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M.Sc. in Civil Engineering

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HASAN KALYONCU UNIVERSITY

GRADUATE SCHOOL OF

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GENERATING RAINFALL INTENSITY-DURATION-FREQUENCY CURVES OF SOUTHEASTERN AND EASTERN MEDITERRANEAN REGIONS OF TURKEY

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Generating rainfall intensity-duration-frequency curves of southeastern and eastern Mediterranean regions of Turkey

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Supervisor

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By

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	GRADUATE SCHOOL OF NATURAL & APPLIED SCIENCES INSTITUTE M.Sc. ACCEPTANCE AND APPROVAL FROM

Civil Engineering Department, Civil Engineering Master programme student **İbrahim Halil DEGER** prepared and submitted the thesis titled **"Generating rainfall intensity-duration-frequency curves of southeastern and eastern Mediterranean regions of Turkey"** defended successfully at the VIVA on the date of 12/06/2019 and accepted by the jury as a M.Sc. thesis.

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

İbrahim Halil DEGER

ABSTRACT

GENERATING RAINFALL INTENSITY-DURATION-FREQUENCY CURVES OF SOUTHEASTERN AND EASTERN MEDITERRANEAN REGIONS OF TURKEY

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M.Sc. in Civil Engineering
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Intensity-Duration–Frequency (IDF) curves are graphical representation of the relationship between duration, intensity and frequency (return period) of rainfall, which are obtained from analysis of observed data. IDF curves are widely used in planning and designing safe and economic water resources engineering projects, particularly urban storm sewer systems. Changes in the local or global climate, as a result of upsurge in greenhouse gases may lead to variations in intensity, duration and frequency of precipitation events. Quantifying the potential impacts of climate change and adapting to them is expected to reduce urban vulnerability to city floods. Studying and updating rainfall, intensity-duration-frequency curves and consistent hydrologic analysis for future climate scenarios is vital.

The aim of this study is to generate rainfall intensity-duration-frequency curves for rainfall stations in Adana, Adıyaman, Hatay (Antakya), Batman, Cizre, Diyarbakır, Gaziantep, Kahramanmaraş, Kilis, Mardin, Osmaniye, Siirt and Şanlıurfa by employing rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours. The maximum rainfall depths of particular durations are acquired from the recorded rainfall measurements which were obtained from the General Directorate of Meteorology of Turkey. Analyses were performed by utilising Gumbel, Normal, Lognormal and Log Pearson Type III distributions. In order to evaluate the suitability of these distribution methods and select the best one, Kolmogorov-Smirnov test was applied to a number of rainfall durations of each station. The results of this investigation are expected to be useful for local authorities.

Keywords: Intensity-Duration–Frequency Curves, Gumbel Distribution, Normal Distribution, Log Pearson Type III Distribution, Frequency Analysis

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ÖZET

TÜRKİYENİN GÜNEYDOĞU VE DOĞU AKDENİZ BÖLGELERİNİN YAĞIŞ ŞİDDET-SÜRE-TEKERRÜR EĞRİLERİNİN BELİRLENMESİ

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Şiddet-süre-tekerrür eğrileri gözlemlenmiş yağmur verisinin bir dizi analizinden elde edilmiş yağmurun süresi, şiddeti ve frekansı (tekerrür) arasındaki ilişkiyi ifade eder.. Bu eğriler su kaynakları projelerinin güvenli ve ekonomik olarak planlanmasında, tasarlanmasında ve özellikle şehir yağmur suyu sistemlerinde kullanılır. Sera gazlarındaki artış sonucu iklimdeki yerel veya küresel değişimler yağış olaylarının şiddet, süre ve frekansının değişmesine neden olur. İklim değişikliğinin potansiyel etkilerini hesaplamak ve bu etkilere uyum sağlamanın şehir taşkınlarına karşı şehir savunmasızlığını azaltması beklenmektedir. Yağmur şiddet-süre-tekerrür eğrilerinin çalışılması, güncellenmesi ve yağmurun tutarlı hidrolojik analizleri gelecekteki iklim senaryoları için yaşamsal öneme sahiptir.

Bu çalışmanın amacı Adana, Adıyaman, Hatay(Antakya), Batman, Cizre, Diyarbakır, Gaziantep, Kahramanmaraş, Kilis, Mardin, Osmaniye, Siirt ve Şanlıurfa yağmur istasyonları için 5 dakikalık, 10 dakikalık, 15 dakikalık, 30 dakikalık ve 1 saatlik, 2 saatlik, 3 saatlik, 6 saatlik, 12 saatlik ve 24 saatlik yağmur süreleri kullanılarak yağmur şiddet-süre-frekans eğrilerinin oluşturulmasıdır. Belirli yağış sürelerine ait maksimum yağmur derinlikleri Meteoroloji Genel Müdürlüğünün kayıtlı yağmur ölçüm verilerinden alınmıştır. Analizler Gumbel, Normal, Lognormal ve Log Pearson Tip III dağılımları kullanılarak yapılmıştır Her istasyonun farklı yağmur süreleri için kullanılan dağılımların uygunluğunu değerlendirmek ve en iyi dağılımın belirlenmesi amacıyla Kolmogorov- Smirnov testi uygulanmıştır. Bu incelemeden elde edilen sonuçların söz konusu şehirlerin yerel makamları için faydalı olması beklenmektedir.

Anahtar Kelimeler: Şiddet-süre-tekerrür eğrileri, İstatistiksel dağılımlar, İklim değişikliği, Frekans analizi.

To My Mother

ACKNOWLEDGEMENTS

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LIST OF SYMBOLS AND ABBREVIATIONS

IDF	Intensity-duration-frequency
i	Rainfall intensity
P	Any rainfall data
t_d	Rainfall duration
T	Return period
n	Number of data or sample size for Kolmogorov- Smirnov test
$\bar{x}$	Arithmetic mean
s	Standard deviation
$\overline{\log x}$	Arithmetic mean of logarithmic data
$S_{\log x}$	Standard deviation of logarithmic data
G	Coefficient of skewness
K_T	Frequency factor
z	Standardized unit
p	Probability of occurrence of return period
x	Any rainfall estimate related to rainfall duration and return period
D_N	Sample statistics of Kolmogorov-Smirnov Test
$F_N(x)$	Theoretical cumulative distribution
$F_o(x)$	Empirical distribution
α	Significance level

CHAPTER 1

INTRODUCTION

Intensity-Duration–Frequency (IDF) curves states a relation among duration, intensity and frequency (return period) of rainfall, that are acquired by a series of analysis of observed rainfall data. They can be defined as IDF curves present a graph which illustrates quantity of water that rains in a certain given return period in any basin (Dupont and Allen, 1999; Elsebaie, 2011). IDF relation can be defined as a connection which is mathematical among duration of rainfall, intensity of rainfall, and return period and these curves (IDF) are one of the most widely used ways for water resources engineering in planning, designing, operating and protecting of different engineering projects against floods (Koutsoyiannis et al., 1998). IDF curves are used for the purpose of estimating the return period of observed rainfall event or the rainfall quantity of a given return period for various rainfall durations (Elsebaie, 2011). Forming this kind of relationships have been made as early as 1932 (Bernard, 1932) and thenceforward numerous relations have been done for numerous parts of the world (Koutsoyiannis et al., 1998).

IDF curves are generally utilized in the designing of water resources, hydrologic, hydraulic projects, particularly storm water collection systems. The first step in numerous hydrologic design projects is to make a determination for rainfall events and using design storm or an event which includes a connection among rainfall intensity i, duration and frequency or return period of rainfall for site area are most common methods (Chow et al., 1988). Being able to successfully fulfil the purpose of a hydraulic structure to be designed is related analysing maximum rainfall events properly (Huang et al., 2016). Measuring the climate change's potential impacts and adapting to these impacts is a way so as to decrease urban vulnerability, especially preventing city floods. Since, IDF curves are regularly utilised for designing water resources projects, so as to have economic and safe hydraulic structures studying and updating rainfall characteristics and consistent hydrologic analysis of rainfall intensity for future climate scenarios is vital. For the present or future climatic conditions in order to analyse and model hydrological events of urban watersheds reliably, it is needed to have both hourly and sub-hourly precipitation data (Watt et al., 2003; Segond et al., 2006; Fadhel et. al., 2017). Therefore, precipitation analysis must be performed for diverse rainfall durations and diverse return periods.

It has been forecasted that an important decreasing in the return period of a yearly maximum precipitation quantity with dense occurrence of extreme rainfall events will take place by the end of 21st century (IPCC, 2012; Fadhel et al., 2017). The tenderness of systems like urban stormwater collection systems can be negatively influenced by these kind of changes (Willems, 2013; Fadhel et al., 2017). Therefore, in order to prevent damages due to storm water collection systems, intensity-duration-frequency analysis must be done cautiously.

In any IDF curves, intensities are described by unit of mm/hr and rainfall durations are shown by hours. Usually, information obtained from analysis are shown as a graph. For obtaining an IDF curve after analysis intensities are drawn on vertical axis while rainfall durations are drawn on horizontal axis then each serial belongs to a certain return period (Chow et al., 1988).

Usually, intensity-duration-frequency (IDF) curves are obtained so as to estimate return periods by using a sequence of observed rainfall data with suitable distribution type according to desired rainfall duration (Overeem et al., 2008; Cheng and Aghakouchak, 2014; Tfwala et al., 2017). With this purpose, there are several distribution types like Gumbel Distribution, Pearson Type 3 Distribution, Log-Pearson Type 3 Distribution, Normal Distribution, Log-normal Distribution, Weibull Distribution and etc. Each distribution method is based on a way in which required parameters such as mean, standard deviation, coefficient of skewness, frequency factor are calculated and rainfall estimates are performed by using a couple of equations.

In this study, it is aimed to obtain IDF curves for cities of Adana, Adıyaman, Hatay (Antakya), Batman, Cizre, Diyarbakır, Gaziantep, Kahramanmaraş, Kilis, Mardin, Osmaniye, Siirt and Şanlıurfa for rainfall durations of rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours. The analyses were conducted for return periods of 2, 5, 10, 25, 50, 100, 1000 years by utilizing Gumbel distribution, Normal distribution, Log-Normal distribution and Log-Pearson Type III distribution which are frequently utilized frequency analysis techniques. Kolmogorov-Smirnov is employed for evaluation of suitability of these distributions for each rainfall durations of stations. The annual maximum rainfall depths over the specific durations were acquired from the recorded rainfall measurements of different year ranges up to 2015, which are acquired from the General Directorate of Meteorology of Turkey.

This study includes 6 chapters. In Chapter 1, a general overview of subject, aim of study and layout of thesis are given. In Chapter 2, a literature review of study from general to specific is given. In Chapter 3, methodology part of study is given with methods starting with Gumbel distribution and ending with Log Pearson Type III distribution. With Chapter 4, study areas and data related to each study area like station information, geography, climate and socio-economic life is given. In Chapter 5, result of each analysis is given with tables and figures. With Chapter 6, based on results of analysis conclusions are given .

CHAPTER 2

LITERATURE REVIEW

2.1. General

During history, there have been a lot of studies in order to represent relationship between intensity-duration-frequency (return period) and even producing curves of rainfall events for different locations all around the world. Investigating hydrologic analysis of precipitation has been vital for water related projects therefore many models have been developed for protection of this structures using a couple of methods such as most commonly used distribution types, special developed methods or deriving equations. Also, scientists have tried to find out the most appropriate distribution type for a series of precipitation data.

2.2. Intensity-Duration-Frequency Curves

2.2.1. Definition

Intensity-Duration–Frequency (IDF) curves represent a relation among duration, intensity and frequency (return period) of rainfall, which are obtained from a sequence of analysis of observed rainfall data. They can be defined as IDF curves present a graph that illustrates quantity of water that rains in a certain given return period in any basin (Dupont and Allen, 1999; Elsebaie, 2011). These curves are used to aid the engineers particularly for water related projects (Rasel et al., 2015).

2.2.2. Historical Aspect

During history, intensity-duration-frequency curves (IDF) took a great deal of interest all around world (Alhassoun, 2011). New rainfall frequency analysis techniques were advanced in the last fifty years and these techniques are being used by governmental corporations (Raiford et al., 2007). Since rainfall is a component of hydrologic cycle, rainfall intensity or rainfall depth estimations were considered by developing many models and techniques. These techniques include using a set of statistical distributions producing new models based on local parameters of cities and deriving general equations based on estimations.

2.2.2.1 Intensity-Duration-Frequency Studies in World

Yarnell (1935) has studied intensity-duration-frequency relationship by producing the first ‘intensity-frequency maps’ for United States. In his study he benefited from maximum-short-periods which have been occurred before. He used different rainfall durations for finding their return periods.

Chow and Maidment (1964) have studied for intensity-duration-frequency estimation with statistical distributions. They presented the procedure of estimating of rainfall intensities with examples of Gumbel and Log Pearson Type III distributions. Also in study they explained deriving equations for intensity-duration-frequency curves.

Frederick et al. (1977) have studied for obtaining precipitation frequency of 5 minutes to 60 minutes for Eastern and Central United States. They made the study with analysis of 2 and 100 year return period of 5, 15 and 60 minutes’ rainfall using Fisher- Tippet Type 1 distribution. They developed the maps which gives rainfall intensity and their durations of studied regions.

Baghirathan and Shaw, (1978) have performed a study dealing with rainfall intensity-duration-frequency for Sri Lanka. They used maximum rainfall data of 19 stations for durations of 3, 6, 12 and 24 hours. They also did their fit analysis with extreme value type 1 distribution. They specified the regions by considering rainfall and topographic properties and forming data sets as station-year concept. In both cases they found acceptable results in which they advised to use in engineering design.

Chen, (1983) has been worked with rainfall intensity-duration-frequency formulas. He has produced a general equation for any place in United States by utilizing 3 rainfall depths which are $R1^{10}$ for 1 hour, 10- year rainfall depth, $R24^{10}$ for 24 hours, 10- year rainfall depth and $R1^{100}$ 1 hour, 100-year rainfall depth.

Canterford et al. (1987) have made an analysis of frequency of Australian data for the purposes of flood analysis and design. They aimed to obtain intensity-frequency-duration curves using 6 minutes to 72 hours’ maximum rainfall data. Log Pearson Type III distribution has been employed so as to fit maximum rainfall data and to find 1-year to 100-year recurrence interval. They made comparisons with United States of

America and developed a computer program which makes automatic calculation of curves for any location.

Koutsoyiannis et al. (1998) studied for obtaining a general equation which is compatible with analysis of maximum rainfall data for intensity-duration-frequency relationships. They worked with two methods for parameter estimation. They stated that distributions of Gumbel, Log Normal, Gamma, Log Pearson Type III, Exponential are alternative distribution functions. They claimed that the studied formulation can be applied for regionalization of IDF curves and incorporating data from ungagged stations.

Dupont and Allen (1999) made a study about updating and revising existent rainfall intensity-duration- frequency curves for Commonwealth of Kentucky. They made their study by beginning of definition and specifying areas of impact. In their study they used rainfall durations of 5 minutes to 1440 minutes for return periods of 2, 5, 10, 25, 50 and 100 years by employing Gumbel distribution.

Madsen et al. (2002) have studied for regional estimation of IDF curves by benefiting from generalized least squares regression for fractional duration sequences. They used the distributions of Gamma, Weibull, Lognormal, Generalized Pareto, and Exponential for testing of goodness of fit. They obtained that final model which has been designed by using the average annual number of exceedances, the mean value of the exceedance quantities and L coefficients can be applied to random region in Denmark.

Hadadin (2005) he studied for obtaining intensity-duration-frequency relation in Mujib Basin, Jordan. He has developed IDF equations for 8 precipitation recording station. He compared the results of equations in which he considered the equation of Chen (1983) with Gumbel Distribution results and Water Authority of Jordan. He used rainfall durations of 20, 30, 60, 120, 180, 360 and 1440 minutes for return periods of 2 to 100 years. He concluded that predicted results are closer to values which were measured..

Raiford et al. (2007) studied for obtaining of rainfall depth-duration-frequency for South Caroline, North Caroline and Georgia. They aimed to update existent IDF curves in those regions. They also used Normal, Lognormal, Generalized Extreme Value, Pearson Type 3 and Log Pearson Type III techniques for fitting annual maximum precipitation data of durations from 15 minutes to 120 hours for return periods of 2, 10, 25, 50, 100 years. They found that new intensity-duration-frequency curves have lower than the curves of 1986.

Madsen et al. (2009) have utilizied a regional model in estimating of extreme rainfall characteristics in Denmark and updated the model with data of 1997-2005. They found that for rainfall durations of 30 minutes to 1 hour and return periods of almost 10 years for most designs of urban drainage amount of increase is %10.

Okonkwo and Mbajiorgu (2010) made a study about rainfall intensity-duration-frequency analyses for seven location of South Eastern Nigeria. They developed intensity-duration-frequency curves for comparing statistical and graphical results. They used annual maximum data series of 15 minutes, 30 minutes, 1 hour, 2 hours, 4 hours and 6 hours for obtaining analysis of 2, 5, 10, 25, 50, 100 year return periods with extreme value type 1 distribution (Gumbel). Also they checked the goodness of distribution fitting with Kolmogorov-Smirnov and X^2 tests. They found that the results of graphical and statistical methods are close to each other for return periods of 2-10 and differ for return periods of 50 to 100 years.

Al Hassoun, (2011) studied for developing an empirical formula for estimating rainfall intensity in Riyadh Region utilizing 3 various distribution types which are Gumbel, Log Pearson Type III, and Lognormal for rainfall durations of 10,20,30 minutes and 1, 2, 24 hours and 2, 5, 10, 25, 50, 100 return period. He found a good match between results of equations and Gumbel Distribution Results.

Elsebaie (2012) studied for obtaining rainfall intensity-duration-frequency relationship for two regions of Saudi Arabia which are Najran and Hafr Albatin. In his study, he investigated rainfall durations 10, 20, 30, 60, 120, 180, 360, 720, 1440 minutes for return periods of 2, 5, 10, 25, 50, 100 using distribution types of Gumbel and Log Pearson Type III distributions. He has obtained that results of Gumbel distribution is higher than Log Pearson Type III distribution.

Abdul Jaleel and Farawn (2013) have made a study for development of rainfall intensity-duration-frequency relationship for Basrah city in Iraq. They were aimed to find an empirical equation for estimation of design rainfall intensities giving intensity-duration-frequency curves. They used 31-year recorded maximum daily rainfall data. They benefited from Gumbel distribution in order to calculate 2, 5, 10, 25, 50, 100 year with rainfall durations of and calculated the intensity-duration-frequency curves and their equations. Also they developed an IDF program which calculates IDF curves.

Al-anazi and Elsebaie (2013) studied so as to get rainfall intensity-duration-frequency relations and their curves for Abha city of Saudi Arabia. The curves were obtained using 34 year recorded rainfall data. In his study, he investigated rainfall durations of 10, 20, 30, 60, 120, 180, 360, 720 minutes for return periods of 2, 5, 10, 25, 50, 100 using distribution types of Gumbel, Log Pearson Type III and Lognormal distributions. They also developed 3 equations with their parameters based on values calculated from distribution by performing a set of regression analysis. For fitting analysis chi-square test method was used. They have found that rainfall estimates increase with increase of return period and rainfall estimates reduce with raise of rainfall duration in all return periods.

Rasel and Hossain (2015) have done a study of developing rainfall intensity-duration-frequency equations and curves of seven areas in Bangladesh. They worked with 35 available data stations which includes 41 years data between 1974-2014. They used rainfall durations of 10, 20, 30, 60, 120, 180, 360, 720 and 1440 minutes. Using Gumbel distribution method, they calculated rainfall intensities for return periods of 2, 5, 10, 25, 50, 100 year. They found a good match between values which have calculated by method’s formula and calibrated formula.

Rasel and Islam (2015) have made a study so as to generate rainfall intensity- duration-frequency relation for North-Western Region in Bangladesh. In their study yearly maximum rainfall data ranging from 1974-2014 was used. They derived IDF equations using Gumbel and Log Pearson Type III distributions and performing nonlinear multiple regression analysis for parameters of equations. Empirical formula of Indian Meteorological Department has been used to estimate rainfall intensities of short durations. IDF curves have been obtained for return periods 2, 5, 10, 25, 50, 100 year. For checking of goodness of fit chi-square test method was performed. They found that results of Gumbel distribution is higher than the results of Log Pearson Type III distribution. Their results showed a high correlation coefficient.

Zope et al. (2016) made a study of developing of rainfall intensity-duration frequency curve for city of Mumbai, India. They used rainfall data ranging from 1901 to 1951 and benefited from empirical equations of Kothyari and Garde (1992) and maximum daily method in order to derive IDF curves. Also in their study, they modified that equation and benefiting short- long rainfall durations with Gumbel distribution rainfall estimations of 2, 3, 5, 10, 25,50,100 return periods have been determined. As a result, they found that the IDF relationships which have been designed in the study can be utilizied in design of drainage system and replace the old curves.

Al-Awadi (2016) worked with intensity-duration-frequency models for Baghdad City, Iraq. In his study he has used maximum rainfall data of last 11 years ranging from 2004-2014. He used data of 0,25 hours, 0,5 hours, 1 hour, 2 hours, 3 hours, 6 hours 12 hours and 24 hours. Gumbel distribution, Log Pearson Type III and Log normal distributions have been utilized for rainfall estimations of 2, 5, 10, 25,50,100 year return periods. Since he used IDF equations a nonlinear regression analysis has been performed so as to calculate the parameters of equations. In checking the goodness of fit he used a software program with Kolmogorov- Smirnow test. As a result, he found that there is not big difference between all techniques.

2.2.2.2 Intensity-Duration-Frequency Studies in Turkey

General Directorate of State Hydraulic Works (1990) made an atlas for maximum precipitation frequency analysis of Turkey. In study the corporation evaluated maximum precipitations of standard terms of 202 stations of General Directorate of Meteorology which has at least 10-year reliable rainfall data and maximum daily and annual data and total annual precipitation data of 1575 stations of General Directorate of State Hydraulic Works /General Directorate Meteorology. In this study a software program which has been developed by Department of Research and Planning of State Hydraulic Works and revised by hydrologists of VII. State Hydraulic Works which is in Samsun was used. They applied the distributions of Normal, Lognormal 2, Lognormal 3, Gamma 2, Log Pearson III and Gumbel or General Extreme Value 1 to data series and found that maximum precipitations conformed to Log Pearson III, Lognormal 2, Lognormal 3 distributions.

Usul, (2001) explained the meaning, benefits and usage areas of intensity-duration-frequency curves for water related structures. Also she explained the distribution types of Normal, Lognormal, Gumbel and Log Pearson Type III and their parameter calculations by giving examples.

Karahan and Ayvaz (2005) studied with specifying intensity-duration-frequency by utilizing nonlinear optimization technique for a case study of Antalya, Turkey. They used GRG2 technique to develop a solution. They benefited from mean squares error so as to minimize errors. Using two empirical equations and two statistical equations for Gumbel and Generalized extreme values distributions they derived two other equations and applied to minimum and maximum rainfall data for durations 5, 10, 15, 30 minutes and 1, 2, 3, 4, 5, 6, 8, 12, 18 ,24 hours. After analysis they recommended their techniques to use and also according to mean square errors technique statistical formulations gave better results compared to empirical formulations.

Senocak and Acar (2007) have made a study about modeling short duration rainfall (SDR) intensity equations for Erzurum city in Turkey. They benefited from maximum annual rainfall data of Erzurum rainfall station ranging with 1956-2004 for rainfall durations of 5, 10, 15, 30 and 60 minutes. They made analysis for return periods of 2, 5, 10, 25, 50, 75, 100 years by utilizing distributions of Generalized extreme values, Two-parameter Lognormal, Three parameter Lognormal, Gumbel, Gamma, Pearson Type 3 and Log Pearson Type III. The data fitting has been tested with X^2 test for choosing most appropriate statistical distribution. IDF equations based on distribution has been obtained benefiting from different equations and making nonlinear estimating methods. They found that except 100-year return period Sherman (1932) equation is most suitable IDF equation.

Karahan et al. (2008) performed a study about specifying intensity-duration-frequency by using genetic algorithm method for a case study of Southeastern Anatolia Project, Turkey. They performed analysis 4 cities of project namely Adıyaman, Diyarbakır, Gaziantep, Şanlıurfa using minimum and maximum rainfall data for durations of 5, 10, 15, 30 minutes and 1, 2, 3, 4, 5, 6, 8, 12, 18 ,24 hours. In this study, they benefited from two empirical equations and two statistical equations for Gumbel and Generalized extreme value distribution. They specified that IDF relationships have the best fitting with these two distributions. For genetic algorithm application, they gave relationships with equations and 6 solving steps. Benefiting from 4 equations they produced two other equations for estimations and compared totally 6 equations giving their root mean square value, correlation factor, the average of absolute errors and, activity coefficient. They found that equation 6 which was recommended by authors gives the best results. Therefore, they applied equation 6 for estimations and checked the change in heavy parameters. They specified that genetic algorithm method gives good results for interest areas. Also in this study they searched whether estimations of all cities can be performed by one equation or not. For this purpose, a new equation has been derived with new three parameters which show latitude, longitude and level. From new equation they derived two different scenarios with three parameters of regional heavy parameters and found two relationships. They found out that two scenarios give close results to analysis result therefore estimations of cities can be performed by one equation.

Karahan and Ozkan (2013) performed a study for showing the best fitting distributions for maximum precipitations in the Aegean Region, Turkey. They used maximum rainfall data ranging with 1929-2005 for rainfall durations of 5, 10, 15, 30 minutes and 1, 2, 3, 4, 5, 6, 8, 12,18, 24 hours for 35 stations using Easyfit software program. They target to check the distributions of and Log Pearson Type III (LPIII), Lognormal 2 (LN2), Lognormal 3 (LN3), GUMBEL (GUM), General extreme value (GEV), Gamma (G1), Gamma 2 (G2) and Gamma 3 (G3) which are most widely seen in hydrological process. Goodness of fit has been checked with Kolmogorov-Smirnow, Anderson- Darling and Chi-Squared tests. They found that according to Kolmogorov-Smirnow and Chi-Squared tests generally General extreme value, Gamma and Lognormal distributions are suitable for short, middle and long rainfall durations. According to Anderson-Darling test, General extreme value distribution is suitable for almost all observations.

Ghiaei et al. (2018) have made a study of regional intensity-duration-frequency analysis for the Eeastern Black Sea Basin, Turkey. In their study, they used L moments for homogeneous evaluation. They used annual maximum rainfall height values for different rainfall duration which are short and long (5 minutes to 24 hours) ranging with 39 to 70 years. The goodness of fit called Z^{DIST} and based on different functions which are generalized normal, Logistic, Pearson type 3, generalized extreme value and generalized pareto distributions has been done. They determined rainfall intensities of 2, 5, 25 ,50, 100, 250, 500 year return periods by obtaining equations based on distribution functions. Also they developed two different scenarios for describing the relationship between intensity-duration-frequency. They applied these two scenario to data and obtained higher correlation coefficients.

2.2.3. Properties and Applications of Intensity-Duration-Frequency Curves

Intensity-duration-frequency curves illustrates three parameters of statistical analysis of rainfall which are rainfall intensity estimations, their durations and frequency at the same time. Rainfall analysis for present and future climatic conditions must be done with data of hourly and sub hourly data (Watt et al., 2003; Segond et al., 2006; Fadhel et. al., 2017). In any IDF curves, intensities are described by unit of mm/hr and rainfall durations are shown by hours. This means that data which is obtained from governmental corporations must be converted to these units. Usually, information obtained from analysis are shown as a graph. For obtaining an IDF curve after analysis intensities are drawn on vertical axis while rainfall durations are drawn on horizontal axis then each serial belongs to a certain return period (Chow et al. 1988).

Generally, rainfall estimates with their durations for a certain return period is determined by performing a set of statistical analysis. There are several types of distributions types in literature which is used in IDF analysis. Statistical distributions such as Gumbel, Pearson Type 3, Log Pearson Type III Normal or Lognormal, can be performed either using their probability distribution function or using frequency factor based on formulas. In first option, parameters of function must be obtained while in second option arithmetic mean, standard deviation, coefficient of skewness and frequency factors based on distribution type are enough for estimation. Also there are special models and software programs which are based on statistical distribution functions for determination of rainfall estimates.

IDF curves are used in studies of regionalization of rainfall analysis of cities, uncertainty analysis of data or deriving general equations of interest areas.

Rainfall intensity-duration-frequency curves can be also employed in water related projects for purposes of planning, designing and operating or protection of different kinds of engineering projects (Koutsoyiannis et al., 1998). These curves are one of the most widely used ways in different engineering projects against hazardous events such as floods (Abdul Jaleel and Farawn, 2013). Rainfall Frequency analysis can be used in system designing of storm runoff, roads and culverts (Brian et al., 2006; Okonkwo and Mbajiorgu, 2010). One of the main fundamental input for storm water drainage systems of cities is to develop IDF relationship (Chawathe et al., 1977; Zope et al, 2016).

2.2.4. Identification and Analyses of Extreme Hydrological Events

The term of extreme can be defined as when a degree, amount or magnitude of any measurable object reaches high or highest point. An extreme hydrological event such as flood, storm can be described like formation of climate inconstant or weather value above or below a verge value close the upper or lower ends of range of observed values of the inconstant (IPCC,2011). In other words, an extreme event of weather or climate is the event which damages to environment and socio-economic life.

Analysis of extreme events in Hydrology is performed with a set of probabilistic approximations. In analysis calculations are based on probability of occurrences. Therefore, the term of return period must be considered. Return period can be described as an mean duration or an estimated duration among events (ASCE, 1996). Return period of any event is estimated by statistical methods.

The hydrologic data must be carefully chosen for satisfying the considerations of independence and identical distribution so this can be provided by choosing annual maximum of variable with successive observations (Chow et al. 1988).

Usually in hydrology the subjects of hydrologic statistics, frequency analysis, flood frequency analysis, risk analysis and design storms are studied for analysing of extreme hydrological events. Frequency analysis are done with event data and statistical distributions and checked with fitting tests.

2.2.5. Statistical Distributions of Extreme Hydrological Events

The initial input of water resource projects which is needed for planning, design, construction and operation studies of different areas like drainage, agriculture, transportation is to know the characteristics of precipitation like amount, duration, intensity, spatial and temporal variation (Karahan and Ozkan, 2013). Being able to successfully fulfil the purpose of a hydraulic structure to be designed is related analysing maximum rainfall events properly (Huang et al. 2016). Therefore, for both safe and economic structures which are affected from rainfall and intensity, analyses must be performed with correct statistical distribution and its analysis.

Recent studies have shown that most of scientists made studies for extreme hydrological analysis considering maximum precipitation data. Most of the studies which have been given with section 2.2.2 have been done with maximum rainfall data using both long and short rainfall durations for a long period of data.

Scientists have performed statistical analysis with different kinds of statistical distributions. Generally, the distribution functions of Gumbel, Exponential, Log Pearson Type III, Gamma, Log Normal are used for intensity-duration-frequency relationships (Koutsoyiannis et al., 1998; Karahan and Ozkan, 2013). Also it is possible to see the distributions of Pearson type 3, Logistic, Weibull, Generalized pareto and Fisher tippet type 1 in studies. However, in recent years, intensity-duration-frequency analysis is done with software programs with a big number of distribution types. Software programs gives the best fitted distribution of entered data according to fitting tests and they can calculate all variables like mean, standard deviation, coefficient of skewness and probability distribution function parameters.

CHAPTER 3

METHODOLOGY

3.1. General

In this study, so as to analyse return periods with rainfall estimations 4 distribution type which are Gumbel, Normal, Lognormal and Log Pearson type III have been done for 13 rainfall stations with 14 rainfall durations of maximum data. Also fitting of distribution have been checked by chi square test. Before applying any method, data must be compatible with the units of intensity-duration-frequency procedures. As it is mentioned in Chapter 2 rainfall intensity is in unit of mm/hour and duration is given with hours. Therefore, any data which have been taken from General directorate of meteorology has been converted to required units by following equation in all distribution types.

$$i = \frac{P}{t_d} \tag{3.1}$$

Where P is any initial rainfall data in any rainfall duration and t_d is rainfall duration in terms of hours.

3.2. Statistical Distributions

3.2.1. Gumbel Distribution

Gumbel represented the extreme theory (Gumbel, 1958) by assuming the distribution of the biggest or the smallest values observed in repeated samples and his idea was that the largest or smallest observed values during the days of a year are the extreme values (Usul, 2001). The Gumbel distribution which is the most frequently employed distribution is applied to IDF studies because of its suitableness for modelling of maximum data. It is comparatively easy and it can be just used for extreme cases (maximum data or peak rainfalls) (Elsebaie,2011).

In the distribution for obtained data, mean which is shown by $\bar{x}$ can be calculated from equation 3.2 and standard deviation shown by s can be calculated by equation using number of data in series denoted by n in equations.

$$\bar{x} = \frac{\sum x}{n} \tag{3.2}$$

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}} \tag{3.3}$$

The design rainfall depth for a desired return period is determined by the following formula (Chow et al. 1988).

$$X_T = \overline{X}_{T_D} + K_T s_{T_D} \tag{3.4}$$

where x̄ and s shows the mean and the standard deviation of different specified rainfall durations of T_D respectively.

K_T which is frequency factor can be calculated from following formula (Chow et al. 1988; Elsebaie,2011; Rasel and Islam, 2015; Zope et al., 2016; Al-awadi, 2016).

$$K_T = -\frac{\sqrt{6}}{\pi}\left[0{,}5772 + \ln\left(\ln\frac{T}{T-1}\right)\right]$$

(3.5)

Where T shows return period. Required K_T values have been calculated and given with Table 1 as follows.

Table 3. 1: Frequency factors of Gumbel distribution

Return Periods (Year)						
2	**5**	**10**	**25**	**50**	**100**	**1000**
Frequency factors, K_T						
-0.16427	***0,719547***	***1,3045632***	***2,0438459***	***2,592288***	***3,1366806***	***4,9355236***

3.2.2. Normal Distribution

Normal distribution which is acknowledged as Gaussian Distribution is the most frequently employed distribution for analysing of hydrologic variables (Usul,2001). The primary limitations of normal distribution are that normal distribution has a symmetric bell shape curve about mean whilst hydrologic data have a tendency to be skewed and the best part of hydrologic variables are not negative it changes over a continuous range [-∞,∞] (Chow et al. 1988).

In normal distribution two parameters to be computed are its mean $\bar{x}$ and standard deviation s and z is a variable which is called standard unit or standardized unit which has zero mean and unit standard deviation. For calculation of z variable equation 3.6 can be used and when z is found, applying an inverse transformation to equation 3.6 value of any x can be found with equation 3.7 (Usul,2001). Therefore, the design rainfall depth for a desired period can be calculated by equation 3.5 finding z values for specified return period.

$$z = \frac{x - \bar{x}}{s} \tag{3.6}$$

$$x = \bar{x} + zs \tag{3.7}$$

Standardized variable z for desired return period can be determined by probability of occurrence of return period which is denoted by p.

$$p = \frac{1}{T_r} \tag{3.8}$$

After calculations of each probability of return periods of T_r, z can be calculated from z tables have been given with Appendix A. Values have been found and given in Table 3.2. Mean and standard deviation of data are computed by equations of 3.2 and 3.3 in normal distribution.

Table 3. 2: Z numbers of Normal Distribution

Return Periods						
2	5	10	25	50	100	1000
Frequency factors, K_T						
0	*0,84162*	*1,28155*	*1,7509*	*2,05375*	*2,32635*	*3,09023*

3.2.3. Log -Normal Distribution

If promiscuous inconstant Y=logx is normally distributed, then x is told to be lognormally distributed (Chow et al. 1988). Since hydrological variables tend to skew right and have positive values, it is not fit the normal distribution but their logarithms which are 10 based or natural fit the normal distribution (Benjamin and Cornell, 1970; Usul, 2001).In this distribution it is needed to compute two parameters that are mean and standard deviation. Also it is required to taking 10 based logarithms of data so as to be symmetric about mean (Chow et al. 1988).

In this distribution after obtaining all data in terms of mm/hr by using equation 3.1, 10 based logarithms of each data is taken.

$$x = \log i \tag{3.9}$$

Then, mean and standard deviation of data becomes as following

$$\overline{\log x} = \frac{\sum \log x}{n} \tag{3.10}$$

$$S_{\log x} = \sqrt{\frac{\sum (\log - \overline{\log x})^2}{n-1}} \tag{3.11}$$

Where n shows the data size . Benefiting from normal distribution equation which is 3.5 equation 3.6 can be written (Usul, 2001). For z values Table 3.2 can be used. For finding any required value of estimation antilog of equation 3.12 which is given by equation 3.13 must be used.

$$\log x = \overline{\log x} + z * S_{\log x} \tag{3.12}$$

$$x = 10^{\log x} \tag{3.13}$$

3.2.4. Log Pearson Type III Distribution

If log x complies a Pearson Type III distribution, it is told that x complies Log Pearson Type III distribution (Chow et al., 1988). Log Pearson Type III distribution is utilized to determine the rainfall intensities belonging to various rainfall durations and return periods for obtaining IDF curves. Log Pearson Type III distribution is often employed in flood studies (Usul, 2001).

Some formulas are used to perform rainfall intensities. Like Lognormal distribution, firstly 10 based logarithms of each data should be taken with equation 3.9. Then using equation 3.10 mean of data must be calculated. Standard deviation of data is calculated from equation 3.11. Coefficient of skewness which denoted by G can be calculated from following formula.

$$G = \frac{n\sum(\log x - \overline{\log x})^3}{(n-1)(n-2)(s_{\log x})^3} \quad (3.14)$$

One other parameter is frequency factor which is denoted by K_T and dependent on skewness of coefficient, G. In this distribution K_T can be determined by two ways. For first way, after obtaining of G, reference tables of frequency factors for Log Pearson type III distribution which have been given in Appendix B (Hoggan, 1989; Usul, 2001) can be used. According to coefficient of skewness G, K_T is obtained by selecting return period and making some iterations if required. For second way an equation which is given by equation 3.15 can be used (Kite, 1977; Chow et al., 1988).

$$K_T = z + (z^2 - 1)k + \frac{1}{3}(z^3 - 6z)k^2 - (z^2 - 1)k^3 + zk^4 + \frac{1}{3}k^5 \quad (3.15)$$

$$k = \frac{C_S}{6}, G = C_s \quad (3.16)$$

Where z is standardized unit with specified return period. After finding frequency factor values then estimations are done. Calculated K_T factors for each rainfall station have been given with appendixes part. Combining three equations with K_T values then rainfall estimations can be done by equation 3.12. For finding any required value of estimation antilog of equation 3.12 which is equation 3.13 must be used.

3.3. Checking the Suitability of Distribution

3.3.1. Kolmogorov- Smirnov Test

Kolmogorov-Smirnov test is a typical used test in checking the goodness of fit statistical distribution. It is a test whose statistics which is D_N is based on the maximum deviation between theoretical cumulative distribution function and empirical cumulative distribution function. (Rao and Hamed, 2000).

$$D_N = \max\left|F_N(x) - F_o(x)\right| \quad (3.17)$$

where $F_N(x)$ theoretical cumulative distribution and $F_o(x)$ is empirical distribution function.

According to test procedure, D_N value must be smaller than the values of D_N which have been given with Appendix C at a required confidence level in order to decide whether the distribution is suitable for the data or not. Otherwise the distribution is rejected (Rao and Hamed, 2000). As sample size is known then a significance level (α) is selected in order compare D_N values.

In this study for data of all rainfall durations of stations significance level has been selected as 0,05 and the test was made for the distributions which have been specified in previous sections based on n which is sample size.

CHAPTER 4

DATA AND STUDY AREA

4.1. Data

In this study, maximum rainfall data of each station has been taken from General Directorate of Meteorology of Turkey. Data consists both hourly and sub hourly information namely each data set of any station starts with 5 minutes to 24 hours. Each station has been studied with a year range. The information about stations have been given with Table 4.1.

4.2. Study Area

4.2.1. Southeastern Region

Southeastern Anatolia Region is a region of seven geographical regions in Turkey. The region has 8% of territory of Turkey and in terms of area it is the smallest. It extends from Southeastern Taurus from its south to border of Syria and Iraq. The region is coated with plateaus and plains and is the region where summer temperatures and evaporation are the highest in Turkey. In the region summers are dry and warm, winters are marrow and dry. Precipitation decreases from North to South. Average annual rainfall is 750 mm in North and 300mm in Southern low areas. The population is mostly collected in the western part of the region. The main reason for this is that climate and soil conditions are more favorable here. Main extracted mines; phosphate, asphaltite, petroleum. In the area, different industrial branches have been improved which are based on animal products and agriculture. There are various industry arms which have been developed like olive oil factories, dairy industry, animal oil factories, and also the nonagricultural industry arms like chemical industry, auto montage, agricultural vehicles, metal goods and cement factories. Also in the region since cities of region have lots of touristic places tourism potential is very high. In this study for investigation of this region, analyses have been done for cities of Adıyaman, Batman, Cizre, Diyarbakır, Gaziantep, Kilis, Mardin, Siirt and Şanlıurfa as it is shown in Figure 4.1.

Table 4. 1: Data Information

Station	**Location**	**Latitude**	**Longitude**	**Height (m)**	**Data Range**
18268	Adana (Çukurova)	37,0578 **N**	35,2614 **E**	165	1944-2015
17265	Adıyaman	37,7553 **N**	38,2775 **E**	672	1966-2015
17372	Hatay (Antakya)	36,2048 **N**	36,1513 **E**	104	1957-2015
17282	Batman	37,8636 **N**	41,1562 **E**	610	1969-2015
17950	Cizre	37,3326 **N**	42,2027 **E**	400	1966-2010
17281	Diyarbakır (Bağlar)	37,9094 **N**	40,2133 **E**	680	1940-2015
17261	Gaziantep (Şahinbey)	37,0585 **N**	37,3510 **E**	854	1957-2015
17255	Kahramanmaraş	37,5760 **N**	36,9150 **E**	572	1966-2015
17262	Kilis	36,7085 **N**	37,1123 **E**	640	1966-2015
17275	Mardin	37,3103 **N**	40,7284 **E**	1040	1966-2015
17355	Osmaniye	37,1021 **N**	36,2539 **E**	94	2001-2015
17210	Siirt	37,9319 **N**	41,9354 **E**	895	1959-2015
17270	Şanlıurfa	37,1608 **N**	38,7863 **E**	550	1959-2015

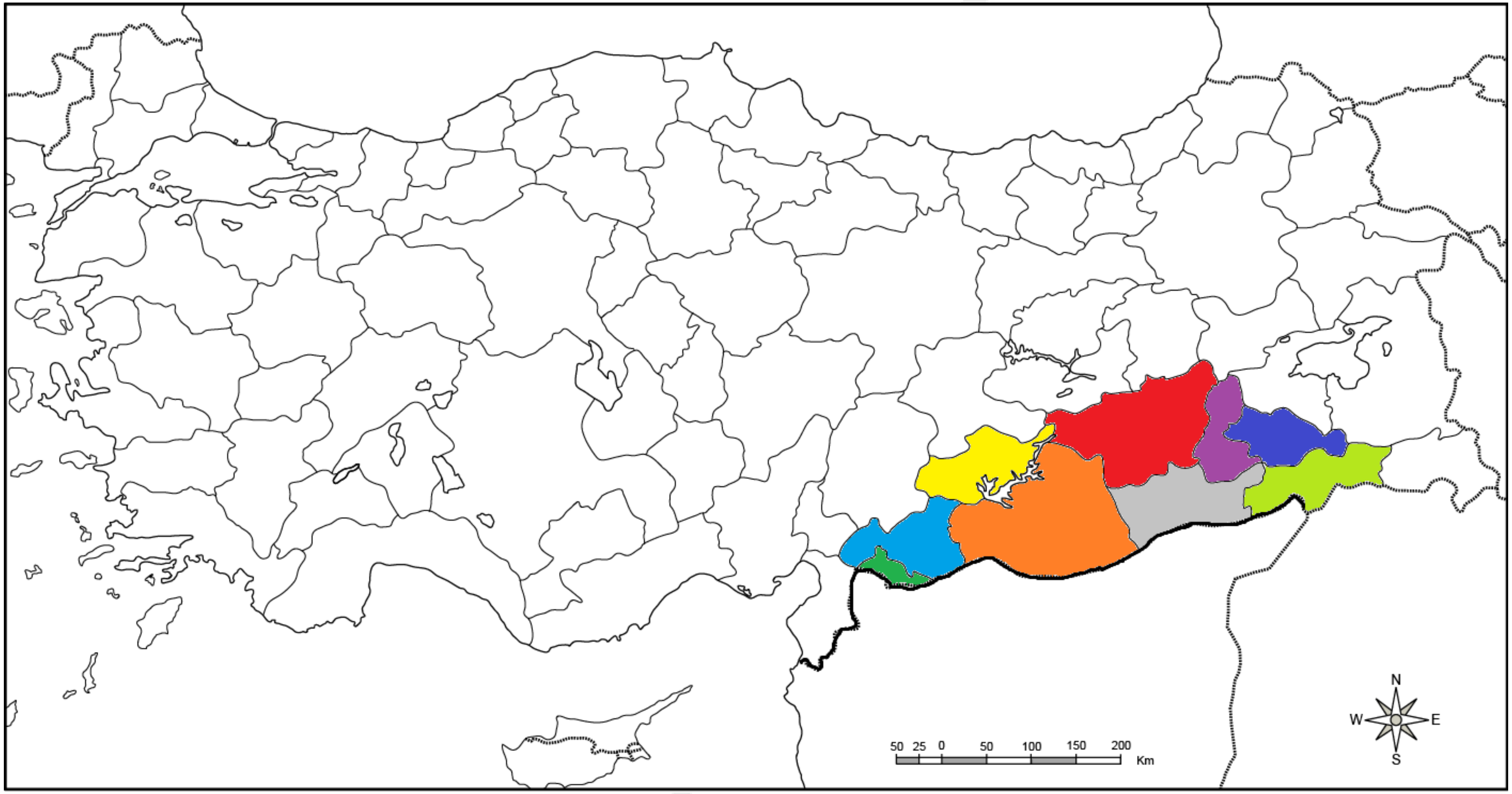

Figure 4. 1: Study Areas in Southeastern Region

4.2.2. Eastern Mediterranean Region

East Mediterranean region is a part of Mediterranean region of Turkey. In the region winters are marrow and rainy, summers are warm and dry. The regions is rugged and mountainous. There are plateau areas in the region. From the shore, when elevation increases the temperature decreases and amount of rainfall increases. The plant cover is maquis. The population is mostly collected in Adana. It is because of rich agricultural areas. Although agricultural areas are limited in the region are limited, the most important economic activity in the coastline is agriculture. Mainly wheat, rice, citrus are products of this region. Also mines like chromium, barite and asbestos are mining materials. Industry has been developed in production with factories of food, chemistry, tobacco, glass, brick, agricultural vehicles and metal ware in this region. . In this study for investigation of this region, analyses have been done for cities of Adana, Kahramanmaraş, Osmaniye and Hatay as it is shown in Figure 4.2.

As activities in both regions have been mentioned it is also needed to keep places from natural hazards. There several natural disasters which threaten social life of cities. One of them is floods due to rainfalls. There are several floods in which a lot of people have been died and lots of places have been damaged in history. When infrastructures are not designed good enough then rainfall causes floods which damages to people and environment. For this kind of reasons in order to keep cities and their social life against floods, rainfall events must be analyzed properly and designs must be done with a huge care. A good design of infrastructure system requires a good analysis of maximum rainfall events.

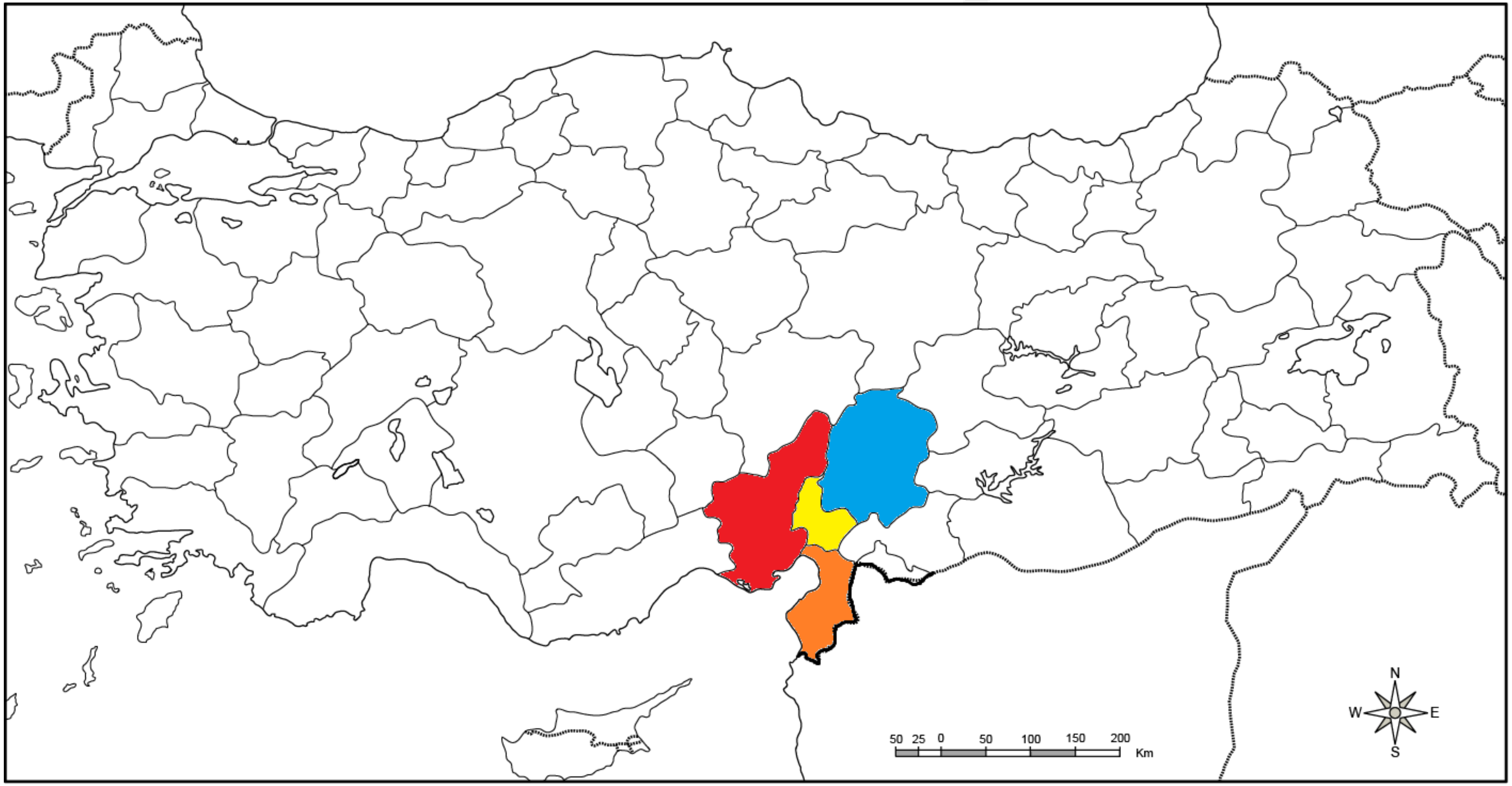

Figure 4. 2:Study Areas in Eastern Mediterranean Region

CHAPTER 5

RESULTS AND DISCUSSION

5.1. General

In Gumbel distribution, frequency factor which is K_T increases with the increasing of return period as can be understood from Table 3.1. Elsebaie (2011), Alhassoun (2011) found the same trend for frequency factor of Gumbel distribution.

In Normal and Lognormal distributions as frequency factor standard normal variable has been used. By looking at Table 3.2 it is said that like Gumbel distribution analysis standard normal variable z increases with the raise of return period. Usul, (2001) and Chow et al., (1988) using same frequency factors for this distributions.

In Log Pearson Type III distribution, as a difference since in this distribution frequency factors are related to coefficient of skewness G, it is not only related to return period. Frequency factors of K_T have been obtained by making a set of interpolation between values of reference tables given with Appendix B (Hoggan, 1989; Usul, 2001). It has been seen that K_T increases with the raise of return period in any rainfall duration. In studies of producing IDF curves with Log Pearson Type III, same relation has been obtained (Elsebaie, 2011; Alhassoun, 2011).

In all distribution analysis it has been obtained that when return period increases rainfall estimates increase in any rainfall duration and rainfall estimates decrease with increasing of rainfall duration in any return period by looking at Appendix E, Appendix F, Appendix G and Appendix H. Elsebaie, (2011) and Al-Awadi, (2016) concluded the same result in their studies.

In all analysis by looking at IDF curves it can be observed that trend of each station in all distribution analysis is same. In most studies of developing IDF curves same situation has been observed. (Al-anazi and El-Sebaie, 2011; Elsebaie, 2011; Al-Awadi, 2016).

Since application manner in Gumbel and Normal distribution are same and only frequency factors are different, comparisons have been done between these two distributions. Normal and Lognormal distributions have been compared since frequency factors are same. Also Lognormal and Log Pearson III distributions have been made because taking 10 based logarithms are same. Binary comparisons have been made between common rainfall durations for same station.

In each rainfall duration of each station, the best fitted distribution has been selected based on the smallest D_N value. D_N values of each station has been given with Appendix I. Mirhosseini et al. (2012) followed the same manner in order to evaluate performance of distributions while producing IDF curves in Alabama.

5.2. Results of Cities

Results of each city has been investigated separately in order to show similar and different sides of stations.

5.2.1 Results of Adana City

For Adana City, IDF curves which have been obtained from distribution analysis have been given with Figure 5.1.

Gumbel distribution has been analyzed for rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours. In this distribution it can be seen from Table E1 which has been given with Appendix E, it is possible to tell that the difference between two consecutive return periods takes the highest value between 100 and 1000 return periods while it takes the smallest value between 50 and 100 year return periods.

In normal distribution rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours have been analyzed. By looking at the results of Normal distribution analysis from Table F1 which has been given with Appendix F it can be said that up to 100 year return period the difference between rainfall estimates becomes less but between 100 year return period and 1000 year return period the difference becomes larger comparing to consecutive return periods. Also the difference between two consecutive return periods takes the highest value between 2 and 5 year return period while it takes the smallest value between 50 and 100 year return periods.

Log Normal analysis have been performed for rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours. Standard normal variable of z is the same with Normal distribution. Since at the beginning of the study 10 based logarithm of each data was taken in Log normal analysis rainfall estimates are different from Normal distribution. Also the difference between two consecutive return periods takes the highest value between 100 and 1000 year return period while it takes the smallest value between 25 and 50 year return periods. Also the difference value of 50 and 100 year return periods is very close to difference between 25 and 50 year return period.

In Log-Pearson Type 3 analysis rainfall durations of 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours have been studied. Looking at Table H1 it can be told that the difference between two consecutive return periods takes the highest value between 100 and 1000 year return period while it takes the smallest value between 25 and 50 year return periods.

For Adana station as a comparison between Gumbel distribution and Normal distribution, looking at results of Table E1 and Table F1, it has been obtained that in 2 and 5 year return periods Normal distribution has given higher results in all rainfall durations while in other return periods Gumbel distribution has given the higher results. A comparison between Normal and Lognormal distributions has been made with reference to Table F1 and Table G1 and it has been got that in return periods of 2 and 5 except at 5 minutes rainfall duration Normal distribution has given higher results and in 25,50,100 and 1000 year return periods Lognormal has higher results. Same comparison has been made between Lognormal and Log Pearson III distribution it has been seen that the situation of the highest intensities changes according to rainfall duration.

Kolmogorov-Smirnov test has been applied to Adana station and results of test have been given in Appendix I with Table I1 for all rainfall durations. The best fitted distribution of each rainfall duration has been given with Table 5.1.

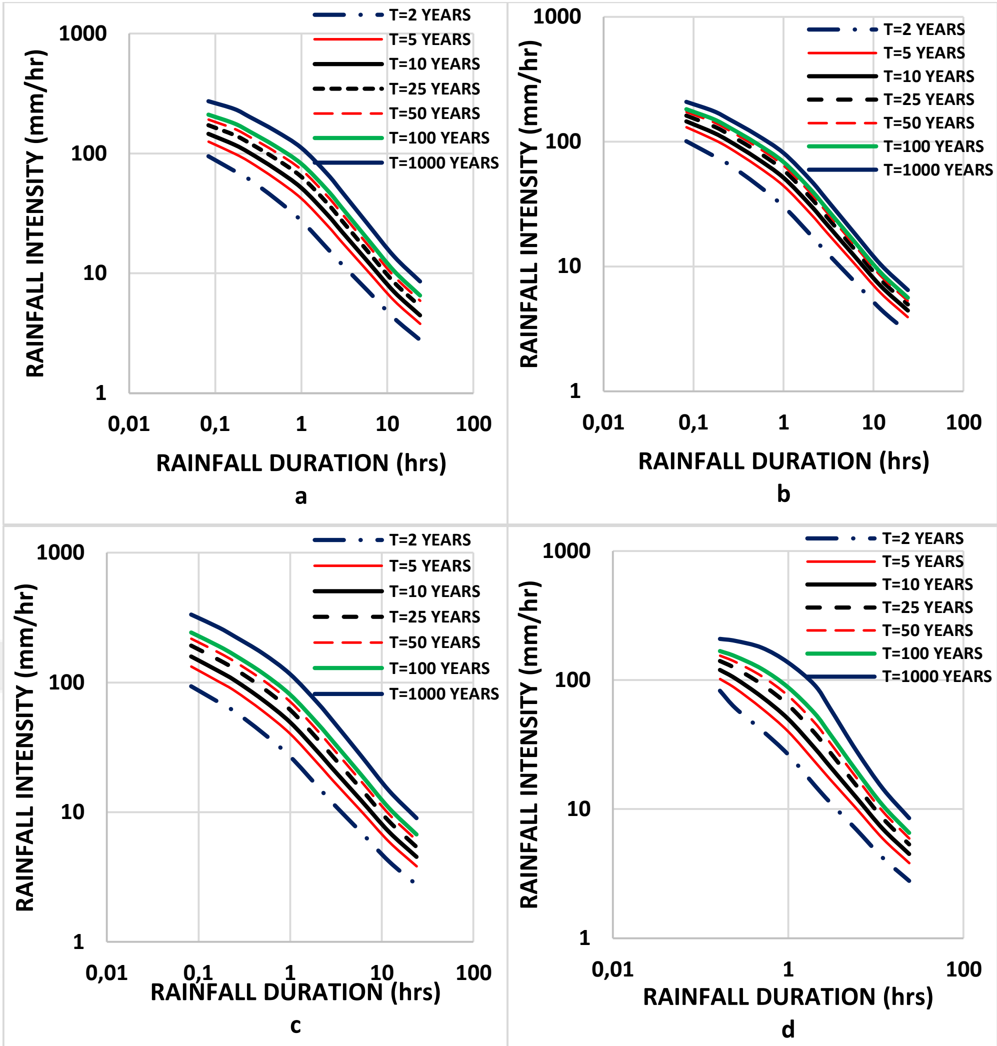

Figure 5. 1: IDF curves for Adana City with a) Gumbel Distribution, b) Normal Distribution, c)Log Normal Distribution, d)Log Pearson Type III Distribution.

Table 5. 1: The Best Fitted Distribution for Adana Station

Rainfall Duration (hour)	*Distribution*	D_N
0,0833333	Normal	0,11811
0,166666	Log-Pearson Type 3	0,06222
0,25	Log-Normal	0,07114
0,5	Log-Pearson Type 3	0,06317
1	Log-Pearson Type 3	0,06849
2	Log-Pearson Type 3	0,06257
3	Log-Normal	0,07558
6	Log-Pearson Type 3	0,07333
12	Log-Pearson Type 3	0,04363
24	Log-Normal	0,08432

5.2.2. Results of Adıyaman City

For Adıyaman City, IDF curves which have been obtained from distribution analysis have been given with Figure 5.2.

Gumbel Distribution has been tested on for rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours. According to results of Table E2, between two consecutive return periods, the highest difference has been observed between 100 and 1000 year return periods and also it is easy to say that difference between 25 and 50 year return period is very close to difference between 50 and 100 year return periods which is the smallest difference.

Similar to Gumbel distribution, rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours have been studied for Normal distribution and results have been given with Table F2. Results have shown that for all rainfall durations the difference between two consecutive return periods has the highest value between 2 and 5 year return period.

In Log normal distribution, rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours was tested and as it can be observed from Table G2, results showed that the difference between two consecutive return periods has the highest value between 100 and 1000 year return period and also the differences between 5 and 10 year return period, between 25 and 50 year return period and between 50 and 100 year return period have close results.

In Log Pearson Type III distribution, it has been worked with rainfall durations of 10, 15, 30 minutes, 1, 2, 3, 6, 12 hours rainfall durations. From the results of Table H2, it has been obtained that when the difference between two consecutive return periods is investigated, maximum difference occurs between 100 and 1000 year return period. Also the differences between 2 and 5 year return period and between 25 and 50 year return period have a close value.

In the comparison between Gumbel and Normal distribution using Table E2 and Table F2, it has been recognized that Normal distribution has the highest rainfall estimates in 2 and 5 year return periods and in the rest return periods Gumbel has been seen as the highest. Normal and Lognormal has been compared by looking at Table F2 and Table G2 and it has been analyzed that Normal distribution has higher values in 2,5,10 year return but except at 12 hours rainfall duration 5 year return period and 12 hours and 24 hours rainfall durations of 10 year return period and in the other return periods which are 25,50,100 and 1000 year Lognormal distribution has higher results. In one other comparison which is between Lognormal and Log Pearson III it is not as easy as to make contact like other comparisons because the highest values change according to rainfall duration.

Kolmogorov-Smirnov test has been applied to Adıyaman station and results of test have been given in Appendix I with Table I2 for all rainfall durations. The best fitted distribution of each rainfall duration has been given with Table 5.2. For 5 minutes and 24 hours rainfall durations Log Pearson III was not taken into account.

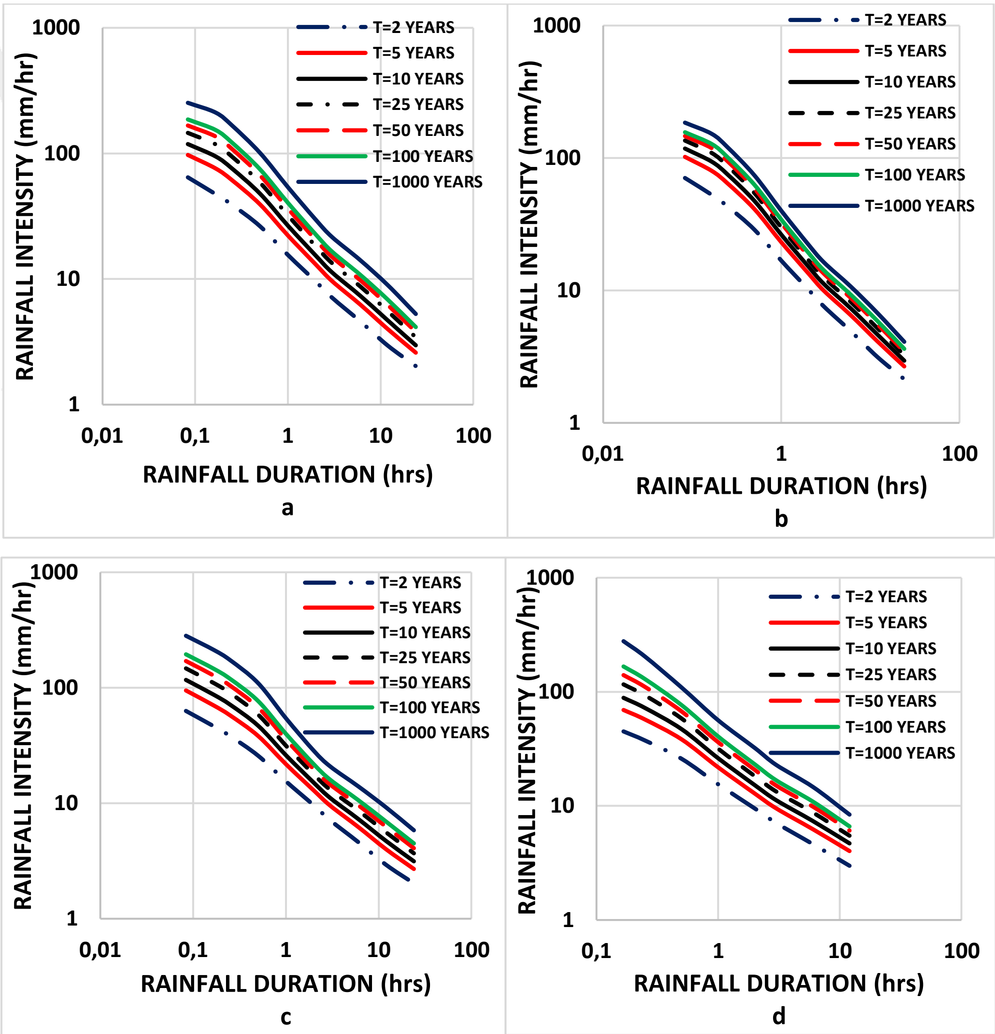

Figure 5. 2: IDF curves for Adıyaman City with a) Gumbel Distribution, b) Normal Distribution, c) Log Normal Distribution, d) Log Pearson Type III Distribution

Table 5. 2: The Best Fitted Distribution for Adıyaman Station

Rainfall Duration (hour)	***Distribution***	D_N
0,0833333	Log Normal	0,07969
0,166666	Log Normal	0,07646
0,25	Log Normal	0,07645
0,5	Log Normal	0,07482
1	Log Normal	0,10016
2	Log Pearson Type III	0,09749
3	Log Pearson Type III	0,06421
6	Log Normal	0,07529
12	Log Normal	0,0888
24	Gumbel	0,0646

5.2.3. Results of Hatay (Antakya) City

For Hatay (Antakya) City, IDF curves which have been obtained from distribution analysis have been given with Figure 5.3.

Rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours have been used for Gumbel distribution analysis. Results of Table E3 have shown that the difference between two consecutive return periods has the highest value between 100 and 1000 year return period and smallest value between 50 and 100 year return period.

For all rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours Normal distribution method have been used and results have been given with Table F3. In this analysis the difference between two consecutive return period has maximum value between 2 and 5 year return period which is similar to Adana and Adıyaman Stations.

Log normal analysis have been performed for same rainfall durations of Normal distribution and results were given with Table G3. Likewise the Gumbel distribution, the difference between two consecutive return periods has the highest value between 100 and 1000 year return period.

Log Pearson Type III analysis have been done for rainfall durations of 10, 15, 30 minutes, 1, 3, 6, 12 and 24 hours. Similar to Gumbel and Log normal distributions, the difference between two consecutive return periods has the highest value between 100 and 1000 year return period.

Normal and Gumbel distributions have been compared by helping of Table E3 and Table F3. In 2 and 5 return periods Normal distribution gave higher and in 10,25,50,100 and 1000 year return period higher values belong to Gumbel distribution. In comparing of Normal and Lognormal distributions, Normal distribution has given higher results in 2,5,10 return periods but except at 5 minutes, 10 minutes and 15 minutes rainfall duration of 10 year return period while in the rest Lognormal has higher results except at 12 hours of 25 return period and 12 hours, 24 hours of 50 year return period. Lognormal and Log Pearson III comparison does not show a certain behavior since the highest estimates change based on rainfall duration.

Kolmogorov-Smirnov test has been applied to Hatay(Antakya) station and results of test have been given in Appendix I with Table I3 for all rainfall durations. The best fitted distribution of each rainfall duration has been given with Table 5.3. In 5 minutes and 2 hours rainfall duration analysis, Log Pearson Type III was not taken into account since it was not used in the analysis.

Table 5. 3: The Best Fitted Distribution for Hatay (Antakya) Station.

Rainfall Duration (hour)	***Distribution***	***D_N***
0,0833333	Gumbel	0,06572
0,166666	Log Pearson Type III	0,05434
0,25	Log Pearson Type III	0,06855
0,5	Log Pearson Type III	0,05182
1	Log Pearson Type III	0,07093
2	Lognormal	0,08813
3	Log Pearson Type III	0,11087
6	Log Pearson Type III	0,08519
12	Log Pearson Type III	0,08217
24	Log Pearson Type III	0,07656

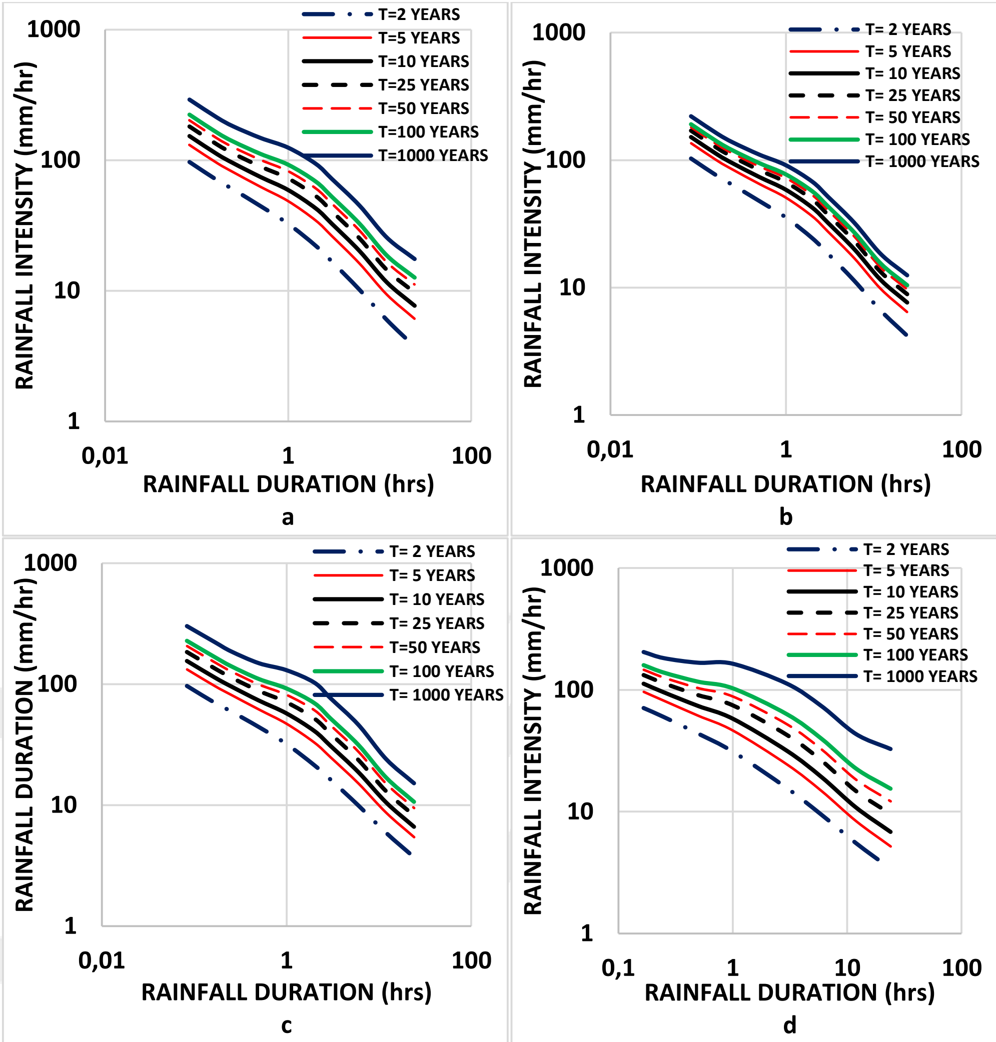

Figure 5. 3: IDF curves for Hatay City with a) Gumbel Distribution, b)Normal Distribution, c)Log Normal Distribution, d)Log Pearson Type III Distribution

5.2.4. Results of Batman City

For Batman City, IDF curves which have been obtained from distribution analysis have been given with Figure 5.4.

Rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours have been used in order to perform Gumbel distribution analysis. From results of Table E4 it has been obtained that the difference between two consecutive return periods has the highest value between 100 and 1000 year return period and smallest value between 50 and 100 year return period. Also the difference between 50 and 100 year return period very close to difference of 25 and 50 year return period.

Rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours have been worked for Normal distribution method and results of Table F4 shows that the difference between two consecutive return periods has maximum value between 2 and 5 year return period and the smallest difference value belongs to 50 and 100 year return period.

In Lognormal distribution similar to Gumbel and Normal distributions rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours have been studied and the results have been given with Table G4. In this analysis it has been found that the difference between two consecutive return periods is maximum in between 100 and 1000 year return periods.

In Log Pearson Type III analysis 5, 10, 15, 30 minutes, 2, 3, 6 and 24 hours rainfall durations have been studied. According to results of Table H4 the difference between 100 and 1000 year return periods is the highest as the difference between two consecutive return periods.

For Batman station in Normal-Gumbel comparison from Table E4 and Table F4, it has been got that Normal has the highest rainfall intensities in the return periods of 2 and 5 year and in 10, 25, 50, 100, 1000 year return periods Gumbel is higher. Normal and Lognormal distribution comparison shows a similar behavior to Normal and Gumbel distribution comparioson because in Normal and Lognormal distribution comparison, Normal distribution has higher results than Lognormal distribution in 2 and 5 year return periods while in 10, 25, 50, 100, 1000 Lognormal is higher than Normal distribution according to Table F4 and Table G4. Also with same manner by checking Table G4 and Table H4, Log normal and Log Pearson III have been compared and it has been seen that 2 and 5 return periods Log Pearson III have higher results while in the rest return periods Log normal distribution have higher results than Log Pearson 3 for all common rainfall durations.

Kolmogorov-Smirnov test has been applied to Batman station and results of test have been given in Appendix I with Table I4 for all rainfall durations. The best fitted distribution of each rainfall duration has been given with Table 5.4. In 1 hours and 12 hours rainfall duration analysis, Log Pearson Type 3 was not taken into account since it was not used in the analysis.

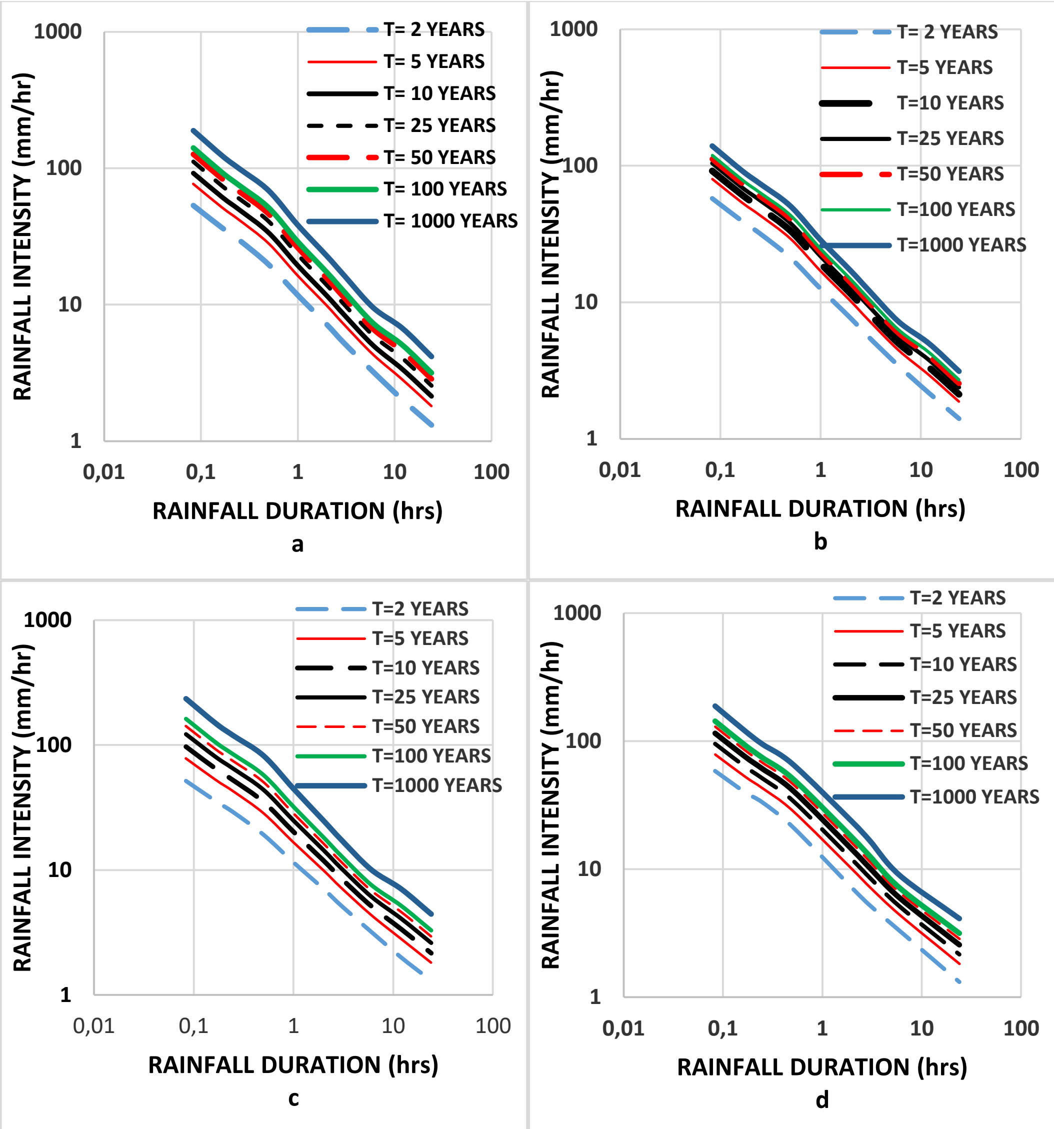

Figure 5. 4: IDF curves for Batman City with a) Gumbel Distribution, b) Normal Distribution, c) Log Normal Distribution, d) Log Pearson Type III Distribution.

Table 5. 4: The Best Fitted Distribution for Batman Station

Rainfall Duration (hour)	*Distribution*	D_N
0,0833333	Lognormal	0,09474
0,166666	Log Pearson Type III	0,08758
0,25	Log Pearson Type III	0,11173
0,5	Log Pearson Type III	0,06743
1	Lognormal	0,09113
2	Lognormal	0,08087
3	Lognormal	0,07562
6	Log Pearson Type III	0,07096
12	Lognormal	0,12952
24	Lognormal	0,06017

5.2.5. Results of Cizre City

For Cizre City IDF curves which have been obtained from distribution analysis have been given with Figure 5.5.

For Cizre Station, Gumbel distribution results which have been obtained by using data of rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours have been given with Table E5. From these results it has been obtained that the difference between two consecutive return periods have been calculated as the highest value in between 100 and 1000 year return periods while it has been calculated as the smallest in between 50 and 100 year return periods.

In Normal distribution similar to Gumbel distribution same rainfall durations have been studied the results have been tabulated in Table F5. In these results it has been analyzed that, maximum difference which can be observed between two consecutive return period has been found between 2 and 5 year return period. In addition to this, the differences between 5 and 10 year return period and between 10 and 25 year return period have a close value. Similarly, the differences between 25-50 year return period and between 50-100 year return period are close to each other.

In Lognormal distribution analysis, same rainfall durations with Gumbel and Normal distributions have been used. Seeing at results of Table G5 it is easy to say maximum difference between two consecutive return periods occur between 100 and 1000 year return period.

In Log Pearson Type III analysis rainfall durations of 15, 30 minutes, 3, 6, 12 and 24 hours have been investigated and results have been given with Table H5. Also in these analysis same relation has been obtained with Gumbel, Normal distribution in care of the highest and smallest difference between consecutive two years.

In Cizre station, according to Table E5 and Table F5, Normal distribution has higher results than Gumbel distribution in return periods of 2 and 5 year and in the same way Gumbel distribution is higher than Normal distribution in return periods of 10, 25, 50, 100, 1000 year. Also Table F5 and Table G5 show that in 2 and 5 year return periods Normal distribution is higher and in 25,50,100,1000 return periods Lognormal has given higher results. In the comparison of Lognormal and Log Pearson III there is no general relationship between return periods of distributions because values change according to rainfall duration.

Kolmogorov-Smirnov test has been applied to Cizre station and results of test have been given in Appendix I with Table I5 for all rainfall durations. The best fitted distribution of each rainfall duration has been given with Table 5.5. Only in analysis of rainfall durations of 15 minutes, 30 minutes, 3 hours, 6 hours, 12 hours and 24, Log Pearson Type III was taken into account since they have been used for Log-Pearson Type 3 analysis.

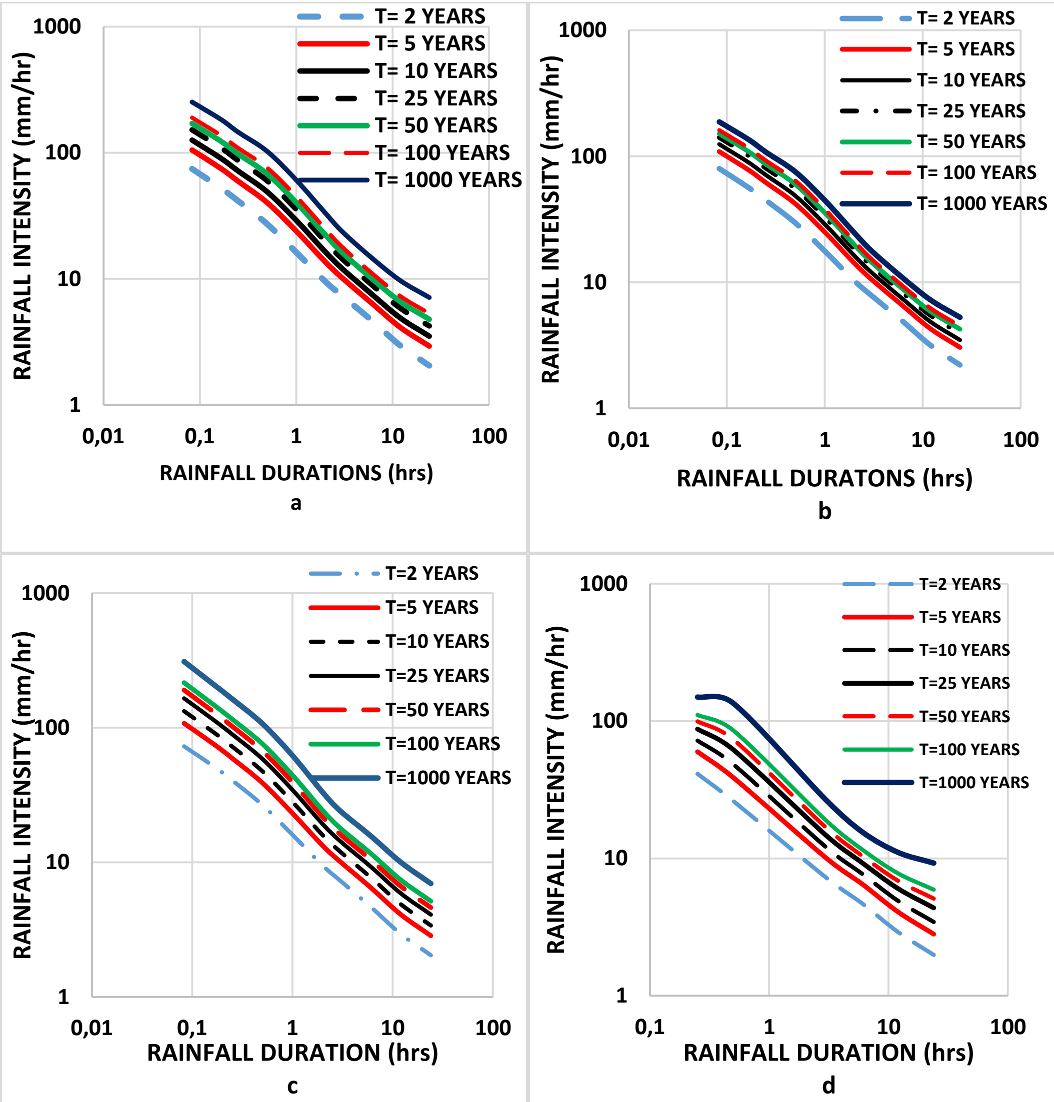

Figure 5. 5*:* IDF curves for Cizre City with a) Gumbel Distribution, b) Normal Distribution, c) Log Normal Distribution, d) Log Pearson Type III Distribution

Table 5. 5: The Best Fitted Distribution for Cizre Station.

Rainfall Duration (hour)	***Distribution***	***D_N***
0,0833333	Gumbel	0,11047
0,166666	Gumbel	0,09111
0,25	Log Normal	0,08518
0,5	Log Pearson III	0,06458
1	Log Normal	0,10297
2	Gumbel	0,08906
3	Log Pearson III	0,0721
6	Log Pearson III	0,11824
12	Log Pearson III	0,06575
24	Log Pearson III	0,10983

5.2.6. Results of Diyarbakır City

For Diyarbakır City IDF curves which have been obtained from distribution analysis have been given with Figure 5.6.

In Diyarbakır Station, for Gumbel distribution rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours have been taken as rainfall data. Results have been presented by Table E6. As a comparison, among all comparisons between consecutive return periods it can be told that the difference between two consecutive return periods have been determined as the highest value in between 100 and 1000 year return periods.

In Normal distribution, data of rainfall durations have been taken as 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours. Giving the results by Table F6, it has been seen that the difference between two consecutive return periods have been observed as the highest value in between 2 and 5 year return period analysis. Second highest difference belongs to the difference which is between 100 and 1000 year return period.

In Lognormal analysis same rainfall durations with Gumbel and Normal distributions have been considered. Having a look at results of Table G6, it has been recognized that the difference between two consecutive return periods has the highest value in between 100 and 1000 year return period. Also second highest difference of two consecutive return periods which belongs to difference of 10 and 25 year return period is very close to difference of 2 and 5 year return period.

In Log Pearson Type III analysis except at 5 minutes and 2 hours rainfall durations, same rainfall durations with Gumbel, Normal and Lognormal distributions have been acquired as rainfall data. Presenting the results with Table H6, it has been found that the highest difference between two consecutive return periods is the difference of 100 and 1000 year return period.

Gumbel and Normal distributions have been compared based on Table E6 and Table F6. Similar to previous stations Normal distribution is higher in 2 and 5 return periods and Gumbel distribution is higher in rest of return periods. Looking to Table F6 and Table G6 and comparing Normal and Lognormal distribution it is possible to say that except at 2 and 5 return periods Lognormal distribution has higher results. In 2 and 5 return periods Normal distribution has higher values similar to Cizre and Batman stations. Also it is not possible to make an exact contact between values when Log Pearson III and Lognormal distributions are compared.

Kolmogorov-Smirnov test has been applied to Diyarbakır station and results of test have been given in Appendix I with Table I6 for all rainfall durations. The best fitted distribution of each rainfall duration has been given with Table 5.6. Only in analysis of rainfall durations of 5 minutes and 2 hours rainfall durations, Log Pearson Type III was not taken into account since they weren’t used for Log-Pearson Type III analysis.

Table 5. 6: The Best Fitted Distribution for Diyarbakır Station

Rainfall Duration (hour)	***Distribution***	D_N
0,0833333	Lognormal	0,0855
0,166666	Log Pearson III	0,06766
0,25	Log Pearson III	0,07134
0,5	Log Pearson III	0,06198
1	Gumbel	0,05922
2	Lognormal	0,0826
3	Lognormal	0,06243
6	Log Pearson III	0,05924
12	Log Pearson III	0,05207
24	Lognormal	0,07699

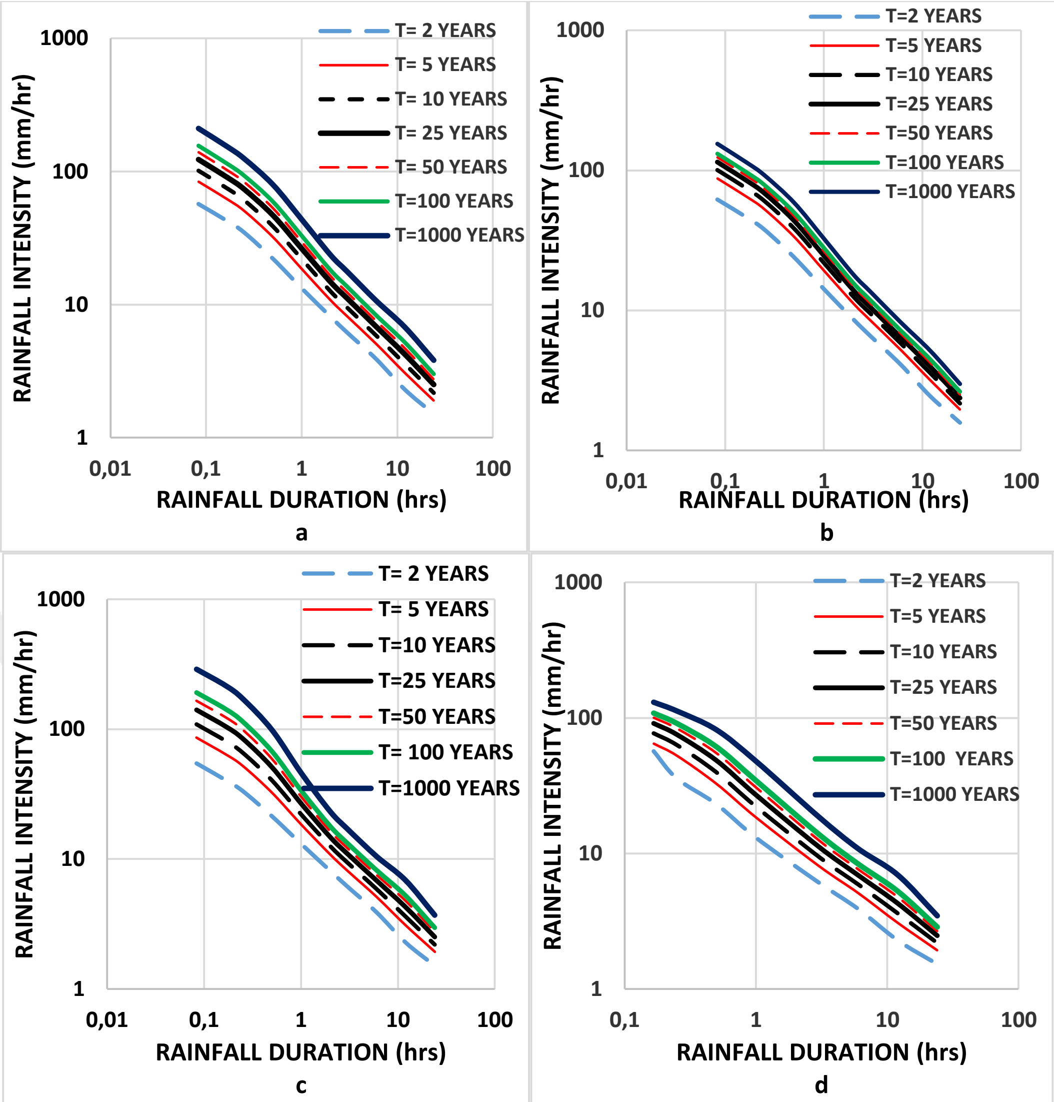

Figure 5. 6: IDF curves for Diyarbakır City with a) Gumbel Distribution, b) Normal Distribution, c) Log Normal Distribution, d) Log Pearson Type III Distribution

5.2.7. Results of Gaziantep City

For Gaziantep City IDF curves which have been obtained from distribution analysis have been given with Figure 5.7.

In Gaziantep station, rainfall durations of Gumbel analysis have been considered as 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours and the results have been given with Table E7. Looking at this table, it has been seen that maximum difference which can be seen between two consecutive return periods is the difference between 100 and 1000 year return period. Also the smallest difference of consecutive 2 return periods can be observed between 50 and 100 year return period.

For Normal Distribution, same rainfall durations with Gumbel distribution have been taken into account and results have been tabulated in Table F7. By checking the results of Table F7 it is possible to claim that the highest difference that can be determined between two consecutive return periods is between 2 and 5 year return periods.

Lognormal distribution has been tested on rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours. Looking at the results of this method which have been presented by Table G7 for Gaziantep Station, similar to Gumbel distribution it has been found that the difference between two consecutive return period has the highest value in between 100 and 1000 year return period.

Log Pearson III analysis has been made for rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours. Showing the results by Table H7 for Gaziantep Station it has been obtained that the maximum difference between two consecutive return periods is between 100 and 1000 year return period similar to the Gumbel and Lognormal distributions.

The comparison based on Table E7 and Table F7 between Gumbel and Normal distribution shows a same behavior with previous stations because Normal distribution has higher values in 2 and 5 year return periods and Gumbel distribution has higher results in 10,25,50,100,1000 return periods. Table F7 and Table G7 shows that Normal distribution is higher in the return periods of 2,5,10 but except at 12 hours and 24 hours of 10 year return period and Lognormal distribution has higher values in the return periods of 25,50,100,1000 return periods. Based on Table G7 and Table H7, In the comparison of Lognormal and Log Pearson III distributions' results except at 12 hours and 24 hours rainfall durations, Lognormal has higher results in 2 and 5 year return periods. In the same way, except at 12 hours and 24 hours rainfall durations Log Pearson III has higher results than Lognormal distribution in 25,50,100,1000 year return periods. In addition to this, for all rainfall duration of 10 year return period Log Pearson III distribution has higher results.

Kolmogorov-Smirnov test has been applied to Gaziantep station and results of test have been given in Appendix I with Table I7 for all rainfall durations. The best fitted distribution of each rainfall duration has been given with Table 5.7.

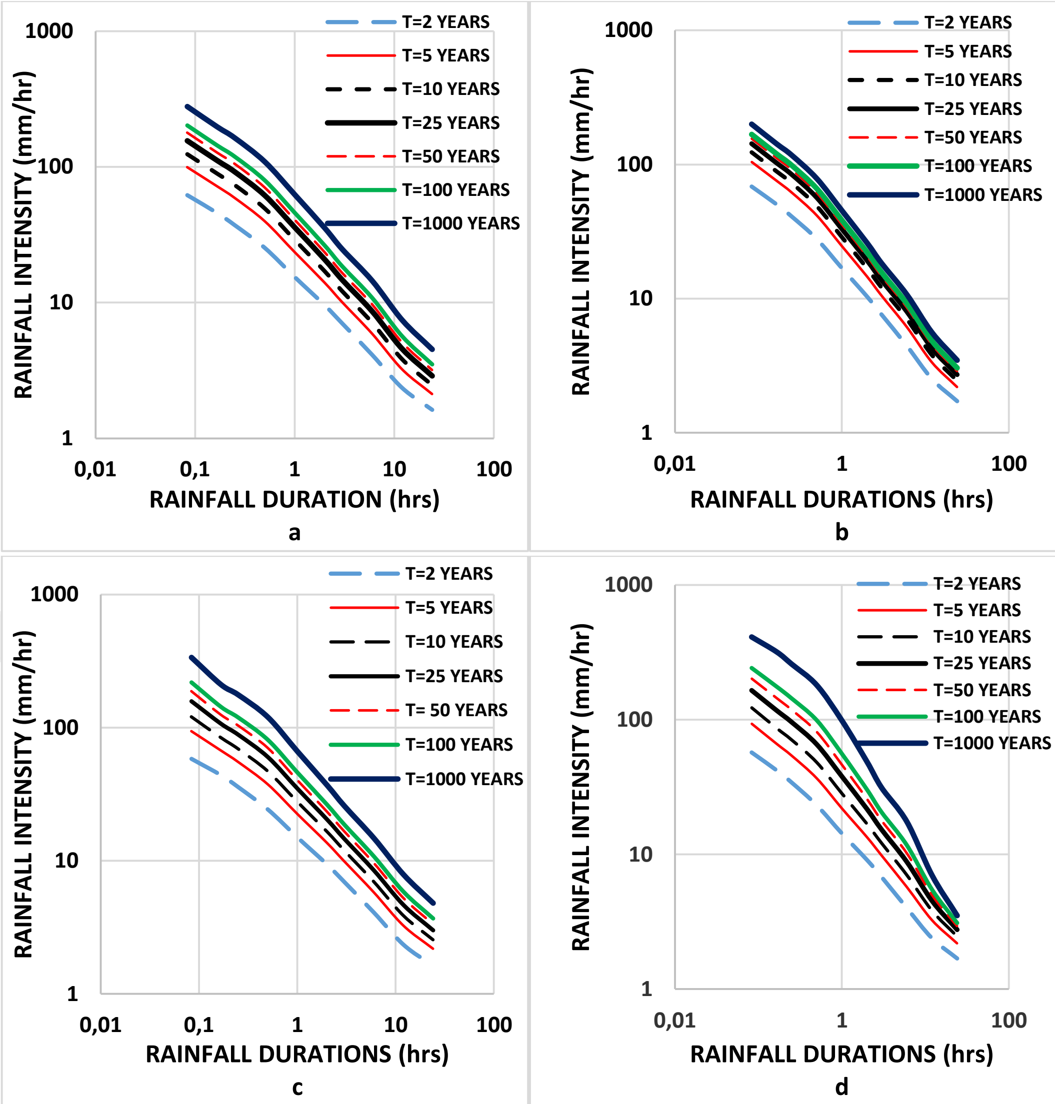

Figure 5. 7: IDF curves for Gaziantep City with a) Gumbel Distribution, b) Normal Distribution, c) Log Normal Distribution, d) Log Pearson Type 3 Distribution

Table 5. 7: The Best Fitted Distribution for Gaziantep Station

Rainfall Duration (hour)	*Distribution*	*D_N*
0,0833333	Log Pearson III	0,08998
0,166666	Log Pearson III	0,07631
0,25	Log Pearson III	0,08098
0,5	Log Pearson III	0,12509
1	Log Pearson III	0,12059
2	Log Pearson III	0,06698
3	Log Pearson III	0,0655
6	Log Pearson III	0,06802
12	Log Pearson III	0,06889
24	Log Pearson III	0,07022

5.2.8. Results of Kahramanmaraş City

For Kahramanmaraş City IDF curves which have been obtained from distribution analysis have been given with Figure 5.8.

In the results of Gumbel distribution for Kahramanmaraş City by using rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours as rainfall data Table E8 has been constructed. It has been analyzed that the highest difference between two consecutive return periods can be seen between 100 and 1000 year return period and the smallest difference can be observed in between 50 and 100 year return period.

Using rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours with Normal distribution method, Table F8 has been obtained and from this table it has been recognized that the maximum difference occurs in between 2 and 5 year return period and this difference is close to the difference of 100 and 1000 year return period.

Lognormal distribution has been applied to rainfall durations which are same with Normal distribution for Kahramanmaraş station. By benefiting from Table G8, it is clearly seen that the maximum difference value of consecutive two return periods can be obtained with the difference of 100 and 1000 year return periods. Again from the same table, it can be observed that the difference between 25 and 50 return period is very close to difference of 50 and 100 year return period.

Log Pearson Type III analysis have been executed by using same rainfall durations with Gumbel, Normal and Lognormal distributions except at 5 minutes and 6 hours. Results have been shown by Table H8. Also in this station the highest difference between two consecutive return periods has been got as the difference between 100 and 1000 year return period.

Similar to previous stations, having a look at Table E8 and Table F8, Normal distribution has higher results in 2 and 5 year return periods compared to Gumbel distribution. For the rest of return periods Gumbel results are higher than Normal distribution results. Investigating Table F8 and Table G8 it is easy to claim that Normal distribution has higher results in only 2 year return period compared to Lognormal distribution and also in the same comparison it has been observed that, in 10,25,50,100,1000 return periods Lognormal has higher values than Normal distribution. In the comparison between Lognormal and Log Pearson III benefiting from Table G8 and Table H8 it has been acquired that Log Pearson III has higher results in 2 and 5 year return period but except at 24 hours of 5 year return period and Lognormal has higher rainfall intensities in return periods of 10,25,50, 100 and 1000 year.

Kolmogorov-Smirnov test has been applied to Kahramanmaraş station and results of test have been given in Appendix I with Table I8 for all rainfall durations. The best fitted distribution of each rainfall duration has been given with Table 5.8. Only in analysis of rainfall durations of 5 minutes and 6 hours rainfall durations, Log Pearson Type III was not taken into account since they weren't used for Log-Pearson Type 3 analysis.

Table 5. 8: The Best Fitted Distribution for Kahramanmaraş Station

Rainfall Duration (hour)	***Distribution***	***D_N***
0,0833333	Gumbel	0,10717
0,166666	Lognormal	0,08582
0,25	Gumbel	0,11801
0,5	Gumbel	0,11268
1	Normal	0,08338
2	Lognormal	0,08949
3	Gumbel	0,14415
6	Lognormal	0,10773
12	Normal	0,11414
24	Normal	0,10791

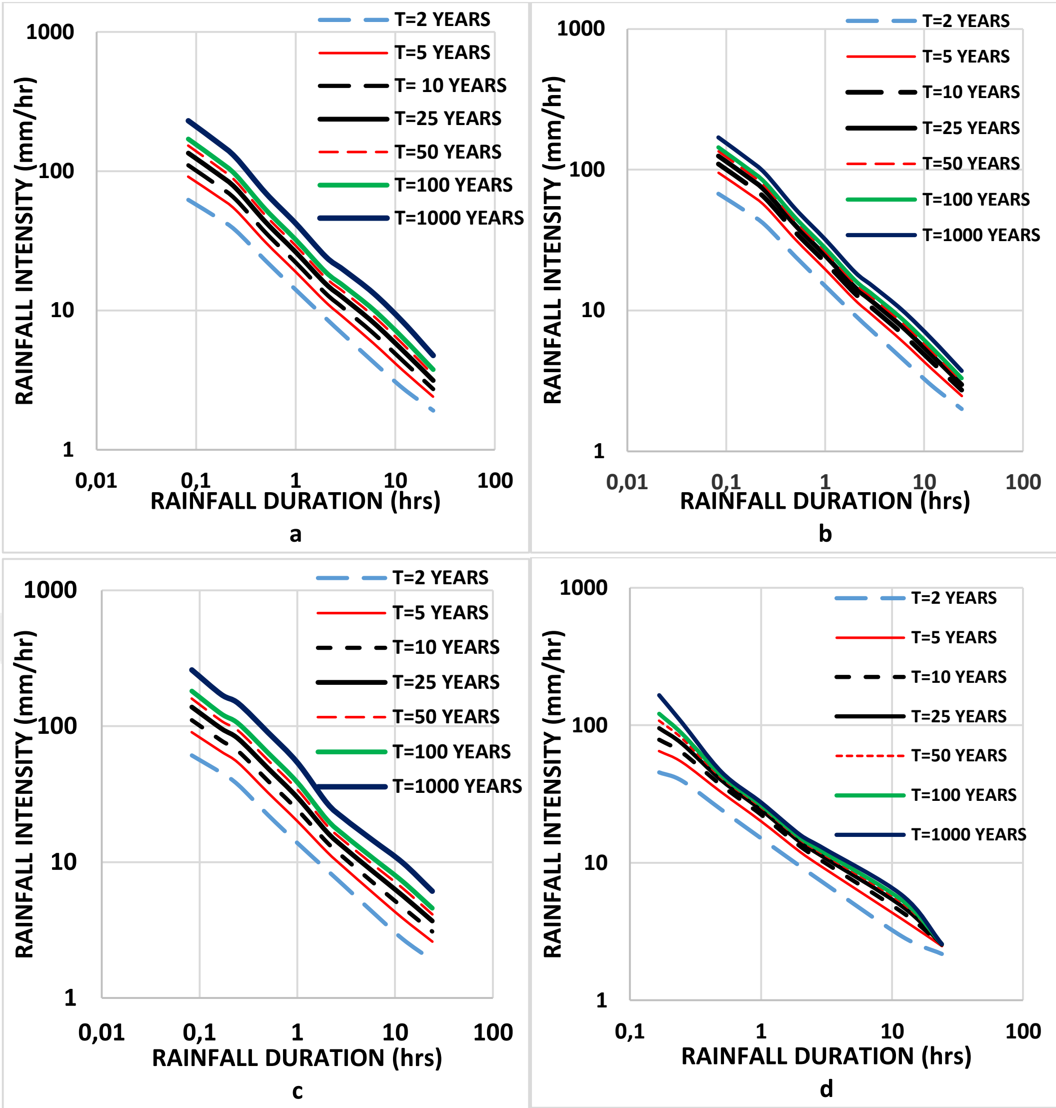

Figure 5. 8: IDF curves for Kahramanmaraş City with a) Gumbel Distribution, b) Normal Distribution, c) Log Normal Distribution, d) Log Pearson Type III Distribution

5.2.9. Results of Kilis City

For Kilis City IDF curves which have been obtained from distribution analysis have been given with Figure 5.9.

Gumbel distribution which have been performed with rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours for Kilis station gave the results of Table E9 in which the difference between two consecutive return periods is the highest between 100 and 1000 year return period. Also with reference to Table E9 it is easy to observe that the difference between 25 and 50 year return period and 50 and 100 year return period is very close to each other.

Normal distribution method has been applied to rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours and the results has been given with Table F9. The difference between two consecutive return period has been recognized in between 2 and 5 year return period.

Similar to Gumbel and Normal distribution, except at 2 hours rainfall duration Lognormal distribution model has been tested on same rainfall durations. As a result, similar to Gumbel distribution maximum difference of two consecutive return periods belongs to the difference between 100 and 1000 year return period.

Log Pearson Type III distribution has been made for rainfall durations which are same with Lognormal distribution. Results of analysis have been presented by Table G9. According to this table the highest difference between two consecutive return periods has been got as between 100 and 1000 year return period which is same situation with Gumbel and Lognormal distributions.

In Kilis station using results of Table E9 and Table F9 by comparing the Normal and Gumbel distribution it has been seen that Normal distribution is higher than Gumbel distribution in 2 and 5 year return periods and Gumbel distribution has higher results than Normal distribution in 10,25,50,100 and 1000 year return period. Again using Table F9 and Table G9, Normal distribution and Lognormal distribution was compared. Results showed that Normal distribution has bigger values than Lognormal distribution in return periods of 2 and 5 while in 25,50,100,1000 Lognormal gave higher results. Seeing Table G9 and Table H9 it is not easy to make a relationship between values of Lognormal and Log Pearson III since rainfall estimates change according to rainfall durations.

Kolmogorov-Smirnov test has been applied to Kilis station and results of test have been given in Appendix I with Table I9 for all rainfall durations. The best fitted distribution of each rainfall duration has been given with Table 5.9. Only in analysis of 2 hours rainfall duration, Log Pearson Type III was not taken into account since it wasn’t used for Log-Pearson Type 3 analysis.

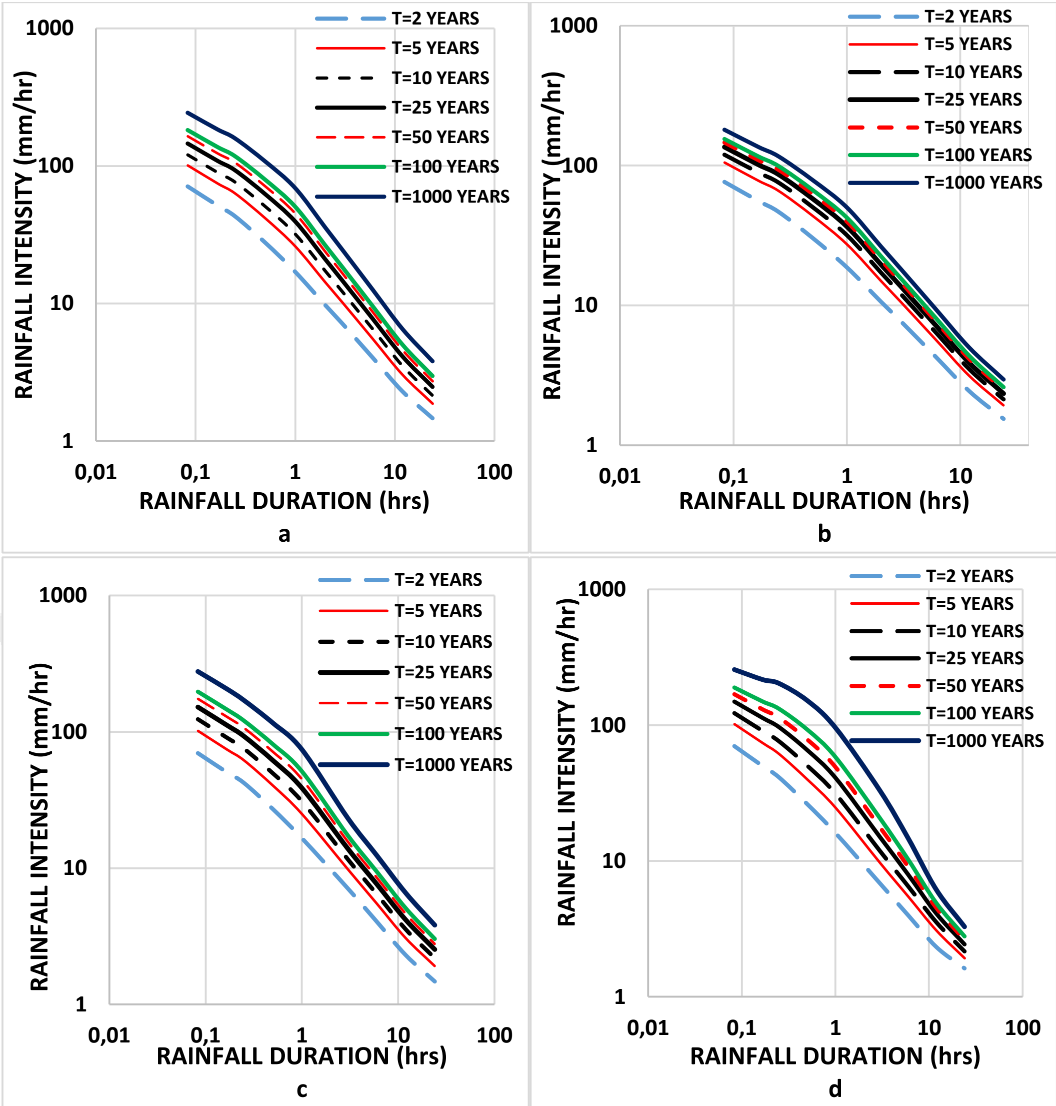

Figure 5. 9: IDF curves for Kilis City with a) Gumbel Distribution, b) Normal Distribution, c) Log Normal Distribution, d) Log Pearson Type III Distribution

Table 5. 9: The Best Fitted Distribution for Kilis Station

Rainfall Duration (hour)	*Distribution*	D_N
0,0833333	Lognormal	0,10019
0,166666	Log Pearson III	0,08606
0,25	Gumbel	0,08246
0,5	Log Pearson III	0,07804
1	Log Pearson III	0,06216
2	Log Normal	0,12691
3	Log Pearson III	0,09373
6	Log Pearson III	0,09307
12	Lognormal	0,011118
24	Log Pearson III	0,07656

5.2.10. Results of Mardin City

For Mardin City IDF curves which have been obtained from distribution analysis have been given with Figure 5.10.

In order to get IDF curves of Mardin station, Gumbel distribution method has been tested on rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours. The results of method have been given with Table E10. From these results, it has been got that the highest difference between two consecutive return periods was observed between 100 and 1000 year return period.

Normal distribution method has been used for obtaining of IDF curves of Mardin station for same rainfall durations with Gumbel distribution. Giving results of analysis with Table F10, it has been seen that the highest the difference between two consecutive return periods occurs in between 2 and 5 year return period.

For Mardin City performing Lognormal distribution method via same rainfall durations with Gumbel and Normal distributions, results that has been got tabulated in Table G10 and from these results it has been recognized that the difference between two consecutive return periods is observed as maximum in between 100 and 1000 year return period.

Log Pearson Type III analysis was made for rainfall durations of 5, 10, 15 minutes, 3, 6, 12 and 24 hours. Having a look at results with Table H10, like Gumbel and Lognormal distributions the highest difference which is between two consecutive return period has been seen in between 100 and 1000 year return period.

Similar to some previous stations in the comparison of Normal and Gumbel distribution using results tables of each distribution, the same situation in which Normal distribution is higher in 2 and 5 year return period and Gumbel distribution has higher results in 10,25,50,100,1000 year return periods has been obtained. Checking Table F10 and Table G10 with the comparison of Normal and Lognormal distributions it has been seen that in 2 and 5 year return period Normal distribution is higher rainfall intensities while in the rest of return periods Lognormal distribution is higher except at 10 year return period. Likewise some previous station it is not easy to make a comparison between Lognormal and Log Pearson III distributions.

Kolmogorov-Smirnov test has been applied to Mardin station and results of test have been given in Appendix I with Table I10 for all rainfall durations. The best fitted distribution of each rainfall duration has been given with Table 5.10. In analysis of 30 minutes, 1 hour, 2 hours rainfall duration, Log Pearson Type III was not taken into account since they weren't used for Log-Pearson Type 3 analysis.

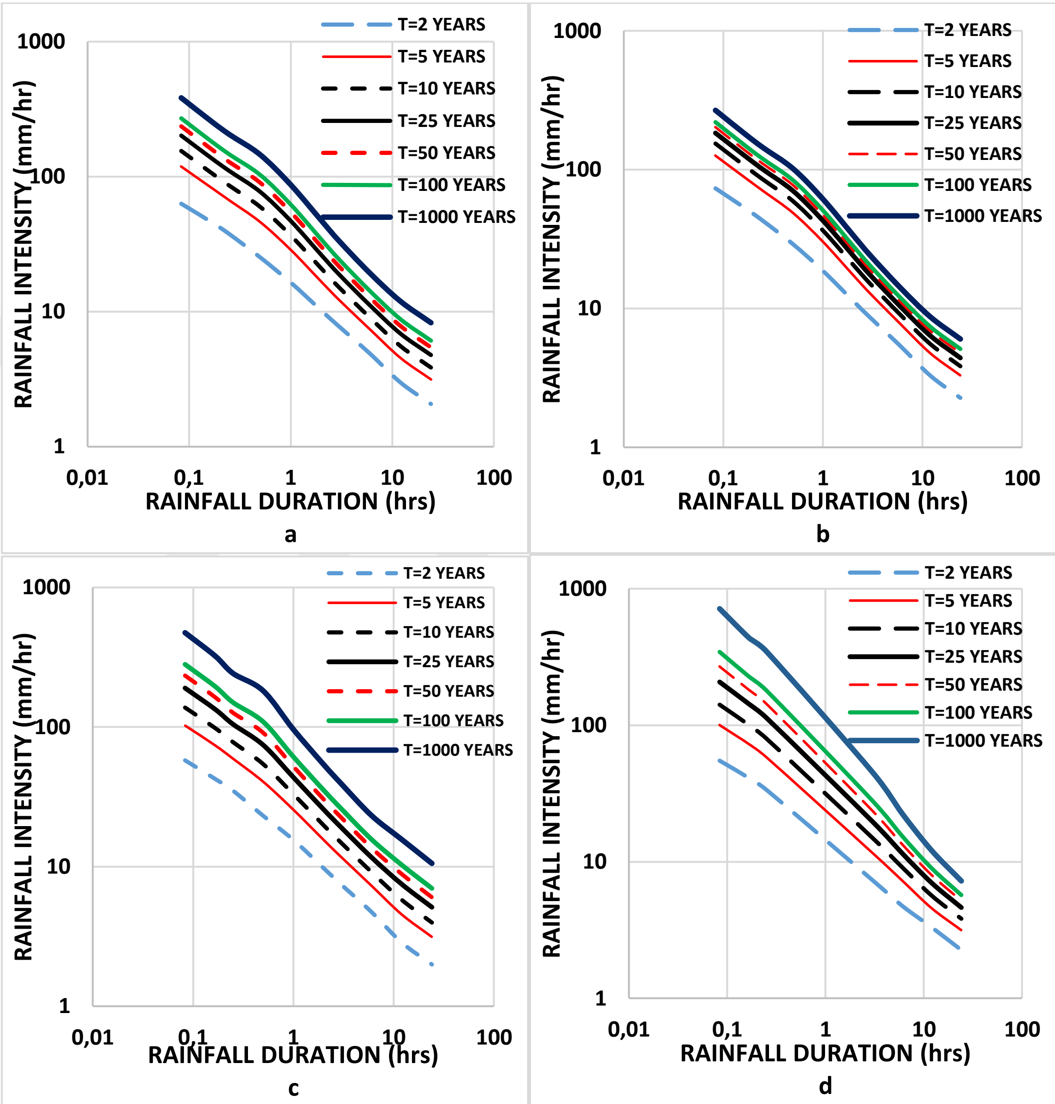

Figure 5. 10: IDF curves for Mardin City with a) Gumbel Distribution, b) Normal Distribution, c) Log Normal Distribution, d) Log Pearson Type III Distribution

Table 5. 10: The Best Fitted Distribution for Mardin Station

Rainfall Duration (hour)	***Distribution***	***D_N***
0,0833333	Log Pearson III	0,092
0,166666	Log Pearson III	0,10328
0,25	Log Normal	0,12403
0,5	Log Normal	0,14847
1	Log Normal	0,11161
2	Log Normal	0,11562
3	Log Pearson III	0,13416
6	Log Normal	0,09993
12	Log Normal	0,06341
24	Log Normal	0,12233

5.2.11. Results of Osmaniye City

For Osmaniye City IDF curves which have been obtained from distribution analysis have been given with Figure 5.11.

Using Gumbel distribution technique with rainfall durations of 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours Table E11 has been obtained. From this table it has been acquired that the difference between 100 and 1000 year return periods is the largest difference between two consecutive return periods. Also the difference between 50 and 100 year return periods is the smallest difference which can be seen between two consecutive return periods.

Normal distribution method has been tested on rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours. From the results that have been given with Table F11, the difference between 2 and 5 year return periods has been observed as maximum difference that can be obtained from Table F11.

Performing Lognormal distribution method with rainfall durations of 5, 10, 15, 30 minutes, 1, 3, 6 and 24 hours, Table G11 has been presented. From this table, the maximum difference can be seen in between 100 and 1000 year return period.

For Osmaniye station, Log Pearson III has been applied to rainfall durations of 5, 15, 30 minutes, 1, 12 and 24 hours. Benefiting from results of H11, the highest difference between two consecutive return periods belongs 100 and 1000 year return period except at 5 minutes rainfall duration which has the highest difference between 2 and 5 year return periods.

For Osmaniye station a comparison has been made between results of Normal and Gumbel distribution using Table E11 and Table F11.In this comparison it has been analyzed that Normal distribution is higher in return periods of 2 and 5 year and Gumbel distribution has higher results than Normal distribution from 10 year return period to 1000 year return period. Crosschecking Table F11 and Table G11, out of 2 and 5 year return periods in which Normal distribution has higher values in 2 and 5 year return periods except at 3 hours rainfall duration of 5 year return period, Lognormal distribution has higher results in all return periods. By comparing Lognormal and Log Pearson III distribution it has been understood that Log Pearson III has higher results in 2 and 5 year return periods and Lognormal distribution has higher results from 10 year return period to 1000 year return period.

Kolmogorov-Smirnov test has been applied to Osmaniye station and results of test have been given in Appendix I with Table I11 for all rainfall durations. The best fitted distribution of each rainfall duration has been given with Table 5.11. Only in analysis of Log Pearson Type III, 5 minutes, 15 minutes, 30 minutes, 1 hour, 12 hours, 24 hours were taken into account.

Table 5. 11: The Best Fitted Distribution for Osmaniye Station

Rainfall Duration (hour)	***Distribution***	***D_N***
0,0833333	Lognormal	0,10329
0,166666	Gumbel	0,17881
0,25	Normal	0,1257
0,5	Log Pearson III	0,12603
1	Normal	0,14682
2	Normal	0,09989
3	Normal	0,12209
6	Gumbel	0,12709
12	Gumbel	0,11428
24	Gumbel	0,10936

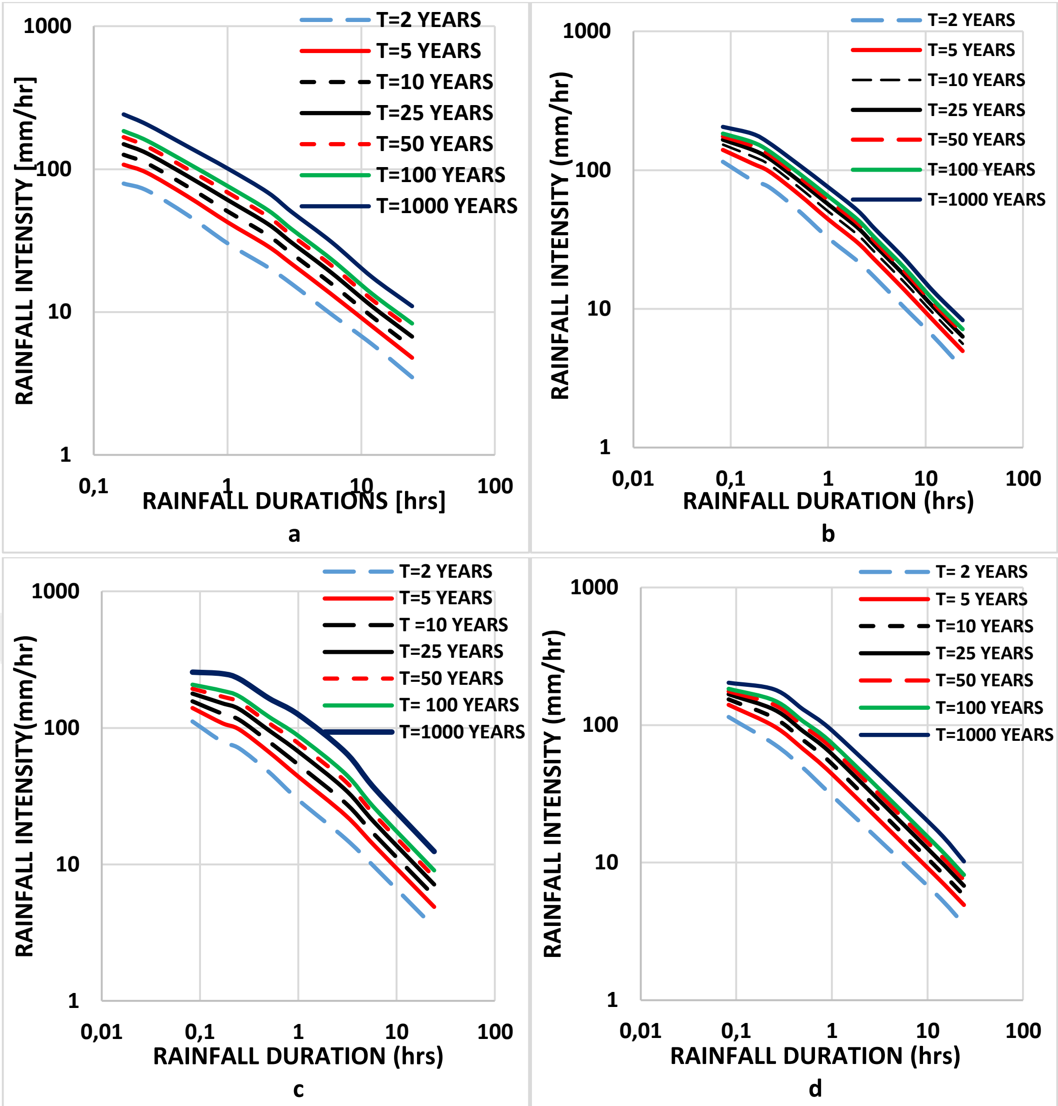

Figure 5. 11: IDF curves for Osmaniye City with a) Gumbel Distribution, b) Normal Distribution, c) Log Normal Distribution, d) Log Pearson Type III Distribution

5.2.12. Results of Siirt City

For Siirt City IDF curves which have been obtained from distribution analysis have been given with Figure 5.12.

For Siirt Station, Gumbel distribution method has been done with rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours. Results have been presented by Table E12. Similar to Gumbel distribution analysis of other 11 stations the maximum difference between two consecutive return periods has been observed in between 100 and 1000 year return period.

Normal distribution which has been done by same rainfall duration with Gumbel Distribution gave results of Table F12 in which the difference between 2 and 5 year return period has been calculated as the highest difference between two consecutive return periods.

Lognormal distribution has been also performed for Siirt Station in order to get IDF curves. Results which has been given by Table G12 shows that the difference between two consecutive return periods becomes maximum with the difference of 100 and 1000 year return period and minimum with the difference of 50 and 100 year return period.

In Log Pearson III analysis using rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6 hours, Table H12 has been got and also similar to Gumbel and Lognormal distribution, maximum difference between two consecutive return periods has been seen in between 100 and 1000 year return periods.

According to results of Table E12 and Table F12, Normal distribution has higher values in the range starting from 2 year period and ending with 5 year return period. Similar to previous stations Gumbel distribution has higher values in return periods of 10, 25, 50, 100, 1000 year. As one other comparison which has been made between Normal and Lognormal distribution results based on Table F12 and Table G12, Normal distribution has higher values in 2 and 5 return periods and except at 24 hours rainfall duration of 25 year return period Lognormal distribution has higher results in return periods of 25, 50, 100, 1000 year. Referencing to Table G12 and Table H12 it has been obtained that out of 24 hours rainfall duration of 2 and 5 year return period Log Pearson III is higher than Lognormal distribution in 2 and 5 year return period. Also out of 24 hours rainfall durations of 25,50,100 and 1000 year return periods Lognormal distribution results are higher than Log Pearson III distribution in 25,50,100 and 1000 year return periods.

Kolmogorov-Smirnov test has been applied to Siirt station and results of a test have been given in Appendix I with Table I12 for all rainfall durations. The best fitted distribution of each rainfall duration has been given with Table 5.12. In 12 hours and 24 hours analysis Log Pearson III distribution method has not been considered.

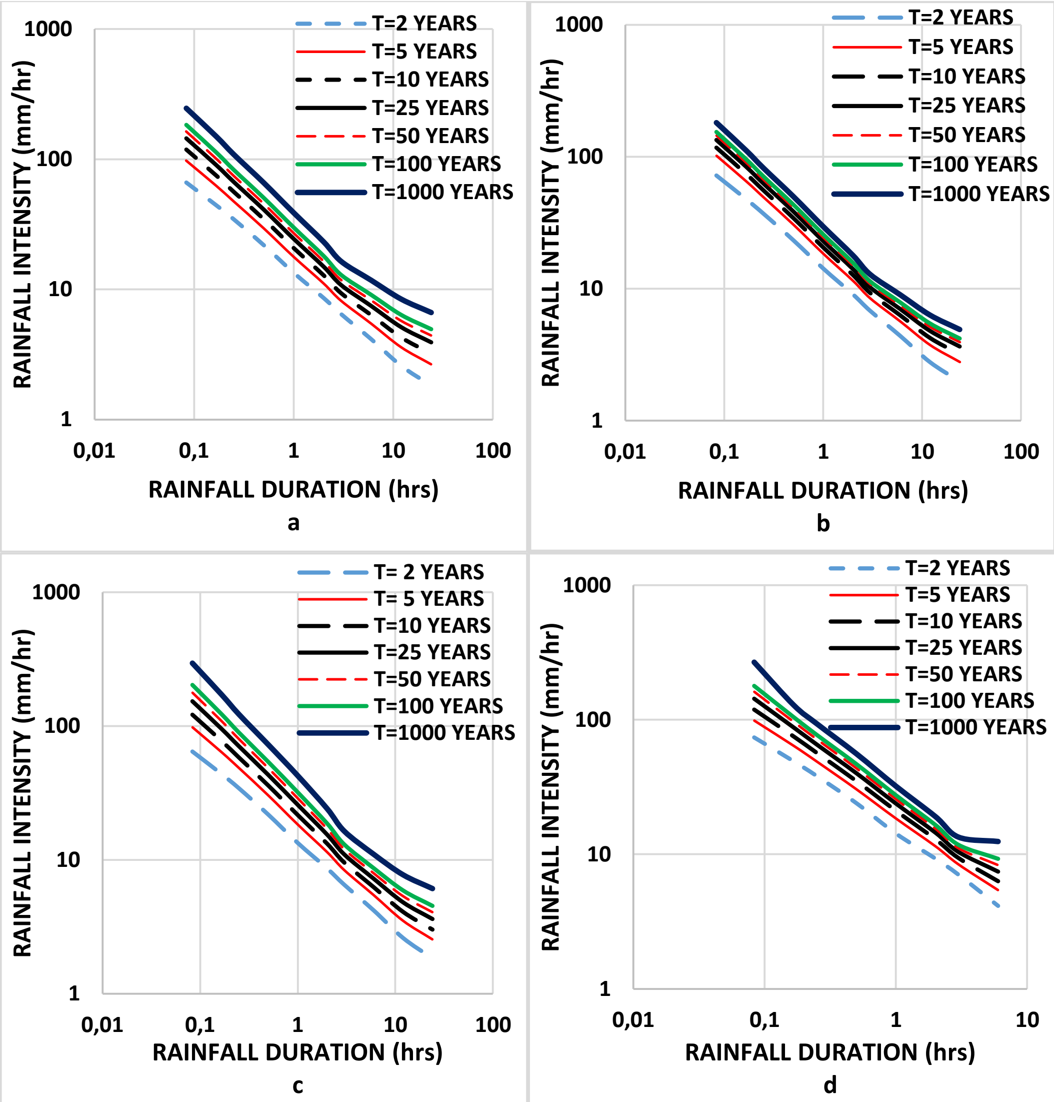

Figure 5. 12: IDF curves for Siirt City with a) Gumbel Distribution, b) Normal Distribution, c) Log Normal Distribution, d) Log Pearson Type III Distribution

Table 5. 12: The Best Fitted Distribution for Siirt Station

Rainfall Duration (hour)	*Distribution*	D_N
0,0833333	Gumbel	0,06269
0,166666	Log Pearson III	0,09386
0,25	Log Pearson III	0,09234
0,5	Log Pearson III	0,06971
1	Log Pearson III	0,09998
2	Lognorrmal	0,09373
3	Lognorrmal	0,08622
6	Log Pearson III	0,09191
12	Lognormal	0,1147
24	Lognormal	0,09844

5.2.13. Results of Şanlıurfa City

For Şanlıurfa City IDF curves which have been obtained from distribution analysis have been given with Figure 5.12.

In Şanlıurfa station using rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours as rainfall data Gumbel distribution method has been used. Producing Table E13 as a table of results it has been seen that in this station the highest difference between two consecutive return periods has been observed in between 100 and 1000 year return period.

Normal distribution has been used with same rainfall duration of Gumbel distribution for getting IDF curves of Şanlıurfa station. Tabulating the results in Table F13, similar to the other 12 stations, the maximum difference between two consecutive return periods is obtained with the difference in between 2 and 5 year return period.

Lognormal distribution has been also made with same rainfall durations of Normal and Gumbel distribution. Looking to Table G13, it is possible to claim that in care of the highest difference between two consecutive return periods, same results with Gumbel distribution have been obtained.

Log Pearson III distribution has been made with same rainfall durations of other 3 distributions except at 5 minutes rainfall duration. Also results of method has been presented with H13. In this distribution, by checking the differences between two consecutive return periods, between 100 and 1000 year return periods it is encountered with the highest difference value.

In the comparison of Gumbel and Normal distribution taking into account the Table E13 and Table F13 it is possible to say that in 2 and 5 year return periods Normal distribution is higher than Gumble distribution and for the rest return periods which are 10,25,50,100 and 1000 years Gumble has higher results. In the comparison of Normal and Lognormal distribution with Table F13 and Table G13 it has been taken that out of 5 minutes and 10 minutes rainfall durations of 10 year return period, Normal distribution has higher values in 2,5 and 10 year return periods. In the same time, out of 12 hours and 24 hours rainfall durations of 25 year return period Lognormal has higher results in 25,50,100 and 1000 year return periods. By following the same manner, a comparison has been made between Lognormal and Log Pearson III distributions based on Table G13 and Table H13. Results showed that Lognormal distribution is higher in 2 and 5 year return period but out of 5 minutes rainfall duration of 2 and 5 year return period. Also out of 5 minutes rainfall durations of 10, 25, 50, 100, 1000 year return periods Log Pearson III has higher results in return periods of 10, 25, 50, 100, 1000 year.

Kolmogorov-Smirnov test has been applied to Şanlıurfa station and results of a test have been given in Appendix I with Table I13 for all rainfall durations. The best fitted distribution of each rainfall duration has been given with Table 5.13. In 5 minutes analysis Log Pearson III distribution method has not been taken into account.

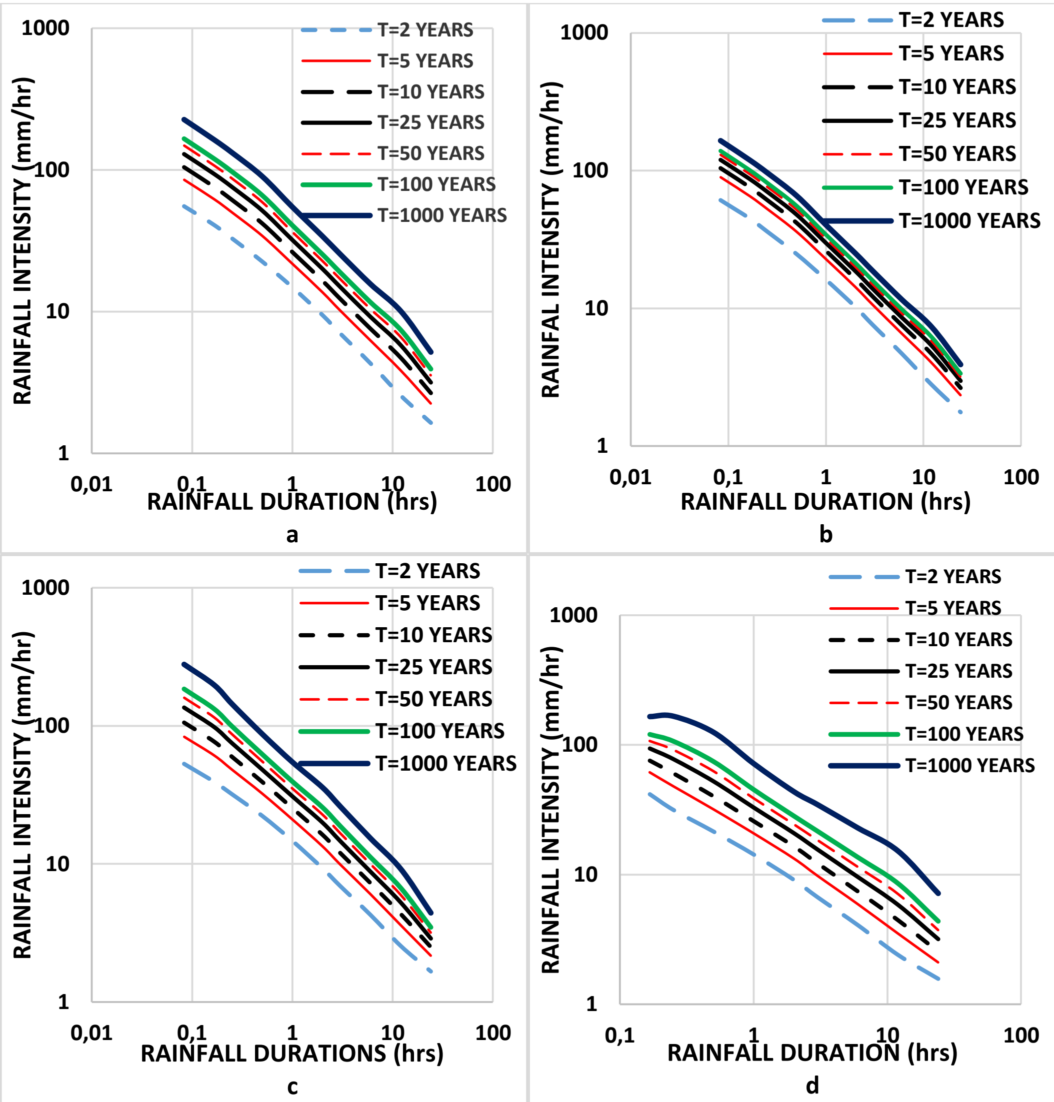

Figure 5. 13: IDF curves for Şanlıurfa City with a) Gumbel Distribution, b) Normal Distribution, c) Log Normal Distribution, d) Log Pearson Type III Distribution

Table 5. 13: The Best Fitted Distribution for Şanlıurfa Station

Rainfall Duration (hour)	***Distribution***	***D_N***
0,0833333	Gumbel	0,0849
0,166666	Gumbel	0,07457
0,25	Gumbel	0,07546
0,5	Lognormal	0,08444
1	Log Pearson III	0,07698
2	Log Pearson III	0,0683
3	Log Pearson III	0,06847
6	Log Pearson III	0,07872
12	Log Pearson III	0,10502
24	Log Pearson III	0,09498

CHAPTER 6

CONCLUSIONS

In this study Intensity-Duration-Frequency Curves (IDF) have been obtained for Adana, Adıyaman, Antakya (Hatay), Batman, Cizre, Diyarbakır, Gaziantep, Kahramanmaraş, Kilis, Mardin, Osmaniye, Siirt and Şanlıurfa for rainfall durations of 5, 10, 15, 30 minutes, 1, 2, 3, 6, 12 and 24 hours. The analyses were conducted for return periods of 2, 5, 10, 25, 50, 100, 1000 years by utilizing Gumbel distribution, Normal distribution, Log-Normal distribution and Log-Pearson Type III distribution which are generally employed frequency analysis methods. Each city has been investigated separately and results have been written for general and specific situations. The results of this investigation is expected to be a guide for local authorities of each city.

From results of Gumbel, Normal and Lognormal distributions it has been decided that frequency factor, K_T increases with the raise of return period however in Log Pearson III, K_T is related to coefficient of skewness and return period therefore in any rainfall duration K_T increases with the raise of return period.

In this study it has been concluded that rainfall estimates increase with increment of return period in any rainfall duration and decrease with increment of rainfall duration in any return period. From the IDF curves it has been concluded trend of each station is same that also supports decreasing of rainfall amount with raising rainfall duration.

Except at Osmaniye station, in all Gumbel, Lognormal and Log Pearson Type III distribution analyses of stations the highest difference which can be observed between two consecutive return periods is the difference between 100-1000 year return periods. Also for all stations in Normal distribution analyses the highest difference has been observed in between 2 and 5 year return periods.

In binary comparisons of distributions, it has been concluded in all stations for 2 and 5 year return periods Normal distribution has higher values than Gumbel distribution. This is simply because of frequency factors. For the rest of return periods Gumbel distribution has higher rainfall intensities. Normal distribution has generally higher values in 2 and 5 year return periods compared to Lognormal distribution. Lognormal distribution has higher values in 25,50,100,1000 year return periods. Same comparison have been made between Lognormal and Log Pearson III distribution for analyzing of all station. However an exact rule like other two binary comparisons cannot be made in comparison of Lognormal and Log Pearson III distributions because except at some stations, the situation of higher values in a certain return period changes according to rainfall duration.

Kolmogorov- Smirnow test results of each station showed that Log Pearson III distribution is suitable for most of rainfall durations due to its smallest D_N value. Also after Log Pearson III distribution, Lognormal distribution gives a good suitability for all rainfall durations. Gumbel distribution in 3rd order and Normal distribution rarely gave smallest sample statistic which is D_N.

REFERENCES

Abdul Jaleel L., Farawn M. A. (2013). Developing rainfall intensity-duration-frequency relationship for Basrah city. *Kufa Journal of Engineering*, **5(1)**: 105-112.

Al-anazi, K.K., El-Sebaie, I.H. (2013). Development of intensity-duration-frequency relationships for Abha city in Saudi Arabia. *International Journal of Computational Engineering Research*, **3 (10)**: 58-65.

Al-awadi, A.T. (2016). Assessment of intensity duration frequency (IDF) models for Baghdad city, Iraq. *Journal of Applied Sciences Research*, **12(2)**: 7-11.

AlHassoun, S.A. (2011). Developing an empirical formula to estimate rainfall intensity in Riyadh region. *Journal of King Saud University-Engineering Sciences*, **23**: 81-88.

ASCE. American Society of Civil Engineers. 1996. Task Committee on Hydrology Handbook of Management Group D of Hydrology Handbook. Doi: 10.1061/9780784401385

Baghirathan, V.R., Shaw, E.M. (1978). Rainfall depth-duration-frequency studies for Sri Lanka. *Journal of Hydrology*, **37(3)**: 223-239.

Bernard, M.M., 1932. Formulas for rainfall intensities of long durations. *Trans. ASCE*, **96**: 592-624.

Benjamin, J.R., Cornell, C.A. (1970). Probability statistics and decision for Civil engineers, McGraw-Hill.

Canterford, R.P., Pescod, N.R., Pearce, N.H., Turner, L.H., Atkinson, R.J., (1987). Frequency analysis of Australian rainfall data as used for flood analysis and design. *In Regional Flood Frequency Analysis: Proceedings. International. Symposium. on Flood Frequency and Risk Analyses, Louisiana State University*, USA, 293-302.

Chawathe, S.D., Shinde, U.R., Fadanvis, S.S. and Goel, V.V. (1977). Rainfall analysis for the design of storm sewers in Bombay. *The Institution of Engineers (India) Journal-EN*, **58**: 14-20.

Chen, C.I. (1983). Rainfall intensity-duration-frequency formulas. *Journal of Hydraulic Engineering*, **109 (12)**, 1603-1621.

Cheng, L., AghaKouchak, A. (2014). Nonstationary precipitation intensity-duration-frequency curves for infrastructure design in a changing climate. *Sci-Rep*. **4**: 1-6.

Chow, V.T., Maidment, D. R., Mays L. W. 1988. Applied hydrology, McGraw-Hill Book Company.

DSI, General Directorate of State Hydraulic Works. (1990). Türkiye Maksimum Yağışları Frekans Atlası, Noktasal Yağışların Frekans Analizi, Cilt I ve II, Bayındırlık ve İskan Bakanlığı, Ankara.

Dupont, B.S., Allen, D.L. (1999). Revision of the rainfall intensity duration curves for the Commonwealth of Kentucky. *Kentucky Transportation Center, College of Engineering, University of Kentucky*, Research Report: KTC-00-18.

Elsebaie, I. H. (2012). Developing rainfall intensity–duration–frequency relationship for two regions in Saudi Arabia. *Journal of King Saud University – Engineering Sciences*, **24**: 131-140.

Fadhel, S., Rico-Ramirez, M.A., Dawei, H. (2017). Uncertainty of intensity–duration–frequency (IDF) curves due to varied climate baseline periods. *Journal of Hydrology*, **547**: 600-612.

Frederick, R.H., Meyers, V.A., Auciello, E.P. (1977). Five-to 60-minute precipitation frequency for the Eastern and Central United States. *National Oceanic and Atmospheric Administration Technical Memomarandum NWS* HYDRO-**35**, Washington, DC.

Gumbel, E.J. (1958). Statics of extremes, Colombia University.

Ghiaei F., Kankal, M., Anilan, T., Yuksek, O. (2018). Regional intensity-duration-frequency analysis in the Eastern Black Sea Basin, Turkey, by using L-moments and regression analysis. *Theoretical and Applied Climatology*, **Vol 131(1-2)**: 245-257

Hadadin, N.A., (2005). Rainfall intensity-duration-frequency relationship in the Mujib basin in Jordan, *Journal of Applied Science*, **8(10)**: 1777-1784.

Hoggan, D.H. (1989). Computer-assisted floodplain hydrology & hydraulics, McGraw-Hill.

Huang Y. F., Mirzaei, M., Mat Amin, M. Z. (2016). Uncertainty quantification in rainfall intensity duration frequency curves based on historical extreme precipitation quantiles. *Journal of Procedia Engineering*, **154**: 426-432.

IPCC. Intergovernmental Panel on Climate Change. (2012). Managing the risks of extreme events and disasters to advance climate change adaptation: Summary for Policy Makers. Cambridge University Press.

Karahan, H., Ayvaz, M.T. (2005). Yağış-şiddet-süre bağıntısının doğrusal olmayan optimizasyon tekniği ile belirlenmesi: Antalya örneği. *Antalya Yöresinin İnşaat Mühendisliği Sorunları Kongresi Bildiriler Kitabı,* Cilt 2, 163-170.

Karahan, H., Ayvaz, M.T., Gürarslan, G. (2008). Şiddet-süre-frekans bağıntısının genetic algoritma ile belirlenmesi: Gap örneği. *İMO Teknik Dergi,* 4393-4407, Yazı 290.

Karahan, H., Özkan, E. (2013). Ege Bölgesi standart süreli yıllık maksimum yağışları için uygun dağılımlar. *Pamukkale Üniversitesi Mühendislik Bilimleri Dergisi,* 19, **3,** 152-157.

Kite, G.W. (1977). Frequency and Risk Analysis in Hydrology, Water Resources Publications.

Koutsoyiannis, D., Kozonis, D. and Manetas, A. (1998). A mathematical framework for studying rainfall intensity-duration-frequency relationships. *Journal of Hydrology,* **206**: 118-135.

Madsen, H., Mikkelsen, P.S., Rosbjerg, D., Harremoes, P. (2002). Regional estimation of rainfall intensity–duration–frequency curves using generalized least squares regressions of partial duration series. *Water Resources Research,* **38** (11).

Madsen, H., Arnbjerg-Nielsen, K., Mikkelsen, P.S. (2009). Update of regional intensity–duration–frequency curves in Denmark: tendency towards increased storm intensities. *Atmospheric. Research*, **92 (3),** 343– 349.

Mirhosseini, G., Srivastava, P., Stefanova, L. (2013). The impact of climate change on rainfall intensity-duration frequency (IDF) curves in Alabama. *Regional Environmental Change*, **13**: 25-33.

Okonkwo, G.I., Mbaijorgu, C.C. (2010). Rainfall intensity-duration-frequency analyses for South Eastern Nigeria. *Agricultural Engineering International: CIGR Journal*, **12 (1)**: 22-30.

Overeem, A., Buishand, A., Holleman, I. (2008). Rainfall depth-duration-frequency curves and their uncertainties. *Journal of Hydrology*, **348**: 124- 134.

Raiford, J.P., Aziz, N.M., Khan, A.A., Powell, D.N. (2007). Rainfall depth-duration-frequency relationships for South Carolina, North Carolina and Georgia. *American Journal of Environmental Sciencies,* **3 (2)**: 78-84.

Rao, A.R., Hamed, K. (2000). Flood frequency analysis, CRC Press.

Rasel, M.M., Islam, M.M. (2015). Generation of rainfall intensity-duration-frequency relationship for North-Western Region in Bangladesh. *IOSR Journal of Environmental Science, Toxicology and Food Technology,* **9 (9):** 41-47.

Rasel M.M., Hossain, S.M. (2015). Development of rainfall intensity-duration-frequency (R-IDF) equations and curves for seven divisions in Bangladesh. *International Journal of Scientific & Engineering Research*, **6 (5)**: 96-101.

Segond, M.-L., Onof, C., Wheater, H.S. (2006). Spatial–temporal disaggregation of daily rainfall from a generalized linear model. *Journal of Hydrology*, **331**: 674–689.

Senocak, S., Acar. R. (2007). Modellıng of short duratıon Raınfall (Sdr) intensıty equatıons for Erzurum. *Journal of Engineering Sciences, Pamukkale Engineering College*, **13**: 75-80

Tfwala, C.M., van Rensburg, L.D., Schall R., Mosia, S.M., Dlamini, P. (2017). Precipitation intensity-duration-frequency curves and their uncertainties for Ghaap Plateau. *Journal of Climate Risk Management*, **16**: 1-9.

Usul, N. (2001). Engineering hydrology, Metu Press.

Yarnell, D.L. (1935). Rainfall intensity-frequency data. *U.S. Department of Agriculture, Washington, D.C., Miscellaneous Publication,* No: **204.**

Zope, P.E., Eldho,T.I., Jothiprakash, V. (2016). Development of rainfall intensity duration frequency curves for Mumbai city, India. *Journal of Water Resource and Protection,* **8:** 756-765.

Watt, W.E., Waters, D., McLean, R., (2003). Climate variability and urban stormwater infrastructure in Canada: Context and case studies. *Report and Working Paper Series, (Toronto-Niagara Region Study on Atmospheric Change),* Report 2003–1.

Willems, P. (2013). Revision of urban drainage design rules after assessment of climate change impacts on p-precipitation extremes at Uccle, Belgium. *Journal of Hydrology,* **496**: 166-177.

APPENDIX A

Table A1: Standardized value, z tables

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990

APPENDIX B

Table B1: Log-Pearson Type 3 Frequency Factor (Hoggan, 1989; Usul, 2001)

Skew Coeff G	Return period (T_r) in years: 1.010	1.25	2	5	10	25	50	100	200	1000	Skew Coeff G
	Percent chance (p): 99	80	50	20	10	4	2	1	0.5	0.1	
3.0	-0.667	-0.636	-0.396	0.420	1.180	2.278	3.152	4.051	4.970	7.250	3.0
2.8	-0.714	-0.666	-0.384	0.460	1.210	2.275	3.114	3.973	4.847	6.915	2.8
2.6	-0.769	-0.696	-0.368	0.499	1.238	2.267	3.071	3.889	4.718	6.672	2.6
2.4	-0.832	-0.725	-0.351	0.537	1.262	2.256	3.023	3.800	4.584	6.423	2.4
2.2	-0.905	-0.752	-0.330	0.574	1.248	2.240	2.970	3.705	4.444	6.168	2.2
2.0	-0.990	-0.777	-0.307	0.609	1.302	2.219	2.912	3.605	4.298	5.908	2.0
1.8	-1.087	-0.799	-0.282	0.643	1.318	2.193	2.848	3.499	4.147	5.642	1.8
1.6	-1.197	-0.817	-0.254	0.675	1.329	2.163	2.780	3.388	3.990	5.371	1.6
1.4	-1.318	-0.832	-0.225	0.705	1.337	2.128	2.706	3.271	3.828	5.095	1.4
1.2	-1.449	-0.844	-0.195	0.732	1.340	2.087	2.626	3.149	3.661	4.815	1.2
1.0	-1.588	-0.852	-0.164	0.758	1.340	2.043	2.542	3.022	3.489	4.531	1.0
0.8	-1.733	-0.856	-0.132	0.780	1.336	1.993	2.453	2.891	3.312	4.244	0.8
0.6	-1.880	-0.857	-0.099	0.800	1.328	1.939	2.359	2.755	3.132	3.956	0.6
0.4	-2.029	-0.855	-0.066	0.816	1.317	1.880	2.261	2.615	2.949	3.666	0.4
0.2	-2.178	-0.850	-0.033	0.830	1.301	1.818	2.159	2.472	2.763	3.377	0.2
0.0	-2.326	-0.842	0.	0.842	1.282	1.751	2.054	2.326	2.576	3.090	0.0
-0.2	-2.472	-0.830	0.033	0.850	1.258	1.680	1.945	2.178	2.388	2.808	-0.2
-0.4	-2.615	-0.816	0.366	0.855	1.231	1.606	1.834	2.029	2.201	2.533	-0.4
-0.6	-2.755	-0.800	0.099	0.857	1.200	1.528	1.720	1.880	2.016	2.268	-0.6
-0.8	-2.891	-0.780	0.132	0.856	1.166	1.448	1.606	1.733	1.837	2.017	-0.8
-1.0	-3.022	-0.758	0.164	0.852	1.128	1.366	1.492	1.588	1.664	1.786	-1.0
-1.2	-3.149	-0.732	0.195	0.844	1.086	1.282	1.379	1.449	1.501	1.577	-1.2
-1.4	-3.271	-0.705	0.225	0.832	1.041	1.198	1.270	1.318	1.351	1.394	-1.4
-1.6	-3.388	-0.675	0.254	0.817	0.994	1.116	1.166	1.197	1.216	1.238	-1.6
-1.8	-3.499	-0.643	0.282	0.799	0.945	1.035	1.069	1.087	1.097	1.107	-1.8
-2.0	-3.605	-0.609	0.307	0.777	0.895	0.959	0.980	0.990	0.995	1.999	-2.0
-2.2	-3.705	-0.574	0.330	0.752	0.844	0.888	0.900	0.905	0.907	0.909	-2.2
-2.4	-3.800	-0.537	0.351	0.725	0.795	0.823	0.830	0.832	0.833	0.833	-2.4
-2.6	-3.889	-0.499	0.368	0.696	0.747	0.764	0.768	0.769	0.769	0.769	-2.6
-2.8	-3.973	-0.460	0.384	0.666	0.702	0.712	0.714	0.714	0.714	0.714	-2.8
-3.0	-4.051	-0.420	0.396	0.636	0.660	0.666	0.666	0.667	0.667	0.668	-3.0

APPENDIX C

Table C1: Critical Values of Kolmogorov-Smirnov Test.

n	Level of significance (α)				
	.20	.15	.10	.05	.01
1	.900	.925	.950	.975	.995
2	.684	.726	.776	.842	.929
3	.565	.597	.642	.708	.828
4	.494	.525	.564	.624	.733
5	.446	.474	.510	.565	.669
6	.410	.436	.470	.521	.618
7	.381	.405	.438	.486	.577
8	.358	.381	.411	.457	.543
9	.339	.360	.388	.432	.514
10	.322	.342	.368	.410	.490
11	.307	.326	.352	.391	.468
12	.295	.313	.338	.375	.450
13	.284	.302	.325	.361	.433
14	.274	.292	.314	.349	.418
15	.266	.283	.304	.338	.404
16	.258	.274	.295	.328	.392
17	.250	.266	.286	.318	.381
18	.244	.259	.278	.309	.371
19	.237	.252	.272	.301	.363
20	.231	.246	.264	.294	.356
25	.210	.220	.240	.270	.320
30	.190	.200	.220	.240	.290
35	.180	.190	.210	.230	.270
OVER 35	$\frac{1.07}{\sqrt{n}}$	$\frac{1.14}{\sqrt{n}}$	$\frac{1.22}{\sqrt{n}}$	$\frac{1.36}{\sqrt{n}}$	$\frac{1.63}{\sqrt{n}}$

APPENDIX D
CALCULATED FREQUENCY FACTORS OF LOG PEARSON TYPE III DISTRIBUTION

Table D1: Frequency Factors for Adana City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,1666	0,362144	0,855029	1,230552	1,604874	1,832354	2,026848	2,529173
0,25	0,030955	0,849504	1,259487	1,684399	1,951754	2,18717	2,825473
0,5	-0,01483	0,836608	1,290538	1,781106	2,101181	2,391604	3,218962
1	-0,03963	0,827188	1,304214	1,830455	2,17949	2,500726	3,435055
2	-0,06558	0,816179	1,316796	1,879209	2,259698	2,613175	3,662312
3	-0,04866	0,823358	1,30859	1,847413	2,207389	2,539839	3,514101
6	-0,01197	0,837649	1,28889	1,775295	2,092074	2,378941	3,194069
12	0,005012	0,843215	1,278355	1,740217	2,037445	2,303522	3,04717
24	0,017603	0,846267	1,269198	1,713127	1,995856	2,247053	2,939573

Table D2: Frequency Factors for Adıyaman City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,1666	-0,06245	0,817507	1,315278	1,873328	2,250023	2,599611	3,634899
0,25	-0,03801	0,827875	1,303428	1,827409	2,17448	2,493702	3,420859
0,5	0,001845	0,842447	1,280658	1,74703	2,047905	2,317724	3,074231
1	-0,00922	0,838649	1,287306	1,769709	2,083321	2,36677	3,170144
2	-0,03993	0,827062	1,304358	1,831011	2,180405	2,502008	3,437646
3	-0,03004	0,831077	1,299295	1,811988	2,149578	2,458899	3,351247
6	-0,01328	0,837171	1,289647	1,777964	2,096258	2,384758	3,205504
12	0,030717	0,849447	1,25966	1,684911	1,95254	2,188237	2,827506

Table D3: Frequency Factors for Antakya (Hatay) City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,1666	0,027606	0,848692	1,261923	1,691606	1,962817	2,202192	2,854096
0,25	0,00881	0,844136	1,275593	1,732046	2,024901	2,286489	3,014716
0,5	-0,03261	0,830141	1,300776	1,817212	2,157765	2,470282	3,373623
1	-0,05723	0,819719	1,31275	1,863529	2,233903	2,577011	3,589226
3	-0,08762	0,805518	1,324206	1,918651	2,325201	2,706715	3,855981
6	-0,10682	0,795259	1,329897	1,951801	2,381284	2,787241	4,024274
12	-0,14877	0,768469	1,338097	2,019206	2,499648	2,959661	4,394425
24	-0,19145	0,734976	1,34	2,081964	2,616386	3,134465	4,782496

Table D4: Frequency Factors for Batman City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	0,244673	0,853178	1,240837	1,632962	1,874442	2,083288	2,633195
0,1666	0,245916	0,853197	1,240737	1,632685	1,874028	2,082731	2,632168
0,25	0,294327	0,853924	1,236811	1,621927	1,857891	2,06107	2,59219
0,5	0,237909	0,853077	1,241386	1,634465	1,876697	2,086314	2,638781
2	0,016419	0,84598	1,270059	1,715675	1,999769	2,252365	2,949695
3	0,01301	0,845154	1,272538	1,723009	2,011028	2,267653	2,978825
6	0,075898	0,850644	1,254522	1,670467	1,930701	2,158805	2,772574
24	0,022606	0,84748	1,265559	1,702363	1,979332	2,224616	2,896822

Table D5: Frequency Factors for Cizre City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,25	0,024326	0,847897	1,264308	1,698662	1,97365	2,216901	2,882123
0,5	-0,05655	0,820011	1,312416	1,862239	2,23178	2,574034	3,583209
3	-0,02877	0,831537	1,298567	1,80942	2,145554	2,453303	3,340247
6	0,003367	0,842816	1,279551	1,743755	2,042878	2,310899	3,061226
12	-0,02808	0,831791	1,298165	1,808002	2,143331	2,450213	3,334172
24	-0,08151	0,808482	1,322169	1,907724	2,30705	2,680785	3,80227

Table D6: Frequency Factors for Diyarbakır City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,1666	0,619841	0,856569	1,185332	1,493486	1,670818	1,816581	2,159713
0,25	0,126841	0,856791	1,203233	1,536133	1,731887	1,895537	2,295633
0,5	0,151687	0,851782	1,248377	1,653625	1,905438	2,124894	2,709985
1	-0,0114	0,837854	1,288565	1,77415	2,09028	2,376446	3,189165
3	-0,03094	0,830748	1,299815	1,813822	2,152453	2,462896	3,359105
6	-0,01161	0,837779	1,288683	1,774567	2,090933	2,377355	3,190951
12	-0,00448	0,840372	1,284578	1,76009	2,068245	2,345808	3,128937
24	0,025604	0,848207	1,263379	1,695913	1,969429	2,21117	2,871203

Table D7: Frequency Factors for Gaziantep City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	-0,0405	0,82682	1,304634	1,832082	2,182168	2,50448	3,442641
0,1666	-0,09332	0,802755	1,326106	1,928841	2,342126	2,730894	3,906067
0,25	-0,08553	0,806532	1,323509	1,914912	2,318989	2,697842	3,837601
0,5	-0,09125	0,803757	1,325417	1,925145	2,335987	2,722124	3,8879
1	-0,09526	0,801815	1,326752	1,932307	2,347884	2,739119	3,923105
2	-0,07147	0,813348	1,318823	1,889779	2,277243	2,638205	3,714067
3	-0,05141	0,822188	1,309928	1,852596	2,215917	2,551795	3,538264
6	-0,04692	0,824094	1,30775	1,844156	2,202031	2,532327	3,498921
12	0,049925	0,850254	1,256628	1,676239	1,939358	2,170427	2,794023
24	0,108091	0,856725	1,190634	1,505962	1,688596	1,839506	2,198857

Table D8: Frequency Factors for Kahramanmaraş City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,1666	0,008635	0,844093	1,27572	1,732421	2,025477	2,287272	3,016207
0,25	0,153153	0,856594	1,206287	1,54382	1,743121	1,91022	2,321747
0,5	0,193009	0,844514	1,088698	1,287395	1,386258	1,457928	1,590424
1	0,194137	0,847963	1,091019	1,285267	1,38068	1,446772	1,56002
2	0,188507	0,845676	1,094797	1,299593	1,402667	1,478113	1,620774
3	0,17047	0,85033	1,119235	1,348469	1,468417	1,558991	1,742382
12	0,160664	0,852417	1,131962	1,374549	1,503886	1,603118	1,810084
24	0,35931	0,710824	0,771537	0,79416	0,799694	0,801205	0,801716

Table D9: Frequency Factors for Kilis City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	0,01883	0,846565	1,268305	1,710486	1,991803	2,241549	2,929087
0,1666	-0,01328	0,83717	1,289648	1,77797	2,096266	2,384771	3,205528
0,25	-0,04532	0,824773	1,306974	1,84115	2,197086	2,525395	3,48491
0,5	-0,0663	0,815856	1,317099	1,880532	2,261883	2,616262	3,668614
1	-0,06113	0,818065	1,31464	1,870854	2,245954	2,593906	3,62337
3	-0,10344	0,797309	1,329077	1,946266	2,371649	2,773301	3,994754
6	-0,05393	0,821121	1,311147	1,857321	2,223689	2,562691	3,560284
12	0,023099	0,8476	1,268305	1,701302	1,977703	2,222404	2,892608
24	0,292134	0,853891	1,236989	1,622415	1,858622	2,062051	2,594

Table D10: Frequency Factors for Mardin City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	-0,0695	0,814301	1,318168	1,886264	2,271405	2,629864	3,696789
0,1666	-0,05329	0,821392	1,310838	1,856122	2,221717	2,559926	3,554697
0,25	-0,06625	0,815881	1,317082	1,88044	2,26173	2,616043	3,668161
3	-0,03104	0,830712	1,299872	1,814023	2,152767	2,463333	3,359963
6	0,006408	0,843553	1,27734	1,737213	2,032835	2,297262	3,035242
12	0,259731	0,853404	1,239616	1,629615	1,869423	2,07655	2,62076
24	0,226132	0,856048	1,214761	1,56514	1,774281	1,950947	2,39418

Table D11: Frequency Factors for Osmaniye City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	0,104026	0,855635	1,194278	1,517129	1,705737	1,862609	2,241653
0,25	0,072164	0,854879	1,225433	1,592707	1,815167	2,00563	2,492588
0,5	0,070429	0,854746	1,227014	1,596718	1,821053	2,013394	2,50649
1	0,08103	0,855413	1,217168	1,572044	1,784972	1,965915	2,42192
12	0,00824	0,843924	1,276132	1,733554	2,027149	2,289961	3,020028
24	0,058509	0,853579	1,237565	1,623987	1,861292	2,066667	2,602646

Table D12: Frequency Factors for Siirt City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	0,277286	0,853668	1,238193	1,625714	1,863571	2,068695	2,883128
0,1666	0,266452	0,855746	1,219442	1,576919	1,791496	1,973447	2,434198
0,25	0,263901	0,855765	1,219146	1,576173	1,790407	1,972024	2,431666
0,5	0,252481	0,85585	1,21782	1,572837	1,785531	1,96565	2,420331
1	0,16931	0,856473	1,208163	1,54854	1,75002	1,919236	2,337783
2	0,220326	0,856091	1,214087	1,563444	1,771802	1,947706	2,388417
3	0,262702	0,855774	1,219007	1,575823	1,789895	1,971355	2,430476
6	-0,04614	0,824427	1,307369	1,842678	2,1996	2,528919	3,492033

Table D13: Frequency Factors for Şanlıurfa City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,1666	0,106772	0,851108	1,252018	1,663606	1,920409	2,144991	2,747077
0,25	-0,03359	0,829749	1,301286	1,81911	2,160826	2,47456	3,382173
0,5	-0,09225	0,803274	1,325749	1,926927	2,338946	2,726352	3,896657
1	-0,07234	0,812925	1,319114	1,891338	2,279833	2,641905	3,721731
2	-0,05102	0,822354	1,309738	1,851859	2,214703	2,550094	3,534826
3	-0,07486	0,811706	1,319952	1,895835	2,287303	2,652575	3,743834
6	-0,11029	0,79316	1,330736	1,957468	2,391148	2,801512	4,054496
12	-0,13687	0,776652	1,336609	2,00061	2,466546	2,910938	4,287681
24	-0,17227	0,751067	1,34	2,054732	2,564398	3,055863	4,606726

APPENDIX E
GUMBEL DISTRIBUTION RESULTS

Table E1: Gumbel Distribution Results forAdana City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	94,81058	125,7218	146,1878	172,0466	191,2301	210,2719	273,1922
0,1666	71,61833	99,96181	118,7277	142,4384	160,0283	177,4884	235,1819
0,25	60,6469	85,20346	101,462	122,0048	137,2446	152,3719	202,3571
0,5	41,93381	61,42282	74,32624	90,62974	102,7246	114,7302	154,4003
1	27,52768	42,09098	51,73315	63,91606	72,95403	81,92528	111,5691
2	16,1953	25,12042	31,02963	38,49592	44,03485	49,53288	67,70008
3	11,80444	17,96588	22,04529	27,19964	31,02343	34,81898	47,36068
6	7,096941	10,28142	12,38983	15,0538	17,03009	18,99179	25,47385
12	4,234175	5,895525	6,995484	8,385284	9,416317	10,43974	13,82144
24	2,785677	3,786957	4,449892	5,287512	5,908907	6,525713	8,563833

Table E2: Gumbel Distribution Results for Adıyaman City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	64,49586	97,18042	118,8205	146,1627	166,4467	186,581	253,1108
0,1666	47,328168	75,76574	94,5939	118,3833	136,0317	153,5497	211,4348
0,25	38,974667	61,14199	75,81868	94,36272	108,1197	121,7752	166,8971
0,5	26,338333	39,2995	47,88092	58,72357	66,76726	74,75156	101,1342
1	15,563286	22,2164	26,62134	32,18699	36,31591	40,41434	53,95684
2	9,559385	13,04411	15,3513	18,26644	20,42906	22,57571	29,66891
3	7,1065572	9,615952	11,27739	13,37662	14,93395	16,47978	21,58769
6	4,6240298	6,283712	7,382565	8,77097	9,800968	10,82336	14,20167
12	2,9464413	3,982814	4,668982	5,535958	6,179131	6,817554	8,927104
24	2,0276437	2,590348	2,962908	3,433638	3,782852	4,129488	5,274881

Table E3: Gumbel Distribution Results for Antakya (Hatay) City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	97,06752	130,6673	152,9133	181,0211	201,8731	222,5712	290,9639
0,1666	70,5771	95,10169	111,3391	131,8551	147,0751	162,1827	212,1028
0,25	59,88267	80,97693	94,94317	112,5896	125,6806	138,6751	181,6127
0,5	44,53255	62,41486	74,25451	89,21394	100,3117	111,3275	147,7272
1	32,6243	48,54123	59,07963	72,39492	82,27296	92,07807	124,4772
2	22,13509	34,52766	42,73262	53,09961	60,79044	68,42448	93,64972
3	16,76943	26,28911	32,59197	40,55565	46,46357	52,32786	71,7053
6	10,21866	16,22371	20,19957	25,22309	28,94982	32,64904	44,8724
12	5,97844	9,347604	11,57828	14,39675	16,48766	18,56312	25,4211
24	3,744526	6,124622	7,700453	9,691519	11,16861	12,63479	17,4795

Table E4: Gumbel Distribution Results for Batman (Hatay) City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	53,30841	76,76463	92,29469	111,917	126,4739	140,9233	188,6687
0,1666	36,38851	51,35972	61,27196	73,79611	83,08724	92,30976	122,7839
0,25	29,60737	41,6182	49,57041	59,61805	67,07197	74,47084	98,91905
0,5	19,65733	28,11011	33,70659	40,77776	46,02356	51,23062	68,43638
1	11,71154	16,30673	19,34914	23,19324	26,04502	28,87573	38,2293
2	7,136055	9,82406	11,60375	13,8524	15,52058	17,17643	22,6479
3	5,233588	7,163776	8,441728	10,05642	11,2543	12,44333	16,37225
6	3,218264	4,3061	5,026341	5,936369	6,611479	7,281605	9,495909
12	2,016422	2,82853	3,366216	4,045584	4,549577	5,04985	6,702906
24	1,312279	1,805323	2,131761	2,544216	2,850198	3,153922	4,157519

Table E5: Gumbel Distribution Results for Cizre City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	74,34895	105,1801	125,593	151,3848	170,5186	189,5111	252,2683
0,1666	52,2	74,9022	89,93304	108,9245	123,0135	136,9985	183,2091
0,25	41,45615	59,5167	71,47436	86,58289	97,79126	108,9169	145,6794
0,5	27,18447	40,25097	48,90213	59,83289	67,94196	75,99115	102,5882
1	16,25488	23,97534	29,08696	35,5455	40,33681	45,09275	60,80784
2	9,534722	13,65167	16,37744	19,82147	22,37644	24,91255	33,29265
3	7,333788	10,16463	12,0389	14,40704	16,16387	17,90772	23,66994
6	4,724131	6,462257	7,613048	9,067075	10,14576	11,21647	14,75445
12	2,95847	4,123332	4,894572	5,869036	6,591949	7,309524	9,680616
24	2,051199	2,926416	3,505885	4,238046	4,781205	5,320353	7,101868

Table E6: Gumbel Distribution Results for Diyarbakır City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	57,07239	83,62269	101,2013	123,4119	139,889	156,2445	210,288
0,1666	42,45216	61,68323	74,41588	90,50361	102,4384	114,2851	153,4302
0,25	34,87218	50,45735	60,77608	73,81384	83,48598	93,08671	124,8105
0,5	22,11667	32,06215	38,64692	46,96679	53,13895	59,26553	79,50968
1	13,25009	18,50515	21,98446	26,38058	29,64187	32,87908	43,57584
2	8,102773	10,78286	12,55732	14,79934	16,46261	18,11359	23,56895
3	6,137346	8,129688	9,448793	11,11548	12,35193	13,57925	17,63469
6	3,890398	5,067991	5,847659	6,832773	7,563586	8,289003	10,68601
12	2,289382	3,062931	3,575088	4,2222	4,702264	5,178784	6,753353
24	1,500784	1,902199	2,167971	2,503774	2,752892	3,000171	3,817257

Table E7: Gumbel Distribution Results for Gaziantep City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	61,77116	99,29708	124,1425	155,5348	178,8233	201,9399	278,3244
0,1666	45,57204	71,83178	89,21802	111,1856	127,4824	143,6588	197,1109
0,25	37,11684	58,98727	73,4674	91,76309	105,3359	118,8084	163,326
0,5	25,28041	39,79136	49,39886	61,53798	70,54346	79,48246	109,0197
1	15,41561	23,5685	28,96643	35,78672	40,8464	45,86872	62,46405
2	9,557578	14,04171	17,0106	20,76179	23,54464	26,30695	35,43446
3	7,024674	10,09185	12,12258	14,68842	16,59191	18,48134	24,72461
6	4,122053	5,914194	7,100747	8,59996	9,712162	10,81615	14,46408
12	2,355403	3,234905	3,817212	4,552958	5,098777	5,640565	7,430803
24	1,626177	2,128424	2,460955	2,88111	3,192804	3,502197	4,524528

Table E8: Gumbel Distribution Results for Kahramanmaraş City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	62,18176	91,26069	110,5135	134,8394	152,8858	170,7989	229,9895
0,1666	45,81058	65,50225	78,53985	95,01289	107,2335	119,3639	159,4466
0,25	37,40766	52,60308	62,66378	75,37549	84,80576	94,16641	125,0969
0,5	22,6634	30,79098	36,17216	42,97128	48,01526	53,02199	69,5658
1	14,04958	18,91956	22,1439	26,21787	29,24018	32,24017	42,15306
2	8,778371	11,48044	13,26945	15,52986	17,20677	18,87129	24,37139
3	6,707549	8,951853	10,43778	12,31525	13,70806	15,09059	19,6589
6	4,259155	5,838266	6,883775	8,204778	9,184773	10,15753	13,37183
12	2,745415	3,699952	4,331939	5,130455	5,72284	6,310852	8,253824
24	1,907026	2,402135	2,729941	3,144125	3,451389	3,756386	4,764188

Table E9: Gumbel Distribution Results for Kilis City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	70,95331	100,7927	120,5489	145,511	164,0293	182,4108	243,1492
0,1666	51,50708	74,44017	89,62387	108,8085	123,0408	137,168	183,8486
0,25	42,98919	62,95214	76,16936	92,86935	105,2584	117,5559	158,1907
0,5	27,75738	41,62411	50,80509	62,40529	71,01097	79,55311	107,779
1	17,04165	26,05719	32,02627	39,56822	45,16326	50,71699	69,06826
2	9,783715	14,28938	17,27252	21,04173	23,83794	26,61351	35,78484
3	7,122063	10,1191	12,10339	14,61056	16,47052	18,31674	24,41724
6	4,057125	5,540793	6,523111	7,764272	8,685036	9,599002	12,61903
12	2,299794	3,029399	3,512462	4,122812	4,575605	5,025054	6,510176
24	1,470806	1,874428	2,14166	2,479309	2,729796	2,978434	3,800011

Table E10: Gumbel Distribution Results for Mardin City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	63,20715	118,8098	155,6237	202,138	236,6451	270,8973	384,0773
0,1666	46,02134	82,37303	106,441	136,851	159,4108	181,8041	255,7984
0,25	37,49384	66,50034	85,70516	109,9705	127,9719	145,8404	204,8835
0,5	25,28134	46,09346	59,8729	77,28325	90,19924	103,0199	145,3832
1	16,45513	28,6855	36,78307	47,01438	54,60454	62,13866	87,03375
2	10,21292	16,64704	20,90699	26,28944	30,28246	34,24599	47,34272
3	7,756586	12,185	15,117	18,82158	21,56985	24,29783	33,31193
6	4,909746	7,409457	9,064483	11,15561	12,70693	14,2468	19,33499
12	2,997344	4,55028	5,578459	6,877566	7,841317	8,797953	11,95897
24	2,073612	3,14981	3,862346	4,762639	5,430527	6,093483	8,284099

Table E11: Gumbel Distribution Results for Osmaniye City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,1666	79,38814	107,6414	126,3476	149,9829	167,5168	184,9214	242,4314
0,25	70,86421	94,18931	109,6326	129,1451	143,6207	157,9894	205,4679
0,5	47,80509	64,56227	75,65698	89,67517	100,0747	110,3974	144,5068
1	30,22757	42,52424	50,66571	60,95248	68,5838	76,15876	101,1888
2	20,57039	28,90679	34,42621	41,40001	46,57357	51,70894	68,67779
3	15,79539	21,78563	25,75168	30,7628	34,48034	38,17043	50,36362
6	9,608026	13,28878	15,72576	18,80489	21,08916	23,35657	30,84879
12	5,954153	7,967121	9,299881	10,98383	12,23307	13,4731	17,57052
24	3,488731	4,785183	5,643547	6,728092	7,532669	8,331306	10,97025

Table E12: Gumbel Distribution Results for Siirt City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	66,43334	97,72507	118,4429	144,62	164,0396	183,3159	247,0106
0,1666	44,41303	62,70108	74,80937	90,10822	101,4578	112,7235	149,9491
0,25	34,63042	47,51246	56,04149	66,81795	74,81254	82,7481	108,9697
0,5	21,90882	29,5498	34,60879	41,00085	45,74283	50,44981	66,00312
1	13,4444	17,84551	20,75943	24,44117	27,1725	29,88366	38,84218
2	8,601286	11,1329	12,80905	14,92687	16,49799	18,05751	23,21065
3	6,462279	8,189448	9,332984	10,77785	11,84973	12,91369	16,42937
6	4,152166	5,474223	6,34954	7,455506	8,275974	9,090384	11,78145
12	2,592148	3,606652	4,278342	5,127023	5,756624	6,381576	8,446611
24	1,829321	2,666732	3,221171	3,921706	4,441403	4,957262	6,661824

Table E13: Gumbel Distribution Results for Şanlıurfa City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	55,38141	85,06962	104,7258	129,5614	147,9859	166,2744	226,7051
0,1666	40,77848	61,95567	75,97681	93,69256	106,8351	119,8806	162,9871
0,25	32,84127	50,1032	61,5321	75,97254	86,68529	97,31894	132,4558
0,5	22,56515	34,26515	42,01157	51,79919	59,06021	66,26761	90,08313
1	14,84618	21,75271	26,32544	32,10309	36,38928	40,64382	54,70216
2	9,430401	13,67818	16,49059	20,04407	22,68024	25,29695	33,94337
3	7,002461	10,18564	12,29318	14,95607	16,93155	18,89244	25,37185
6	4,308994	6,271262	7,570455	9,211988	10,42977	11,63856	15,63278
12	2,556659	3,861272	4,72504	5,816412	6,626055	7,429719	10,08528
24	1,640716	2,252165	2,656998	3,168506	3,547971	3,924635	5,169249

APPENDIX F

NORMAL DISTRIBUTION RESULTS

Table F1: Normal Distribution Results for Adana City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	100,5565	129,9949	145,382879	161,7924	172,3929	181,928	208,6473
0,1666	76,88696	103,8799	117,989613	133,036	142,756	151,4989	175,9987
0,25	65,21159	88,59808	100,822613	113,8587	122,28	129,8548	151,0812
0,5	45,55652	64,11691	73,818759	84,16465	90,84814	96,8598	113,7059
1	30,23478	44,10416	51,3539343	59,08497	64,07925	68,57151	81,15984
2	17,85435	26,3542	30,7972244	35,53519	38,59594	41,34902	49,06378
3	12,94976	18,81762	21,8848526	25,1557	27,26868	29,16927	34,49514
6	7,688889	10,72164	12,3069072	13,99741	15,08949	16,07179	18,82441
12	4,542995	6,125185	6,95222327	7,834164	8,403901	8,916368	10,35242
24	2,9718	3,925371	4,42381956	4,955357	5,298732	5,607592	6,473086

Table F2: Normal Distribution Results for Adıyaman City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	70,57143	101,6986	117,969371	135,3202	146,5289	156,611	184,8631
0,1666	52,61429	79,69686	93,8534024	108,9497	118,702	127,474	152,055
0,25	43,09524	64,20632	75,2414593	87,00915	94,61113	101,449	120,6101
0,5	28,74762	41,09121	47,5434201	54,42395	58,86881	62,86686	74,07033
1	16,8	23,1361	26,448097	29,97995	32,26155	34,31379	40,06466
2	10,20714	13,52583	15,2605609	17,11045	18,30549	19,3804	22,39256
3	7,573016	9,962842	11,2120465	12,54418	13,40474	14,1788	16,34789
6	4,93254	6,513141	7,3393486	8,220403	8,789568	9,301521	10,73613
12	3,139087	4,126078	4,64199611	5,192162	5,547572	5,867256	6,763083
24	2,132242	2,668135	2,94825556	3,246972	3,439944	3,613518	4,099913

Table F3: Normal Distribution Results for Antakya (Hatay) City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	103,3132	135,312	152,038349	169,875	181,3976	191,762	220,8052
0,1666	75,13585	98,49189	110,700509	123,7196	132,13	139,6949	160,8937
0,25	63,80377	83,89293	94,3938934	105,5919	112,8259	119,3328	137,5664
0,5	47,8566	64,88686	73,7888719	83,28183	89,41433	94,93038	110,3876
1	35,58302	50,74154	58,6651648	67,11479	72,57328	77,48309	91,24148
2	24,43868	36,24077	42,4099276	48,98862	53,23848	57,06115	67,77313
3	18,53899	27,60508	32,3440876	37,39769	40,66233	43,59881	51,82751
6	11,33491	17,05383	20,0432075	23,23103	25,29038	27,14273	32,33342
12	6,604717	9,813346	11,4905538	13,2791	14,43451	15,47378	18,38604
24	4,18695	6,453639	7,63847705	8,901969	9,718191	10,45237	12,50969

Table F4: Normal Distribution Results for Batman City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	57,66857	80,00714	91,683905	104,1358	112,1798	119,4152	139,6905
0,1666	39,17143	53,42929	60,882124	68,82971	73,96388	78,58196	91,52289
0,25	31,84	43,27853	49,257657	55,6337	59,75264	63,45756	73,83956
0,5	21,22857	29,2786	33,48649	37,97372	40,87248	43,47987	50,78635
1	12,56571	16,94195	19,229488	21,66888	23,24474	24,66219	28,63421
2	7,635714	10,19564	11,53376	12,96071	13,88252	14,71168	17,03515
3	5,592381	7,430599	8,3914677	9,416123	10,07805	10,67345	12,34188
6	3,420476	4,456478	4,9980151	5,575501	5,948559	6,284118	7,224429
12	2,167381	2,940793	3,3450694	3,776183	4,054684	4,30519	5,007166
24	1,403929	1,87348	2,1189221	2,380658	2,549741	2,701827	3,128008

Table F5: Normal Distribution Results for Cizre City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	80,08	109,4421	124,790191	141,1571	151,7303	161,2406	187,8906
0,1666	56,42	78,04048	89,3418909	101,3935	109,1789	116,1818	135,8052
0,25	44,81333	62,01333	71,0040746	80,59166	86,78527	92,35631	107,9676
0,5	29,61333	42,05724	48,5618864	55,49834	59,97931	64,00986	75,30438
1	17,69	25,04259	28,8859223	32,98439	35,63201	38,0135	44,68696
2	10,3	14,22078	16,2702406	18,45575	19,8676	21,13753	24,69617
3	7,86	10,55596	11,9651886	13,46797	14,43877	15,31198	17,75893
6	5,047222	6,70253	7,56778849	8,490486	9,086553	9,622703	11,12512
12	3,175	4,284358	4,86423982	5,482616	5,882089	6,241408	7,2483
24	2,213889	3,047403	3,48309511	3,94771	4,247854	4,517827	5,274353

Table F6: Normal Distribution Results for Diyarbakır City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	62,00769	87,29292	100,5099493	114,6044	123,7094	131,8993	154,849
0,1666	46,02692	64,34167	73,91511608	84,12408	90,71911	96,65121	113,2743
0,25	37,76923	52,61179	60,37025917	68,64376	73,98848	78,79595	92,26757
0,5	23,96538	33,43697	38,38794291	43,66757	47,07824	50,14606	58,7428
1	14,22692	19,23159	21,84762368	24,63732	26,43947	28,06047	32,60288
2	8,600962	11,15335	12,48753009	13,91028	14,82938	15,65609	17,97273
3	6,507692	8,405103	9,396913631	10,45456	11,13781	11,75238	13,47453
6	4,109295	5,230777	5,816995595	6,442129	6,845969	7,209214	8,22711
12	2,433173	3,169864	3,55494542	3,96559	4,230868	4,46948	5,138126
24	1,575401	1,957689	2,157518135	2,370612	2,508272	2,632095	2,979073

Table F7: Normal Distribution Results for Gaziantep City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	68,74667	104,4845	123,165353	143,0863	155,9553	167,5307	199,9676
0,1666	50,45333	75,46184	88,5342353	102,4744	111,4798	119,58	142,2786
0,25	41,18222	62,01057	72,8979142	84,508	92,00817	98,75441	117,6589
0,5	27,97778	41,7973	49,0210107	56,72426	61,70059	66,17669	78,71977
1	16,93111	24,69553	28,754133	33,08216	35,87808	38,39296	45,44021
2	10,39111	14,66158	16,8938343	19,27427	20,81204	22,19524	26,07126
3	7,594815	10,51584	12,0427139	13,67095	14,72279	15,6689	18,32013
6	4,455185	6,161934	7,05408132	8,005453	8,620043	9,172854	10,72196
12	2,518889	3,356484	3,79431011	4,2612	4,562814	4,834109	5,594339
24	1,719537	2,197853	2,44787724	2,714499	2,886738	3,041663	3,475799

Table F8: Normal Distribution Results for Kahramanmaraş City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	67,5871	95,28047	109,756281	125,1931	135,1653	144,1351	169,2705
0,1666	49,47097	68,22436	78,0270923	88,48056	95,23355	101,3077	118,329
0,25	40,23226	54,70365	62,2680987	70,33471	75,54577	80,23301	93,36775
0,5	24,17419	31,91452	35,960519	40,27511	43,06236	45,56943	52,59481
1	14,95484	19,59277	22,017094	24,60236	26,27245	27,77466	31,9842
2	9,280645	11,85397	13,1990883	14,6335	15,56014	16,39363	18,72927
3	7,124731	9,262098	10,3793371	11,57074	12,3404	13,03268	14,97263
6	4,552688	6,056557	6,84265594	7,680939	8,222473	8,709573	10,07454
12	2,922849	3,831904	4,30708327	4,813806	5,141152	5,435592	6,260682
24	1,999059	2,470578	2,71704885	2,979882	3,149673	3,302396	3,730363

Table F9: Normal Distribution Results for Kilis City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	76,5	104,9176	119,7719128	135,6124	145,8454	155,0497	180,8425
0,1666	55,77	77,61036	89,02671044	101,2009	109,0655	116,1395	135,9626
0,25	46,7	65,71176	75,64954007	86,24703	93,09305	99,25091	116,5066
0,5	30,335	43,541	50,4440133	57,80527	62,56067	66,83807	78,82429
1	18,7175	27,30347	31,79151285	36,57749	39,66924	42,45022	50,24314
2	10,62125	14,91223	17,1551957	19,54706	21,09222	22,48205	26,37669
3	7,679167	10,5334	12,02535297	13,61635	14,64414	15,56862	18,15922
6	4,332917	5,745891	6,484477608	7,272094	7,780898	8,238557	9,521021
12	2,435417	3,130258	3,493463309	3,88078	4,130988	4,356045	4,986707
24	1,545833	1,930223	2,131150015	2,345415	2,483832	2,608335	2,95722

Table F10: Normal Distribution Results for Mardin City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	73,54286	126,4962	154,175824	183,6929	202,7611	219,9126	267,9748
0,1666	52,77857	87,39816	105,494436	124,792	137,2583	148,4715	179,8934
0,25	42,88571	70,5101	84,9498517	100,3482	110,2955	119,243	144,3159
0,5	29,15	48,97046	59,3309651	70,37924	77,51647	83,93627	101,926
1	18,72857	30,37619	36,4646037	42,95719	47,15143	50,92406	61,49584
2	11,40893	17,53647	20,7394502	24,15505	26,36154	28,34624	33,90781
3	8,579762	12,79717	15,0016838	17,35254	18,87121	20,23721	24,06508
6	5,374405	7,755008	8,99939198	10,32638	11,18362	11,9547	14,11541
12	3,286012	4,764953	5,53802202	6,36241	6,894968	7,373993	8,716331
24	2,273661	3,29858	3,83432312	4,405631	4,774698	5,106667	6,036919

Table F11: Normal Distribution Results for Osmaniye City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	114,96	139,6106	152,4958	166,2428	175,1131	183,0974	205,471
0,1666	84,64	111,547	125,6118	140,6172	150,2995	159,0147	183,4363
0,25	75,2	97,41367	109,0252	121,4131	129,4066	136,6015	156,7633
0,5	50,92	66,8787	75,22061	84,12037	89,86297	95,03198	109,5166
1	32,51333	44,22408	50,3455	56,87628	61,0903	64,8834	75,51243
2	22,12	30,05917	34,20912	38,63659	41,49344	44,06493	51,27076
3	16,90889	22,61369	25,59569	28,77711	30,82994	32,67772	37,85557
6	10,29222	13,79759	15,62991	17,58476	18,84614	19,98152	23,1631
12	6,328333	8,245384	9,247461	10,31655	11,00639	11,62732	13,36729
24	3,729722	4,964398	5,609786	6,298333	6,742621	7,142532	8,263162

Table F12: Normal Distribution Results for Siirt City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	72,25	102,0507	117,6281082	134,2396	144,9706	154,623	181,6712
0,1666	47,8125	65,22916	74,33316238	84,04152	90,31316	95,95437	111,7623
0,25	37,025	49,29323	55,7060559	62,54459	66,9623	70,93595	82,07102
0,5	23,32917	30,60607	34,4098294	38,4661	41,08647	43,44344	50,0482
1	14,2625	18,45391	20,64482856	22,98119	24,49049	25,84808	29,65234
2	9,071875	11,48286	12,7431298	14,08706	14,95524	15,73615	17,92445
3	6,783333	8,428206	9,288009828	10,20489	10,7972	11,32997	12,82291
6	4,397917	5,65698	6,315115132	7,016939	7,470321	7,878128	9,020898
12	2,780729	3,746893	4,251924703	4,790482	5,138392	5,45133	6,328254
24	1,984983	2,782493	3,199365096	3,643911	3,93109	4,189401	4,913249

Table F13: Normal Distribution Results for Şanlıurfa City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	60,9	89,17362	103,9527384	119,713	129,8941	139,0519	164,714
0,1666	44,715	64,88313	75,42536978	86,66744	93,92987	100,4623	118,7676
0,25	36,05	52,48943	61,08260942	70,24624	76,16598	81,49067	96,41166
0,5	24,74	35,88252	41,70691078	47,91795	51,9303	55,53934	65,65267
1	16,13	22,70745	26,14559716	29,81198	32,18048	34,3109	40,28082
2	10,22	14,26538	16,37997843	18,63495	20,09167	21,40196	25,07369
3	7,594167	10,62567	12,21029612	13,90011	14,99174	15,97364	18,72514
6	4,67375	6,54252	7,519358569	8,561044	9,233977	9,839266	11,53543
12	2,799167	4,041618	4,691068621	5,383633	5,831032	6,233459	7,36115
24	1,754375	2,33669	2,64107669	2,965669	3,175358	3,363968	3,892497

APPENDIX G

LOG NORMAL DISTRIBUTION RESULTS

(Results have been given based on equation 3.13.)

Table G1: Log Normal Distribution Results for Adana City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	93,64106	132,2945	158,485264	192,1514	217,613	243,3851	333,0486
0,1666	70,55221	101,1653	122,137175	149,3122	170,0034	191,0532	264,9831
0,25	59,68892	85,71664	103,567004	126,716	144,3537	162,3063	225,4185
0,5	41,07649	60,28157	73,6656065	91,22748	104,7404	118,5967	167,9874
1	26,94435	40,10075	49,3648591	61,61344	71,09814	80,87055	116,0179
2	15,81835	23,68367	29,2465685	36,62548	42,35488	48,27015	69,6267
3	11,54502	17,16397	21,1174747	26,34161	30,38497	34,54948	49,51732
6	6,985997	10,10423	12,2541004	15,05294	17,19235	19,37527	27,08436
12	4,191066	5,898685	7,0524919	8,532583	9,650049	10,77968	14,70032
24	2,768909	3,81908	4,51810554	5,405051	6,068579	6,734716	9,017176

Table G2: Log Normal Distribution Results for Adıyaman City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	62,876497	94,58056	117,0811	147,0024	170,2841	194,3593	281,5408
0,1666	46,310184	70,09936	87,06085	109,693	127,3531	145,6543	212,1932
0,25	38,102751	57,54926	71,392053	89,84091	104,2224	119,1148	173,1841
0,5	25,80996	38,2781	47,034912	58,59083	67,52498	76,71914	109,7128
1	15,474659	21,78693	26,053065	31,5266	35,65973	39,83833	54,34416
2	9,5904261	12,89083	15,045975	17,74258	19,73642	21,72054	28,40861
3	7,130227	9,547496	11,121487	13,08687	14,53753	15,97925	20,82725
6	4,6274009	6,260871	7,3327407	8,678685	9,676837	10,67236	14,04205
12	2,9395564	4,013033	4,7221463	5,616907	6,283169	6,94971	9,218721
24	2,0280254	2,704524	3,1436903	3,690853	4,093971	4,494047	5,8359

Table G3: Log Normal Distribution Results for Antakya (Hatay) City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	96,81972	132,0383	155,2848443	184,6007	206,4197	228,2401	302,4706
0,1666	70,27609	96,24584	113,4414591	135,1764	151,3841	167,6164	222,9852
0,25	59,71191	81,48752	95,8680255	114,0097	127,5163	141,0267	187,0077
0,5	44,28376	61,64572	73,28172721	88,11978	99,26679	110,4929	149,1846
1	32,0011	46,92267	57,31492491	70,94478	81,42813	92,17476	130,4599
2	21,37081	32,79035	41,01401892	52,06791	60,74642	69,78166	102,9184
3	16,23902	24,75126	30,85135992	39,02138	45,41647	52,05934	76,3185
6	9,919646	15,07177	18,75536081	23,68048	27,53012	31,52462	46,08272
12	5,885751	8,624593	10,5311712	13,03085	14,9529	16,92279	23,93767
24	3,706059	5,435609	6,640410493	8,220789	9,436481	10,68282	15,1237

Table G4: Log Normal Distribution Results for Batman City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	51,67391	78,05283	96,831444	121,8595	141,3704	161,575	234,9348
0,1666	35,51345	52,43141	64,273898	79,86361	91,89172	104,2508	148,4738
0,25	28,94694	42,51031	51,96745	64,38129	73,93607	83,73597	118,683
0,5	19,16668	28,49162	35,052074	43,72044	50,4292	57,33867	82,17039
1	11,50408	16,64903	20,197814	24,81936	28,353	31,95925	44,69979
2	7,058819	9,943153	11,893245	14,39593	16,28617	18,19752	24,83482
3	5,194559	7,232439	8,5984103	10,34044	11,64924	12,96742	17,51109
6	3,206021	4,381325	5,1582979	6,139232	6,870002	7,601338	10,09255
12	1,997525	2,817611	3,3726341	4,085462	4,624185	5,169182	7,063374
24	1,302099	1,819414	2,1670846	2,61133	2,945635	3,282746	4,44739

Table G5: Log Normal Distribution Results for Cizre City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	72,5985	107,7639	132,477869	165,1072	190,3437	216,3225	309,6011
0,1666	51,25612	75,02146	91,5511613	113,2095	129,8545	146,907	207,5875
0,25	40,71047	59,47537	72,509133	89,56966	102,67	116,0826	163,754
0,5	26,73282	39,05196	47,6081374	58,80728	67,40652	76,2105	107,5003
1	16,0323	23,19368	28,1319459	34,56168	39,47703	44,49274	62,20851
2	9,471869	13,32504	15,9276814	19,2655	21,78502	24,33158	33,16741
3	7,303992	10,10865	11,9802541	14,35939	16,142	17,9337	24,08613
6	4,689696	6,524985	7,75452944	9,321988	10,49926	11,68468	15,76896
12	2,938605	4,105422	4,88950641	5,891302	6,645121	7,405223	10,03094
24	2,042282	2,85131	3,394698	4,088716	4,610785	5,137087	6,954392

Table G6: Log Normal Distribution Results for Diyarbakır City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	54,51764	85,92443	108,992102	140,4525	165,4538	191,7221	289,7358
0,1666	40,50086	63,93347	81,1641744	104,684	123,3883	143,0511	216,4923
0,25	33,37423	52,1332	65,8213012	84,39952	99,10403	114,5068	171,6496
0,5	21,38834	32,44906	40,3484678	50,90185	59,14522	67,69446	98,82292
1	13,11558	18,47506	22,0986338	26,74905	30,26145	33,81312	46,14661
2	8,127357	10,82097	12,5675	14,74162	16,34222	17,92987	23,24938
3	6,163077	8,137838	9,41037849	10,98737	12,14399	13,28799	17,10099
6	3,907604	5,116508	5,89066851	6,845696	7,543473	8,231667	10,51328
12	2,287375	3,085411	3,60789312	4,262893	4,747969	5,231264	6,863996
24	1,512915	1,930178	2,19225882	2,51106	2,741251	2,966276	3,700187

Table G7: Log Normal Distribution Results for Gaziantep City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	58,48661	94,30353	121,053401	157,9884	187,6439	219,0453	337,9421
0,1666	44,04749	67,49686	84,3676113	107,0286	124,8096	143,3132	211,1191
0,25	35,78599	55,28593	69,3995632	88,44102	103,437	119,086	176,7316
0,5	24,32568	37,57817	47,1695393	60,10927	70,29957	80,93333	120,1027
1	14,99647	22,48528	27,7874856	34,82605	40,29472	45,94357	66,35689
2	9,390577	13,64731	16,5925385	20,43677	23,38166	26,39135	37,05275
3	6,930114	9,919379	11,9645038	14,61198	16,62615	18,67398	25,85804
6	4,080005	5,795423	6,96241782	8,466895	9,60752	10,76419	14,80222
12	2,339581	3,257673	3,87309624	4,657983	5,247692	5,841642	7,889054
24	1,624908	2,184808	2,55050675	3,008165	3,346602	3,683428	4,819031

Table G8: Log Normal Distribution Results for Kahramanmaraş City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	60,77364	90,17121	110,824802	138,0867	159,1677	180,8655	258,7505
0,1666	45,24774	64,97433	78,5026322	96,04606	109,4124	123,0171	170,8423
0,25	36,74642	53,55884	65,2163083	80,45606	92,14589	104,1048	146,5462
0,5	22,20111	32,49682	39,6581947	49,04183	56,25357	63,64205	89,93464
1	13,80982	20,02145	24,3116162	29,90402	34,18341	38,55339	54,00959
2	8,751872	11,9308	14,0284831	16,6733	18,64141	20,60939	27,30261
3	6,705572	9,147311	10,759347	12,79257	14,30604	15,81974	20,97012
6	4,234057	5,905914	7,02806357	8,460567	9,537707	10,62324	14,36937
12	2,709788	3,855885	4,63658757	5,64402	6,408419	7,184033	9,894815
24	1,893389	2,606731	3,08090936	3,681967	4,131248	4,582016	6,124737

Table G9: Log Normal Distribution Results for Kilis City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	69,58179	101,3372	123,343102	152,099	174,1486	196,6998	276,6919
0,1666	50,40491	73,985	90,4201976	111,9878	128,5843	145,6036	206,2758
0,25	42,15918	61,67121	75,2368026	93,00585	106,6582	120,6421	170,385
0,5	27,09207	40,26746	49,5359244	61,78152	71,25824	81,01804	116,0905
1	16,59513	24,96061	30,8972398	38,79142	44,9336	51,28495	74,28318
3	7,107025	9,820113	11,6284277	13,9251	15,64465	17,37202	23,29744
6	4,05663	5,50126	6,450837	7,644703	8,530999	9,415654	12,41445
12	2,304601	3,066495	3,56027418	4,174737	4,626978	5,075464	6,577556
24	1,478553	1,915875	2,19375805	2,534633	2,782509	3,026111	3,828434

Table G10: Log Normal Distribution Results for Mardin City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	57,713282	102,29678	137,975625	189,8317	233,283	280,8016	472,0901
0,1666	42,441542	73,646462	98,235845	133,5654	162,8869	194,7218	321,1195
0,25	35,045852	59,292703	78,0497452	104,6323	126,4441	149,922	241,6223
0,5	23,130639	40,525119	54,3281886	74,26375	90,88097	108,9818	181,2993
1	15,561344	25,53616	33,082369	43,60154	52,11481	61,18349	95,91226
2	9,7615644	15,539672	19,8148266	25,67707	30,35683	35,29057	53,81835
3	7,4422403	11,696458	14,8146144	19,06074	22,43078	25,9682	39,14322
6	4,7381138	7,304285	9,15870607	11,65771	13,62388	15,67417	23,21639
12	2,863752	4,5473629	5,79073901	7,493366	8,851004	10,28109	15,64278
24	1,9940682	3,1381817	3,97760003	5,121508	6,029955	6,983962	10,54022

Table G11: Log Normal Distribution Results for Osmaniye City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	111,3197	139,5916	157,1216	178,2577	193,3821	208,0901	255,5407
0,1666	79,33114	108,3348	127,4983	151,6951	169,6941	187,7147	249,0708
0,25	70,58415	97,13525	114,7789	137,1496	153,8487	170,6117	227,9657
0,5	47,42532	66,5333	79,41338	95,9153	108,3415	120,8975	164,3862
1	29,59752	43,80503	53,76833	66,90847	77,04614	87,47838	124,8653
3	15,43447	22,9495	28,23761	35,22937	40,63488	46,20625	66,23212
6	9,485265	13,61187	16,44052	20,1093	22,90048	25,7427	35,72996
24	3,455447	4,899013	5,879697	7,143331	8,099428	9,068989	12,44972

Table G12: Log Normal Distribution Results for Siirt City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	64,51261	97,68213	121,337046	152,9057	177,5423	203,0761	295,9291
0,1666	43,67256	63,39916	77,0368219	94,82662	108,4477	122,3633	171,6226
0,25	34,23442	48,44057	58,0773746	70,47508	79,858	89,36033	122,4524
0,5	21,74546	30,19745	35,8517826	43,05261	48,45622	53,89368	72,60526
1	13,37218	18,33333	21,6209218	25,77877	28,8808	31,98865	42,59683
2	8,615235	11,40571	13,2074275	15,44338	17,08527	18,71072	24,1374
3	6,504772	8,364231	9,53901743	10,97413	12,01408	13,03341	16,37443
6	4,185288	5,445746	6,24914604	7,236879	7,956491	8,664697	11,00335
12	2,603781	3,501644	4,08816916	4,822258	5,365163	5,905518	7,727538
24	1,8318	2,541606	3,01616016	3,620228	4,073354	4,529186	6,096956

Table G13: Log Normal Distribution Results for Şanlıurfa City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	53,11842	83,46589	105,705998	135,988	160,0199	185,2437	279,1768
0,1666	39,31099	61,02445	76,7958306	98,12932	114,967	132,5666	197,5983
0,25	31,99924	48,21801	59,7433338	75,08421	87,03029	99,39092	144,2012
0,5	22,30447	32,35696	39,3030427	48,36056	55,29347	62,37461	87,42982
1	14,69347	21,01688	25,3408716	30,93632	35,19193	39,51764	54,68612
2	9,285002	13,40682	16,2450896	19,93676	22,7565	25,63192	35,77574
3	6,906851	9,91897	11,9847989	14,66389	16,70518	18,78294	26,08743
6	4,270512	6,04946	7,25722715	8,811964	9,989233	11,18194	15,33857
12	2,545466	3,613225	4,33925184	5,274892	5,984031	6,702975	9,211789
24	1,660728	2,167568	2,49136775	2,890126	3,181049	3,467664	4,415979

APPENDIX H

LOG PEARSON TYPE III DISTRIBUTION RESULTS

(Results have been given based on equation 3.13.)

Table H1: Log Pearson Type III Distribution Results for Adana City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,1666	82,38736	101,7478	119,4987	140,2742	154,6264	168,0563	208,3891
0,25	60,48875	86,00769	102,589	123,1551	138,1594	152,8777	201,1621
0,5	40,79982	60,14399	73,96793	92,50113	107,0294	122,177	178,1384
1	26,44457	39,82823	49,89624	63,97974	75,44976	87,81516	136,5451
2	15,32861	23,39645	29,7451	38,95393	46,75169	55,38821	91,60625
3	11,28335	17,01691	21,38824	27,56993	32,66619	38,20575	60,46369
6	6,949437	10,08664	12,29359	15,21625	17,48372	19,82729	28,34607
12	4,199605	5,902504	7,043343	8,496383	9,586369	10,68022	14,44548
24	2,787594	3,825866	4,49683	5,328041	5,935822	6,53374	8,512786

Table H2: Log Pearson Type III Distribution Results for Adıyaman City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,1666	44,90737	69,27165	88,51923	116,5237	140,2801	166,6399	277,4887
0,25	37,39976	57,16298	72,16139	93,28237	110,5734	129,2933	203,6386
0,5	25,83227	38,29291	47,01523	58,4906	67,34044	76,40995	108,8938
1	15,4168	21,76062	26,11407	31,77133	36,09097	40,49832	56,13839
2	9,456813	12,82505	15,16704	18,25052	20,63468	23,10356	32,09742
3	7,056318	9,512639	11,19015	13,36813	15,02889	16,7311	22,80093
6	4,605377	6,250869	7,354094	8,764144	9,825735	10,89865	14,63571
12	2,973144	4,024665	4,684066	5,481908	6,052312	6,603616	8,365051

Table H3: Log Pearson Type III Distribution Results for Antakya (Hatay) City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,1666	71,00474	96,50047	112,6125	132,225	146,327	160,0181	204,1536
0,25	59,90656	81,56325	95,65722	113,2273	126,1645	138,9654	181,8627
0,5	43,71978	61,36819	73,83754	90,45422	103,4091	116,9238	166,7618
1	31,17895	46,45764	58,13387	74,68041	88,38009	103,304	163,6917
3	15,54191	24,3078	31,51744	42,44554	52,02944	62,98277	111,9867
6	9,406713	14,72844	19,21148	26,16991	32,39725	39,6402	73,30872
12	5,501353	8,342875	10,80501	14,72025	18,30798	22,55994	43,27337
24	3,396833	5,178107	6,819406	9,558428	12,19013	15,43121	32,66727

Table H4: Log Pearson Type III Distribution Results for Batman City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	58,25639	78,49613	94,91863	115,0284	129,4786	143,4317	187,7927
0,1666	39,79528	52,71311	63,07093	75,61818	84,5562	93,13286	120,105
0,25	33,1106	42,74977	50,91662	60,70537	67,61113	74,18363	94,54267
0,5	21,43956	28,64578	34,39513	41,3913	46,39408	51,20872	66,42965
2	7,106156	9,960813	11,83773	14,19221	15,93219	17,65764	23,45391
3	5,221203	7,242493	8,567988	10,22851	11,45517	12,67154	16,76049
6	3,297603	4,39602	5,106816	5,959168	6,563355	7,143124	8,970272
24	1,313852	1,823656	2,153353	2,56165	2,859779	3,152647	4,118292

Table H5: Log Pearson Type III Distribution Results for Cizre City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,25	41,15898	59,64373	71,94817	87,49525	99,03196	110,4989	149,1019
0,5	26,06068	38,67376	48,27447	61,8369	73,03312	85,20311	134,2216
3	7,223291	10,06937	12,05922	14,68876	16,72446	18,83472	26,52726
6	4,695897	6,528046	7,748444	9,296669	10,45456	11,61405	15,59048
12	2,906009	4,089419	4,921886	6,026994	6,885885	7,778759	11,05177
24	1,977334	2,814088	3,449813	4,351401	5,097929	5,912235	9,223022

Table H6: Log Pearson Type III Distribution Results for Diyarbakır City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,1666	56,68689	64,45394	77,03667	91,05225	100,2456	108,4934	130,6882
0,25	35,69476	52,55402	63,14529	75,32856	83,56287	91,13351	112,658
0,5	23,05704	32,61276	39,69095	48,51283	54,95652	61,26638	81,85967
1	13,05484	18,44674	22,16182	27,00578	30,71485	34,50981	48,04312
3	6,100418	8,108669	9,46731	11,21887	12,54637	13,90094	18,68895
6	3,893104	5,110215	5,904139	6,898256	7,633847	8,367245	10,85794
12	2,283737	3,084041	3,611778	4,277171	4,772507	5,26759	6,959121
24	1,524167	1,93386	2,180759	2,471568	2,675166	2,869029	3,472914

Table H7: Log Pearson Type III Distribution Results for Gaziantep City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	57,15757	93,51457	122,6499	165,4591	201,8327	242,3517	412,7776
0,1666	42,01152	66,1795	86,29559	117,1488	144,4646	175,9484	319,3086
0,25	34,23865	54,29238	70,92087	96,27514	118,634	144,2921	260,0524
0,5	23,20529	36,85008	48,25092	65,77977	81,33745	99,29897	181,3677
1	14,32449	22,05862	28,39859	38,00715	46,42222	56,04012	99,0756
2	9,097148	13,47699	16,86952	21,73924	25,82195	30,31245	48,88354
3	6,779943	9,837581	12,11005	15,26047	17,81563	20,55684	31,29716
6	4,000947	5,753217	7,0389	8,803438	10,22036	11,72967	17,55269
12	2,385979	3,268754	3,835312	4,523561	5,01681	5,494141	7,021423
24	1,687886	2,196447	2,470222	2,760021	2,943171	3,103642	3,521875

Table H8: Log Pearson Type III Distribution Results for Kahramanmaraş City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,1666	45,41604	65,04342	78,30605	95,29479	108,0905	120,9676	165,4907
0,25	39,35399	53,91902	63,05571	73,34031	80,18408	86,41181	103,8906
0,5	24,22819	32,5394	36,34269	39,76325	41,58327	42,95456	45,60984
1	15,04516	20,07757	22,35094	24,35151	25,39879	26,15053	27,49071
2	9,38084	11,94862	13,09635	14,12198	14,66818	15,08132	15,8946
3	7,14087	9,176751	10,13391	11,0283	11,52732	11,91905	12,75344
12	2,898536	3,87337	4,354825	4,820872	5,089403	5,305529	5,786286
24	2,170307	2,48037	2,538243	2,560152	2,565539	2,567013	2,567511

Table H9: Log Pearson Type III Distribution Results for Kilis City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	70,16954	101,5613	122,6154	149,3921	169,3958	189,3883	257,4746
0,1666	50,10051	73,83496	90,75465	113,3898	131,1016	149,5347	217,4108
0,25	41,30443	61,20339	76,10623	96,88717	113,7963	131,998	203,6561
0,5	26,25937	39,78187	50,37207	65,67682	78,59569	92,8687	152,432
1	16,11031	24,67706	31,39708	41,11945	49,32377	58,39115	96,20279
3	6,830119	9,654343	11,8427	15,01177	17,67702	20,62655	32,97859
6	3,978215	5,460592	6,520311	7,945528	9,072212	10,25656	14,7169
12	2,322739	3,072723	3,544305	4,105352	4,509092	4,899543	6,150873
24	1,617697	1,923126	2,163866	2,436488	2,620274	2,78963	3,286031

Table H10: Log Pearson Type III Distribution Results for Mardin City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	55,04866	100,4136	141,4548	208,1679	270,5024	345,1817	713,1505
0,1666	40,98595	72,67726	100,1381	143,1134	181,8264	226,9057	435,2738
0,25	33,62494	58,34678	79,80172	113,4679	143,9899	179,6681	346,6982
3	7,319169	11,62812	14,96114	19,72042	23,65622	27,95121	45,24649
6	4,753753	7,311547	9,138889	11,57721	13,47813	15,44146	22,56902
12	3,303021	4,576898	5,658842	7,011122	7,998517	8,962583	12,08622
24	2,252447	3,16267	3,837003	4,634259	5,187034	5,705037	7,243934

Table H11: Log Pearson Type III Distribution Results for Osmaniye City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,08333	114,4776	140,1187	153,4772	167,397	176,1059	183,6936	203,4043
0,25	72,54329	97,62511	112,3611	129,1605	140,5347	151,0654	181,7184
0,5	48,78811	66,88553	77,69024	90,14729	98,66055	106,597	129,9833
1	30,73608	44,08741	52,17967	61,55971	67,97891	73,95726	91,46094
12	5,978348	8,078079	9,438844	11,12945	12,3709	13,59919	17,68962
24	3,54033	4,923375	5,773401	6,77703	7,478012	8,142939	10,17019

Table H12: Log Pearson Type III Distribution Results for Siirt City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,0833	73,96132	98,2639	118,7713	143,7706	161,6552	178,8552	267,2093
0,1666	49,1425	63,79698	74,94668	87,8028	96,55607	104,6587	128,3497
0,25	38,17082	48,72396	56,60167	65,58098	71,63912	77,21119	93,32731
0,5	23,99651	30,36556	34,97134	40,16662	43,64188	46,81902	55,90647
1	14,24855	18,4357	21,03413	23,89721	25,77233	27,4604	32,12609
2	9,27187	11,46087	12,91369	14,50883	15,55248	16,49181	19,10193
3	7,035836	8,39967	9,362437	10,41557	11,10344	11,72196	13,44522
6	4,125324	5,416536	6,299816	7,448146	8,327891	9,231498	12,47695

Table H13: Log Pearson Type III Distribution Results for Şanlıurfa City.

	Return Periods						
Rainfall Duration	**2**	**5**	**10**	**25**	**50**	**100**	**1000**
0,1666	41,56654	61,32769	75,61983	93,76433	107,2295	120,581	165,1622
0,25	31,47985	47,93994	60,3205	77,6293	91,69079	106,833	166,2408
0,5	21,41323	31,81308	40,07848	52,27889	62,72295	74,43912	124,8758
1	14,24831	20,76196	25,74893	32,84328	38,7436	45,19319	71,53397
2	9,080504	13,29454	16,44619	20,83693	24,41277	28,26156	43,43792
3	6,688047	9,79218	12,18436	15,60839	18,47018	21,61184	34,55431
6	4,080016	5,929366	7,406431	9,599105	11,48581	13,6114	22,85915
12	2,404513	3,51683	4,439834	5,853137	7,105738	8,549398	15,16315
24	1,572613	2,106332	2,53788	3,182039	3,738997	4,368208	7,136041

APPENDIX I

KOLMOGOROV-SMIRNOV TEST RESULTS

Table I1: Kolmogorov-Smirnov Test Results for Adana City.

	Distribution Type							
	Gumbel		Normal		Log Normal		Log Pearson Type III	
Value Type / Duration	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$
0,08333	0,13434	0,16088	0,11811	0,16088	0,12634	0,16088	0,14363	0,16088
0,1666	0,06222	0,16088	0,10935	0,16088	0,08196	0,16088	0,06622	0,16088
0,25	0,08686	0,16088	0,10889	0,16088	0,07114	0,16088	0,07731	0,16088
0,5	0,07895	0,16088	0,14436	0,16088	0,06346	0,16088	0,06317	0,16088
1	0,10468	0,16088	0,17477	0,16088	0,07885	0,16088	0,06849	0,16088
2	0,11046	0,16088	0,15168	0,16088	0,08859	0,16088	0,06257	0,16088
3	0,09448	0,16088	0,15969	0,16088	0,07558	0,16088	0,07605	0,16088
6	0,09225	0,16088	0,15763	0,16088	0,07523	0,16088	0,07333	0,16088
12	0,05	0,16088	0,10367	0,16088	0,04435	0,16088	0,04363	0,16088
24	0,09314	0,16088	0,14756	0,16088	0,08432	0,16088	0,09069	0,16088

Table I2: Kolmogorov-Smirnov Test Results for Adıyaman City.

	Distribution Type							
	Gumbel		Normal		Log Normal		Log Pearson Type III	
Value Type / Duration	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$
0,08333	0,08766	0,20517	0,12061	0,20517	0,07969	0,20517	0,07757	0,20517
0,1666	0,12651	0,20517	0,16919	0,20517	0,07646	0,20517	0,0891	0,20517
0,25	0,11541	0,20517	0,15894	0,20517	0,07645	0,20517	0,08529	0,20517
0,5	0,10181	0,20517	0,14022	0,20517	0,07482	0,20517	0,07768	0,20517
1	0,11432	0,20517	0,1353	0,20517	0,10016	0,20517	0,10467	0,20517
2	0,10673	0,20517	0,17169	0,20517	0,09949	0,20517	0,09749	0,20517
3	0,07245	0,20517	0,1382	0,20517	0,07637	0,20517	0,06421	0,20517
6	0,08065	0,20517	0,1316	0,20517	0,07529	0,20517	0,07639	0,20517
12	0,08958	0,20517	0,16012	0,20517	0,0888	0,20517	0,10146	0,20517
24	0,0646	0,20517	0,12014	0,20517	0,11074	0,20517	0,15239	0,20517

Table I3: Kolmogorov-Smirnov Test Results for Hatay (Antakya) City.

	Distribution Type							
	Gumbel		Normal		Log Normal		Log Pearson Type III	
Value Type / Duration	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$
0,08333	0,06572	0,18311	0,08609	0,18311	0,07447	0,18311	0,06448	0,18311
0,1666	0,05885	0,18311	0,109	0,18311	0,06231	0,18311	0,05434	0,18311
0,25	0,07279	0,18311	0,08281	0,18311	0,07274	0,18311	0,06855	0,18311
0,5	0,06777	0,18311	0,1364	0,18311	0,06045	0,18311	0,05182	0,18311
1	0,10677	0,18311	0,16647	0,18311	0,09416	0,18311	0,07093	0,18311
2	0,10828	0,18311	0,1767	0,18311	0,08813	0,18311	0,06416	0,18311
3	0,16471	0,18311	0,22419	0,18311	0,14637	0,18311	0,11087	0,18311
6	0,147	0,18311	0,20913	0,18311	0,12835	0,18311	0,08519	0,18311
12	0,16001	0,18311	0,20004	0,18311	0,12994	0,18311	0,08217	0,18311
24	0,19839	0,18311	0,21689	0,18311	0,14296	0,18311	0,07656	0,18311

Table I4: Kolmogorov-Smirnov Test Results for Batman City.

	Distribution Type							
	Gumbel		Normal		Log Normal		Log Pearson Type III	
Value Type / Duration	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$
0,08333	0,12186	0,22425	0,12639	0,22425	0,09474	0,22425	0,10141	0,22425
0,1666	0,10192	0,22425	0,1297	0,22425	0,10569	0,22425	0,08758	0,22425
0,25	0,13055	0,22425	0,12634	0,22425	0,1273	0,22425	0,11173	0,22425
0,5	0,06808	0,22425	0,1262	0,22425	0,08154	0,22425	0,06743	0,22425
1	0,10598	0,22425	0,10276	0,22425	0,09113	0,22425	0,08767	0,22425
2	0,09488	0,22425	0,14755	0,22425	0,08087	0,22425	0,08619	0,22425
3	0,08428	0,22425	0,14387	0,22425	0,07562	0,22425	0,08	0,22425
6	0,08183	0,22425	0,0959	0,22425	0,07314	0,22425	0,07096	0,22425
12	0,13739	0,22425	0,19281	0,22425	0,12952	0,22425	0,12363	0,22425
24	0,06327	0,22425	0,1139	0,22425	0,06017	0,22425	0,06761	0,22425

Table I5: Kolmogorov-Smirnov Test Results for Cizre City.

	Distribution Type							
	Gumbel		Normal		Log Normal		Log Pearson Type III	
Value Type / Duration	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$
0,08333	0,11047	0,2417	0,11181	0,2417	0,1126	0,2417	0,08948	0,2417
0,1666	0,09111	0,2417	0,14767	0,2417	0,10752	0,2417	0,0914	0,2417
0,25	0,08699	0,2417	0,13898	0,2417	0,08518	0,2417	0,08704	0,2417
0,5	0,08498	0,2417	0,15329	0,2417	0,08123	0,2417	0,06458	0,2417
1	0,10769	0,2417	0,14965	0,2417	0,10297	0,2417	0,09408	0,2417
2	0,08906	0,2417	0,1581	0,2417	0,1043	0,2417	0,08583	0,2417
3	0,08816	0,2417	0,1574	0,2417	0,08255	0,2417	0,0721	0,2417
6	0,12842	0,2417	0,17818	0,2417	0,11838	0,2417	0,11824	0,2417
12	0,07361	0,2417	0,14086	0,2417	0,07182	0,2417	0,06575	0,2417
24	0,14914	0,2417	0,21724	0,2417	0,13135	0,2417	0,10983	0,2417

Table I6: Kolmogorov-Smirnov Test Results for Diyarbakır City.

Distribution Type								
	Gumbel		Normal		Log Normal		Log Pearson Type III	
Value Type / Duration	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$
0,08333	0,10653	0,18482	0,11178	0,18482	0,0855	0,18482	0,08173	0,18482
0,1666	0,09131	0,18482	0,10739	0,18482	0,09307	0,18482	0,06766	0,18482
0,25	0,09863	0,18482	0,09093	0,18482	0,08753	0,18482	0,07134	0,18482
0,5	0,07536	0,18482	0,08324	0,18482	0,07348	0,18482	0,06198	0,18482
1	0,05922	0,18482	0,10554	0,18482	0,06702	0,18482	0,07131	0,18482
2	0,08526	0,18482	0,10881	0,18482	0,0826	0,18482	0,08388	0,18482
3	0,06331	0,18482	0,10651	0,18482	0,06243	0,18482	0,07032	0,18482
6	0,0699	0,18482	0,09593	0,18482	0,06183	0,18482	0,05924	0,18482
12	0,05755	0,18482	0,11886	0,18482	0,05456	0,18482	0,05207	0,18482
24	0,0868	0,18482	0,08776	0,18482	0,07699	0,18482	0,0786	0,18482

Table I7: Kolmogorov-Smirnov Test Results for Gaziantep City.

Distribution Type								
	Gumbel		Normal		Log Normal		Log Pearson Type III	
Value Type / Duration	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$
0,08333	0,09709	0,19837	0,13611	0,19837	0,09526	0,19837	0,08998	0,19837
0,1666	0,12145	0,19837	0,1735	0,19837	0,08924	0,19837	0,07631	0,19837
0,25	0,1324	0,19837	0,16885	0,19837	0,10902	0,19837	0,08098	0,19837
0,5	0,128	0,19837	0,1532	0,19837	0,14401	0,19837	0,12509	0,19837
1	0,16293	0,19837	0,2147	0,19837	0,15388	0,19837	0,12059	0,19837
2	0,10975	0,19837	0,18033	0,19837	0,09431	0,19837	0,06698	0,19837
3	0,09889	0,19837	0,16426	0,19837	0,086	0,19837	0,0655	0,19837
6	0,08258	0,19837	0,12795	0,19837	0,08514	0,19837	0,06802	0,19837
12	0,07322	0,19837	0,10864	0,19837	0,08161	0,19837	0,06889	0,19837
24	0,09715	0,19837	0,09209	0,19837	0,10775	0,19837	0,07022	0,19837

Table I8: Kolmogorov-Smirnov Test Results for Kahramanmaraş City.

Distribution Type								
	Gumbel		Normal		Log Normal		Log Pearson Type III	
Value Type / Duration	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$
0,08333	0,10717	0,23788	0,13538	0,23788	0,12727	0,23788	0,12762	0,23788
0,1666	0,09413	0,23788	0,13013	0,23788	0,08582	0,23788	0,08856	0,23788
0,25	0,11801	0,23788	0,13684	0,23788	0,13948	0,23788	0,123	0,23788
0,5	0,11268	0,23788	0,12046	0,23788	0,14636	0,23788	0,1219	0,23788
1	0,12497	0,23788	0,08338	0,23788	0,13885	0,23788	0,11359	0,23788
2	0,09425	0,23788	0,0934	0,23788	0,08949	0,23788	0,10941	0,23788
3	0,14415	0,23788	0,19279	0,23788	0,15654	0,23788	0,18861	0,23788
6	0,11151	0,23788	0,18174	0,23788	0,10773	0,23788	0,13875	0,23788
12	0,17409	0,23788	0,11414	0,23788	0,18254	0,23788	0,1169	0,23788
24	0,15169	0,23788	0,10791	0,23788	0,19571	0,23788	0,18727	0,23788

Table I9: Kolmogorov-Smirnov Test Results for Kilis City.

	Distribution Type							
	Gumbel		Normal		Log Normal		Log Pearson Type III	
Value Type / Duration	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$
0,08333	0,11661	0,21012	0,13592	0,21012	0,10019	0,21012	0,10274	0,21012
0,1666	0,08998	0,21012	0,10643	0,21012	0,08639	0,21012	0,08606	0,21012
0,25	0,08246	0,21012	0,12216	0,21012	0,09315	0,21012	0,08392	0,21012
0,5	0,09754	0,21012	0,15418	0,21012	0,09305	0,21012	0,07804	0,21012
1	0,09453	0,21012	0,1475	0,21012	0,06386	0,21012	0,06216	0,21012
2	0,13232	0,21012	0,19849	0,21012	0,12691	0,21012	0,08036	0,21012
3	0,12567	0,21012	0,14122	0,21012	0,11956	0,21012	0,09373	0,21012
6	0,10028	0,21012	0,12749	0,21012	0,10866	0,21012	0,09307	0,21012
12	0,10877	0,21012	0,15588	0,21012	0,011118	0,21012	0,10439	0,21012
24	0,11381	0,21012	0,08662	0,21012	0,09609	0,21012	0,07656	0,21012

Table I10: Kolmogorov-Smirnov Test Results for Mardin City.

	Distribution Type							
	Gumbel		Normal		Log Normal		Log Pearson Type III	
Value Type / Duration	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$
0,08333	0,17518	0,24993	0,21222	0,24993	0,11701	0,24993	0,092	0,24993
0,1666	0,14845	0,24993	0,16798	0,24993	0,11264	0,24993	0,10328	0,24993
0,25	0,1668	0,24993	0,18289	0,24993	0,12403	0,24993	0,13054	0,24993
0,5	0,17919	0,24993	0,20753	0,24993	0,14847	0,24993	0,12701	0,24993
1	0,16925	0,24993	0,18766	0,24993	0,11161	0,24993	0,11634	0,24993
2	0,12788	0,24993	0,17824	0,24993	0,11562	0,24993	0,089	0,24993
3	0,14564	0,24993	0,17474	0,24993	0,14604	0,24993	0,13416	0,24993
6	0,12369	0,24993	0,17489	0,24993	0,09993	0,24993	0,10126	0,24993
12	0,07729	0,24993	0,14167	0,24993	0,06341	0,24993	0,06604	0,24993
24	0,138	0,24993	0,19618	0,24993	0,12233	0,24993	0,14286	0,24993

Table I11: Kolmogorov-Smirnov Test Results for Osmaniye City.

	Distribution Type							
	Gumbel		Normal		Log Normal		Log Pearson Type III	
Value Type / Duration	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$	D_N	$D_{N(critical)}$
0,08333	0,11483	0,3376	0,10859	0,3376	0,10329	0,3376	0,10995	0,3376
0,1666	0,17881	0,3376	0,17956	0,3376	0,18255	0,3376	0,16927	0,3376
0,25	0,15933	0,3376	0,1257	0,3376	0,16382	0,3376	0,13498	0,3376
0,5	0,15937	0,3376	0,13276	0,3376	0,15184	0,3376	0,12603	0,3376
1	0,15356	0,3376	0,14682	0,3376	0,17797	0,3376	0,1484	0,3376
2	0,11579	0,3376	0,09989	0,3376	0,16268	0,3376	0,12675	0,3376
3	0,13425	0,3376	0,12209	0,3376	0,13607	0,3376	0,1096	0,3376
6	0,12709	0,3376	0,13447	0,3376	0,13311	0,3376	0,10949	0,3376
12	0,11428	0,3376	0,18442	0,3376	0,11678	0,3376	0,12353	0,3376
24	0,10936	0,3376	0,14769	0,3376	0,11421	0,3376	0,11287	0,3376

Table I12: Kolmogorov-Smirnov Test Results for Siirt City.

Distribution Type								
	Gumbel		**Normal**		**Log Normal**		**Log Pearson Type III**	
Value Type / Duration	**D_N**	**$D_{N(critical)}$**	**D_N**	**$D_{N(critical)}$**	**D_N**	**$D_{N(critical)}$**	**D_N**	**$D_{N(critical)}$**
0,08333	0,06269	0,19221	0,12782	0,19221	0,08674	0,19221	0,06517	0,19221
0,1666	0,11251	0,19221	0,10979	0,19221	0,1252	0,19221	0,09386	0,19221
0,25	0,10493	0,19221	0,09681	0,19221	0,12182	0,19221	0,09234	0,19221
0,5	0,07317	0,19221	0,08177	0,19221	0,09284	0,19221	0,06971	0,19221
1	0,10096	0,19221	0,10286	0,19221	0,12523	0,19221	0,09998	0,19221
2	0,11204	0,19221	0,12107	0,19221	0,09373	0,19221	0,09443	0,19221
3	0,09498	0,19221	0,13356	0,19221	0,08622	0,19221	0,10886	0,19221
6	0,10115	0,19221	0,1688	0,19221	0,11029	0,19221	0,09191	0,19221
12	0,1165	0,19221	0,18603	0,19221	0,1147	0,19221	0,08245	0,19221
24	0,13076	0,19221	0,18806	0,19221	0,09844	0,19221	0,10064	0,19221

Table I13: Kolmogorov-Smirnov Test Results for Şanlıurfa City.

Distribution Type								
	Gumbel		**Normal**		**Log Normal**		**Log Pearson Type III**	
Value Type / Duration	**D_N**	**$D_{N(critical)}$**	**D_N**	**$D_{N(critical)}$**	**D_N**	**$D_{N(critical)}$**	**D_N**	**$D_{N(critical)}$**
0,08333	0,0849	0,21012	0,1439	0,21012	0,09922	0,21012	0,0894	0,21012
0,1666	0,07457	0,21012	0,14098	0,21012	0,09224	0,21012	0,0803	0,21012
0,25	0,07546	0,21012	0,13594	0,21012	0,08571	0,21012	0,0837	0,21012
0,5	0,10636	0,21012	0,15228	0,21012	0,08444	0,21012	0,09963	0,21012
1	0,10646	0,21012	0,16757	0,21012	0,10077	0,21012	0,07698	0,21012
2	0,1	0,21012	0,15954	0,21012	0,08914	0,21012	0,0683	0,21012
3	0,10866	0,21012	0,16944	0,21012	0,09889	0,21012	0,06847	0,21012
6	0,13193	0,21012	0,19906	0,21012	0,12264	0,21012	0,07872	0,21012
12	0,15027	0,21012	0,21479	0,21012	0,14511	0,21012	0,10502	0,21012
24	0,11079	0,21012	0,17992	0,21012	0,11147	0,21012	0,09498	0,21012