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Multivariate analysis of flood phenomena using copula functions: Karkheh River catchment area

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Abstract

Flood is a natural phenomenon, which can cause significant damage to infrastructure. Since many factors play a role in the occurrence of floods, multivariate analysis of flood phenomena is necessary for the design of hydraulic structures related to floods. For the multivariate analysis, the use of classical multivariate methods is not appropriate due to considering the same marginal distribution function for all variables. Therefore, the method of copula functions has gradually been used to analyze the two, three, and four variables of the flood phenomenon. In these analyses, four variables of peak discharge, volume, base time and time to reach the flood peak are generally used. In this research, the method of multivariate copula functions has been used to analyze the effect of temperature and sediment on the occurrence and intensity of flood phenomenon. Six variables of peak discharge, volume, base time, peak time, temperature and flood sediment were used for multivariate analysis of flood phenomenon. For this purpose, first, six flood variables were extracted using the data of daily discharge, temperature and sediment for 40 years recorded in three stations, Abdul Khan, Pai Pol and Hamidieh, located in the Karkheh watershed, and with the help of easyfit software, the marginal distribution function of each One of the flood variables was determined.In the following, coding in the R software environment was used for frequency analysis. Archimedean (Frank, Clayton, Gamble and Joe) and elliptic (Normal and T) copula functions were fitted on each of the pairs of flood variables whose correlation was significant at a certain level of 5%; Based on Kramer-von Mises test and selected criteria, the most suitable copula function was determined for each of them.; Two famous vine copula structures, C-Vine and D-Vine, were used for the six-variable analysis of the flood phenomenon, and it was found that the C-Vine structure performs better than the D-Vine structure. Finally, the combined return period in two states {or} and {and} was calculated and compared with the single variable return period. The findings showed that with the increase in the number of variables, the return period in {or} state is less and the return period in {and} state becomes more than the single variable return period. In general, 1) the copula function has the ability to analyze floods in the Karkhe river catchment area, 2) the multivariate analysis of the Karkhe river basin shows that if structures are designed based on bivariate analysis, the probability of damage to the increase, and 3) among the two variables of temperature and sediment, the variable of flood sediment due to having a significant correlation (at the 5% level) with the two important variables of floods, i.e. peak discharge and volume, has more influence on the occurrence of floods than the temperature variable. Karkheh watershed plays a role.

Key Words: Flood, Multivariate analysis, Copula functions, Karkheh River, Joint return period, Goodness of fit.