0. 0001By the comparison of 36 years rainfall data analysis of both gauge stations on the basis of average rainfall, a rainfall factor(means ratio) is estimated i. e. 0. 95 which reveal that rainfall distribution over the entire area is almost symmetricalAnother factor i. e. area factor is also counted for further interpolation of data. By the calculation we find out the area factor(Area ratio) i. e. Area factor = 0. 007415So the data of both the station was interpolated to select the design discharge of proposed site by different empirical relationA flood frequency study for estimation of flood peak of unknown events of proposed site after interpolation of flow data Mozaffarabad station by multiplying the area factor (Table 4. 1) has been done by the following methods: Gumbel distributionLog Pearson Type III DistributionThe annual peaks of Janderbain Nullah and their ranking (arranging in descending order) after the interpolation of Mozaffarabad flow data is depicted in Table 4. 1 and in Figs. 4. 8 & 4. 9. It is observed that the maximum flow at Janderbain Nullah was 291. 1 cumecs in 1995 & 2004. The flood frequency analysis of the synthesized discharge data of Janderbain

Nullah by Gumbal method resulted the peak discharges (cumecs) i. e. 182. 96, 264. 65, 305. 77, 336. 27, 366. 55 against 2, 5, 10, 25, 50 and 100 years return period respectively and by Log-Pearson type III estimated value of peak discharges (cumecs) are 186. 2, 257. 03, 281. 83, 301. 99, 316. 22 respectively as shown in Table 4. 2 & 4. 3 respectively. The comparison of calculated value of peak flow for different return periods of time shows that the results of both distributions are almost closer to each otherFigure 4. 9Synthesized Annual peak discharge of Janderbain NullahTable 4. 4Results of flood frequency analysis by Gumbal distributionStd. = 49. 3822827, Avg. = 190. 6T(Return Period)Yt(Reduce variate)K(Frequency Factor)Peak discharge of JB(cumecs)10006. 9072550715. 588562584466. 61004. 6001492273. 562652992366. 5704. 24130953. 247549613351. 0503. 9019386582. 949542201336. 3303. 3842944932. 494989896313. 8253. 1985342612. 331870619305. 8202. 9701952492. 131362179295. 9102. 2503673271. 499268816264. 751. 4999399870. 840305573232. 120. 366512921-0. 154976361183. 0Table 4. 5Results of flood frequency analysis by Log Person Type III distributionSkew coeff. = 1. 22, Std. = 0. 162, Avg. = 5. 02T(Return Period)KzZtXt10002. 542. 56363. 071002. 0292. 50316. 22501. 8742. 48301. 99251. 6062. 45281. 83101. 2312. 41257. 0320. 0662. 27186. 2Figure Comparison of flood peak estimation studies methodsThe frequency analysis of 36 years rainfall data to calculate the value of precipitation at various return periods and weibull’s plotting position resulted that at 2, 10, 25, 50, 100 years return period the values of rainfall (mm) are 199. 52, 261. 03, 290. 08, 411. 35 and 653. 90 respectively as shown in Table 4. 5 & by rainfall frequency curve for 36 years rainfall(Fig 4. 11). The computed values of peak discharge (cumecs) by SCS curve no. method are 176. 71, 231. 50, 257. 38, 366. 49, 582. 58for various return periods i. e. 2, 10, 25, 50, 100 as shown in Table 4. 6. Table Value of precipitation at various return periods resulted from frequency analysis of rainfall data. Return periodP(Precipitation)2199. 5210261. 0325290. 0850411. 35100653. 90Figure 4. 11Rainfall Frequency Curve for 36 years rainfall data

Flow calculation by SCS method

tc = 0. 8193 (by Kirpich equation for time of concentration)Slope = 0. 055D= duration of rainfall = 24Table Peak discharge value for various return periods by SCS methodT(years)P(mm)D(hrs)A(km2)Q(mm)qb(m3/s)2199. 52232453. 97198. 34176. 7110261. 02852453. 97259. 85231. 5025290. 0752453. 97288. 89257. 3850411. 352453. 97411. 35366. 49100653. 92453. 97653. 90582. 58The comparison of calculated value of peak flow for different return periods of time shows that the results of all methods are almost closer to each other i. e. for 2 & 50 year return period the values of peak flow estimated by Gumbel’s method, log Pearson type-III & by using SCS curve no method are 182. 96, 186. 2, 176. 71 & 336. 27, 301. 99, 366. 49cumecs respectively. The comparison results of flood frequency analysis and SCS method is shown in Tables 4. 7 & Figure 4. 12. It is noted that there is almost variation for discharges at larger return period of time by SCS method. Table Comparison of Flood peak estimation studies methodsT(years)Gumbel methodLog person methodSCS method2182. 96186. 2176. 7110264. 65257. 03231. 5025305. 77281. 83257. 3850336. 27301. 99366. 49100366. 55316. 22582. 58FigureComparison of flood peak estimation studies methods

Conclusion

For comprehensive study related many water resource planning and management at ungauged site, design discharge estimation has been a crucial and recurrent hydrological task for addressing problems related to hydropower generation, river and reservoir sedimentation water-use assessment, water allocation and habitat suitability. In this paper, a relation for the estimation of design discharge has been developed and validated using some empirical relation, statistical analysis and by using some design discharge estimation techniques. In this study, the hydrological parameters extracted from the hydrological analysis of source gauged sites, have been linked to peculiar ungauged catchment and its characteristics, such as the area, the mean annual rainfall and the mean areal value of Curve Number. This study considers three zones(two gauge and one ungauge site) in the study area i. e. northern area of Pakistan. The comparison of calculated values of annual peak discharges for different return period by the different empirical approaches resulted that values are almost closer to each other. The conclusions of this study has been carried out and evaluated on the based on long-term recorded hydro meteorological, hydrological, and flood data procured from various agencies. As resulted that values are almost closer to each other, it has been found to provide reasonably accurate estimates using two readily available catchment characteristics predictor variables, catchment area and design rainfall intensity, the technique represented in this study obtains a satisfactory results in term of design discharge estimation at ugauged site. The method of design discharge prediction developed here has been primarily applied to the ungauged region of northern area of Pakistan; however, in future this method can be applied to other similar regions of the world and can be validated along with the locally developed prediction equation to derive preliminary design flood estimation.