FLOOD FREQUENCY ANALYSIS OF ADYAR RIVER USING GUMBEL METHOD AND ARTIFICIAL NEURAL NETWORK

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BY

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CANDIDATE'S DECLARATION

I S. PRAGADEESWARI, Roll No. **2K19/HFE/21** of **M.Tech (HWRE),** hereby declare that the Project Dissertation titled, "Flood Frequency Analysis of Adyar River using Gumbel Method and Artificial Neural Network" which is submitted by me to the Hydraulics and Water Resource Engineering ,Department of Civil Engineering Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the Degree of Master of Technological, is original and not copied from any source without proper citation.

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Date: 16-08-2021

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Place: Delhi

Date: 16-08-2021

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ABSTRACT

Floods are the most affected natural disaster which may leads to damages in movable and immovable properties. Floods are caused due to the extreme rainfall such that which develops within short period of time. The major factors causing floods are events such as deforestation, uncontrolled urbanization and global warming. The major flood event that occurred in December 2015 during northeast monsoon season in Adyar river basin has driven attention from the public nationwide due to many peoples lost their life and properties. The flood is very dangerous occurrence which depends on several factors such as rainfall conditions, catchment characteristics such as its size, shape and land use. Flood frequency analysis plays major role in effective design of hydraulic structures such as roads, flood control structures, culvert, bridges, railways, spillways, urban drainage systems and waterways. The objective is to assess the flood frequency curve by Gumbel method and the Artificial Neural Networks (ANN)is a soft computing technique which is used to analyze the frequency of flood. To analyze the frequency of flood the various return periods were used to obtained the frequency curve using Gumbel method and ANN model was used for further accuracy in occurrence of flood. The flood frequency curve was constructed by plotting a graph of discharge vs recurrence interval. The results of analysis shows that the selected ANN models are more accurate and appropriate than Gumbel method. This study shows that ANN models can be effective tools for flood frequency analysis for water resource planners, managers and analyzers to take safety measures and save the nation.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

ANN	-	Artificial Neural Network
RMSE	-	Root Mean Square Error
ARX	-	Autoregressive with Exogenous variables
GEV	-	Generalized Extreme Value distribution
LP3	-	Log Pearson Type III distribution
LN3	-	Log Normal distribution
NIDM	-	National Institute of Disaster Management
IWS	-	Institute for Water Studies
DMS	-	Directorate of Medical and Rural Health Services
MAE	-	Mean Absolute Error
MAR	-	Missing at Random
RFFA	-	Regional Flood Frequency Analysis
WHO	-	World Health Organisation
ANFIS	-	Adaptive Neuro Fuzzy Interference System
GA	-	Genetic Algorithm
GMDH	-	Group Method of Data Handling
GP	-	Genetic Programming
GEP	-	Gene Expression Programming
MAR	-	Mean Annual Rainfall
SF	-	Shape Factor

CHAPTER-1

INTRODUCTION

CHAPTER-1

INTRODUCTION

1.1 GENERAL

In earth, the water is essential phenomena to survival of life. With the development in food production and technology, water has also become mandatory for industrial and power production. More than 85% of the water is used for agricultural purposes. Water being natural resources, its primary source on Earth is rain. Two extremes water which occur due to consequent high rainfall or scarce rainfall are flood and drought. The severity of flood is more pronounced recently, due to the drastic increase in global warming. In India, flood is the major disasters phenomenon and about 12 percent of total land area is prone to flood. The damages occur to crops, infrastructure, lives and property due to overflow in river banks.

1.2 FLOOD

Flood is disastrous event which cause damage to buildings and loss of lives by submergence of land due to overflow of water. Floods are widespread event that occurs frequently in parts of the world. The major causes of flood were due to heavy rainfall, melting snow and ice, ocean waves coming on shore and dams breaking. Due to rapid urbanization in cities also contributes to causes of flood.

The residents live in areas of less awareness of flooding and lack of warning system are at the risk of flooding. The flood can cause severe damage to common public health facilities as well as loss of personal belongings of people and their lives. The most frequent and deadliest flood occurs due to intrinsic threshold and extrinsic threshold which happens due to geomorphic equilibrium in the river system.

Flood event occurs frequently in Adyar river basin, Chennai, Tamil Nadu. Due to heavy rainfall, encroachment of water bodies and excess release of water from Chemparambakkam lake are the primary causes of flood. The past events of flood which occurs in Adyar river are 1976, 1985, 1996, 2005, 2008 and 2015. Many people were killed and several people was affected due to Chennai flood in 2015.

1.3 TYPES OF FLOODS

World Health Organization (WHO), broadly classified flood in to the following types:

i. Flash Flood
ii. River flood
iii. Coastal Flood

1.3.1 Flash flood

Flash floods occurs in low-lying areas especially with heavy rainfall along with snow flowing, cyclone and hurricane. Such that it increases the height of water and causes severe damages to both natural as well as man-made hydraulic structures.

Figure 1.1 Flash Flood

Due to collapse of dam, natural ice as well as debris dam, it causes impacts in urban areas such as damages in buildings, human lives, infrastructure, livestock and vegetation.

1.3.2 River flood

Due to exceedance ability of river which occurs because of continuous rain and melting of snow, results in river flood. It is also known as fluvial flood. Flooding makes the soil to spread nutrients for the growth of living organisms.

Figure 1.2 River Flood

River floods have also been productive forces and also plays significant role for development in human wellbeing as such in fertility of soil and the process of cultivation.

1.3.3 Coastal flood

Coastal floods usually result from cyclones causing flood and wave damage. These floods are caused may be due to tidal floods, cyclonic storm and Tsunami. Due to human interpretation in coastal areas can lead to flooding of coastal naturally. The process of taking excess of groundwater which may lead to chances of coastal flooding.

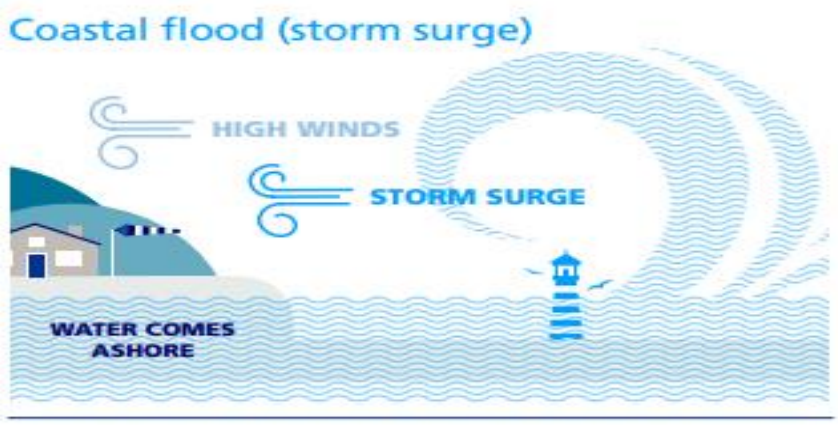

Figure 1.3 Coastal Flood

The flood risk occurs along the coast in hydraulic protective structures in case of sea wall and also causes erosion along the boundary of coast. The continuous increase in sea level as well as changes in the pattern of weather will results in the risk of rise in flooding along the coast.

1.4 IMPACTS OF FLOOD

During floods majority of death occurs due to immersion in water. The flood events are continuously occurred for several reasons. The countries which are under the low-income and middle-income faces a rapid risk of immersion due to absence of required warning systems and protection of people from floods. In addition to causes of flooding, it also associated with several health issues like heart attacks and physical trauma. There may be medium as well as long term impacts on health due to floods.

These impacts may include the following:

- Water-borne diseases like malaria, cholera and typhoid.
- Effect to basic necessities such as shelter, food and water supplies.
- There is no proper access for primary health care centres.
- It causes punctures or wound on the occurrence of cleaning of disaster process as well as evacuations.
- The effects of hazards in the chemical and severe damage to mental wellbeing.

1.5 FLOOD FREQUENCY ANALYSIS

The peak flow records of flood frequency analysis were able to predict the expected future flood. The magnitude of peak flows and return period of flood are determined by flood frequency analysis. The earlier find out of flood lead to minimize the damage to life of people as well as properties. There are several methods of flood frequency analysis which are very useful for future prediction of floods.

On the basics of forecast or current conditions of information related with harmful floods are provided by flood frequency analysis. It involves in the updating of past flood events in terms of use for detection of future flood events. The timely distribution of floods may be varied from specific periods.

The data needed for flood frequency analysis should satisfy the conditions such as independent and homogeneous. The event of flood cannot occur over the time intervals. While considering the case of independent it should not influence with one another and in the case of homogeneous with the events of flood may happen in same conditions during rainfall.

1.6 APPLICATIONS OF FLOOD FREQUENCY ANALYSIS

The flood flow frequency analysis results can be used for various engineering applications, which include the following:

1. Economic purpose of yielding a systematic guard to the hydraulic structures is not feasible, when the design experiences an ultimate flood in the catchment. Hence, the frequency analysis helps for architectural plan such as reservoir, bridges as well as canals, as deterioration of design directs to massive destruction of life and enormous devastation to property located on the downstream of the construction.
2. Agricultural projects require the knowledge of flood magnitude and the frequency of its occurrence, whereas the assessment of flood frequency

analysis is essential to mitigate and manage the hazards caused by a disaster.

3. Flood regulating mechanisms are essential and hence the regulation of monetary value of the strategies related to flood control becomes compulsory. For the purpose of defining the regions that are subjected to get affected, when the river water over flows and also to ascertain the intrusions on the flood plains.

1.7 NEED FOR STUDY

Chennai is a cosmopolitan city, located on eastern coast of India in Tamil Nadu. This study is consistently facing the problem of floods during monsoon every year. The study concentrates on flood frequency analysis using soft computing tools in Adyar sub-basin using Gumbel distribution and ANN is a technique which is used to analysis the flood frequency of Adyar river to predict flow values. The analysis of flood frequency plays an important role to estimate recurrence of floods and designing of hydraulic structures. It can also be helps to local administrators and water resources planners to take precautionary measures well in advance.

1.8 OBJECTIVES OF THE STUDY

The objectives of the study are in the following:

- To assess the flood frequency curve by Gumbel method.
- To analyze frequency of flood using soft computing technique such as Artificial Neural Network.

1.9 ORGANISATION OF THESIS

The report is divided into six chapters which are presented sequentially.

In Chapter 1, it includes the various aspects of the study with introduction of flood. The need for the study and the objectives is elaborated.

In Chapter 2, includes literature review on Gumbel distribution method and ANN model.

In Chapter 3, the details of study area have discussed. The appropriate data has been collected and presented for analysis.

In Chapter 4, the methodology of the study along with the explanation of Gumbel method and ANN analysis is presented.

In Chapter 5, shows the results obtained from Gumbel method and ANN analysis.

In Chapter 6, which comprises the Conclusions drawn from the study and describes about the Future Scope of Study.

CHAPTER-2

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

2.1 GENERAL

To obtain the objectives of the study, literature grouped under the following sub-headings were reviewed to understand the state-of-the-art of the chosen problem. The literatures reviewed in this chapter are related to Gumbel method and ANN model for flood frequency analysis.

2.2 FLOOD

Nandy (2005) states that people living in areas of flood plain facing problems due to devastating floods causes fear and insecurity among them. It also leads to loss of their cattle's, human lives and will results in heavy damage to public as well as private property. Due to sudden happenings of unexpected events like floods, leads to not having access to basic necessity like medicines, floods and loss to place of residence.

J.Parker et al., (2007) suggested that growth of population causes flooding risk along with changes in the climatic condition such as with severe weather on account of tropical cyclones and record breaking rainfall. Due to pattern of catchment changes with urbanization, makes the rate of flood disaster grows faster instantly.

NIDM (2015) describes on account of huge amount of rainfall with more water not having sufficient places to withhold water in river banks, lead to flood. All parts of India not receive same amount of rainfall it may varies from place to place and time to time because of bursting of clouds as well as pouring of down. Usually, India receives rainfall in the month of June, July, August and September. As a result, some gets more rainfall and other gets low rainfall. Due to improper maintenance of drainage facility in urban areas causes flood in such places like Chennai, Kolkata, Delhi, Mumbai and some other metro city.

J.Saravanan .,(2015) conducted such that it discussed about several urban flood protection measures like Thames Barrier from United Kingdom ,Retarding Basin from Australia, SMART Tunnel from Malaysia. Concluded that with the improvement in technology various civil engineering problems should be solved with latest possible guidelines to attain sustainable urban development.

Prakash Tripathi (2015) concluded, that several thousands of people were tied because of flood in India for last several years. But its frequent occurrence has made people in troubles on account of several aspects. The various precautionary measures have taken by Government of India by using advanced features like of telecommunication along with science and technology. The method of alarming with media as the earlier measure for flood reduction. By changing the people to a safest place, creating awareness and campaigning to them for protection from flood. The flood trend should be analysed in advance in order to safe from the disaster event naturally.

2.3 FLOOD FREQUENCY ANALYSIS

Geoff Pegram et al., (2004) described based on the specified geomorphological information for observed areas of flood, the model with annual peak flood over a particular water shed area. The fitting of model for discrimination of large recurrence interval for prediction of maximum flood.

R.Kidson et al .,(2005) stated that the power low models are widely used the estimation of floods with respective return period. These models with self – similarity was difficult for gauged records for analysis of flood frequency. For testing different models with specific time scales for wide range of river with extreme behaviour of flood detection.

Vikas Kamal., (2016) in this work to analyze flood frequency in river ganga they applied statistical distributions such as Log Pearson III, Gumbel distribution, Lognormal distribution and Generalized Extreme Value distribution on discharge data

at two different stations. They have predicted the return period with discharge along with normal distribution for Haridwar and Gumbel EV1 for Garhmukteshwar. They have also done reliability test with easy fit software.

Kalpalatha Ganamala et al., (2017) in their study proposed that for prediction of future flood, in the surrounding areas of Vijayawada, applied by Gumbel's method. This method is very suitable for flood detection. The discharge of flood in the upcoming years are estimated for 20 years is 1823.33 TMC and for 50 years is 1873.34 TMC.

Rabin Selvaraj et al., (2018) conducted frequency of flood in Gelana with the model devolvement and its comparison. The performance of the model for watershed which was used for calibration and validation are done. The Nash Sutcliffe coefficient value R2 value are comparatively same for both calibration as well as validation of the model performance with good correlation among the observed and simulated flows.

TejasKeluskar., (2019) they have performed flood flow in Periyar river basin for frequency analysis with the several distributions like Log Normal, the normal, Gumbel extreme value Type I and Log Pearson Type III. Such that the best performing was Log Pearson type III among others methods can be used for modelling maximum monthly flood magnitude.

Samara kousar et al., (2020), the report suggested that for annual maximum peak flow data for analysis of flood frequency at Ume River in Sweden. For detection of different parameters of distribution such as maximum likelihood and L-moment methods. The most suitable methods for peak flow identification are as log-normal, gumbel distribution and generalised logistic. In this study L – moment estimation method preferred well with best fitted log-normal distribution for the selected gauging sites.

Esmaeel Dodangeh., (2020), conducted study for distribution of flood along various return period by mapping the univariate flow peak quantile from bivariate form. The probability of occurrence can be determined for peak flood flows with identical

magnitude. The gamma margins and gaussian copula with Weisbull fits good in this study for interconnected rivers.

2.4 ARTIFICIAL NEURAL NETWORK

Ian Flood., (1994) suggested that various applications of neural networks within civil engineering and main issues regarding its usage. Such as in case of factor affects ability to learn, selection of appropriate data for training process and network validation. Basically, primary concepts of neural networks and how to tackle issues with civil engineering problems are also discussed briefly. To develop a model with the application of civil engineering.

A. Bonafe et al., (1994) worked with Neural networks for finding flood forecasting on daily basics with the available datas such as mean discharge, precipitation of 26 rain gauges and mean temperature from 13 stations. While comparing this ANN model with other models of persistence and rainfall-runoff model. Finally, ANN model performed better with less value of Root Mean Squared Error (RMSE).

Gokmen Tayur., (2007) in this study to predict hourly discharge in upper Tiber River at 4,8 and 12 hours ahead. By using records of 6 events trained with feedforward network along backpropagation. The model performed good in time of 8 hrs at sites receiving lateral inflow significantly.

C. Shu et al., (2007) described the procedure for evaluation at ungauged sites in canonical analysis of correction. For detection of accuracy CCA based ANN model performs well than original ANN model. Such that better ability of the model performance with ANN ensemble than single model of ANN.

Kashif Aziz et al., (2014) performed case study in Australia for Neural Network application for regional flood frequency analysis on account of testing models with two

variables of predictor will provide desired results for flood analysis with ANN based RFFA model. It also added that with a greater number of datasets are required for the purpose of training and testing of ANN to avail better results.

Abhijit Paul., (2014) conducted with the data of water level available at present along with rainfall data on the particular river for prediction of flood with usage of ANN. They have used feedforward and backpropagation algorithm such that occurs in Multilinear Perceptron (MLP) architecture. It concludes with 24 hrs ahead of time the prediction of flood was identified.

Javed Alam., (2015) conducted analytical modelling of river Tapi with Gene Expression Programming for analysis of flood frequency using different flood prediction models such as Artificial Neural Network (ANN), Gene Expression Programming (GEP) and Gumbel's method. They also performed qualitative assessment of flood prediction of models and found that GEP is performing good rather than other two methods.

Yaser Tashmasebi Biragani., (2016) in this study proposed that multi-model data fusion technique was conducted on karun river for estimation of discharge with ANN for flood forecasting. They have used Multilinear Perceptron ANN Architecture (MLP). Finally results showed that models were performed with greater accuracy only with less input variables when compared with more input variables.

Mohd Danish., (2017) they compared flood frequency of ganga river with the performance of several techniques such as ANN, Group Method of Data Handling (GMDH), Gumbel's method and Gene Expression Programming (GEP). The methods which were performed for soft computing approach with the use of Gene Expression Programming and Group Method of Data Handling yield better results for analysis of flood.

Sasan Kordrostami et al., (2020), conducted performance of model with regional flood frequency analysis by using Artificial Neural Network. Such that several variables are adopted for testing. They have found that models provide good results only with

selected specific variables in prediction of flood along ungauged catchment with less amount of predictor variables. Predicted models with all eight predictor variables entire performance was good but while considered its results only with three predictor variables results are similar to all eight variables. Finally, the use of less variables in predictor provides better results for regional flood frequency model with ANN.

2.5 SUMMARY

From the literatures, a detailed study on flood concepts has been carried out. Various types of floods, frequency analysis using Gumbel method have been studied. ANN model was used for flood frequency analysis.

CHAPTER-3
STUDY AREA
AND
DATA COLLECTION

CHAPTER-3

STUDY AREA AND DATA COLLECTION

3.1 GENERAL

Adyar river origin from Malaipattu tank, Manimangalam village, Sriperumbudur taluk in South Chennai. The water released from Chembarambakkam lake reaches into Adyar river at Thiruneermalai and finally it reached into Bay of Bengal. The index map of Adyar river basin is shown in figure 3.1

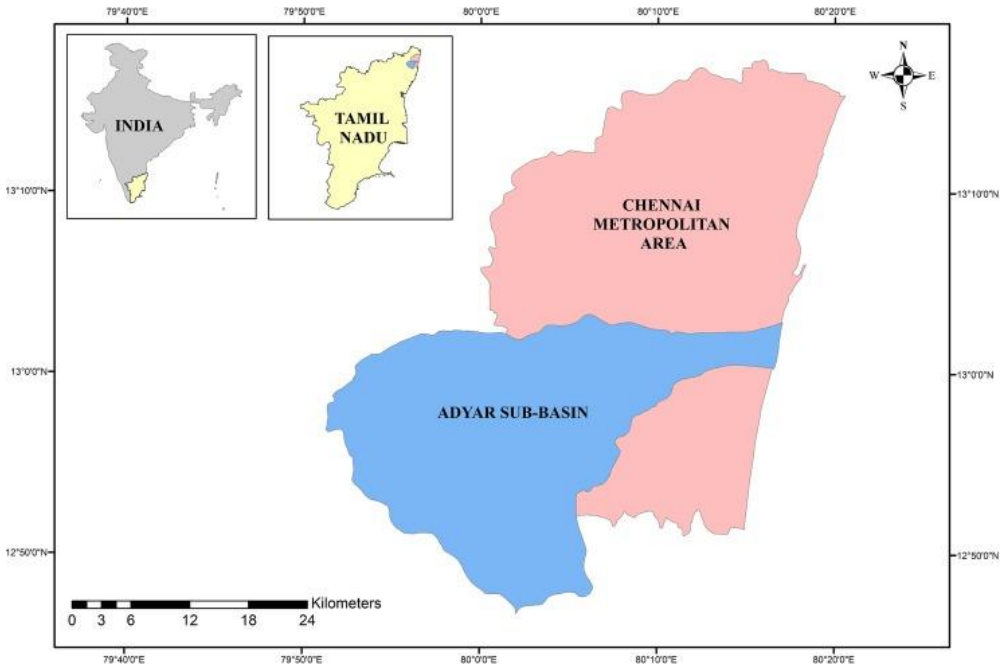

Figure 3.1 Index Map of Study Area

The annual average rainfall observed in Adyar river basin is 1472 mm. The water level increases in the Adyar river due to unexcepted rainfall. So that the flood may causes in Adyar river and its surrounding areas. During 1976, 1985, 1996, 2005, 2008 and 2015 these are major flood incidents occurred in Adyar river and causes lot of damages. The rain gauge stations are listed in table 3.1.

Table 3.1 Rain gauge Stations in Adyar Sub-basin

S.No	Rain Gauge Stations	Districts
1	Chengalpattu	Chengalpattu
2	Chembarambakkam	Kancheepuram
3	Korattur Anicut	Kancheepuram
4	Meenambakkam	Kancheepuram
5	Mylapore	Chennai
6	Nungabakkam	Chennai
7	Sriperumbudur	Kancheepuram
8	Poonamalle	Tiruvallur
9	Tambaram	Kancheepuram
10	Tiruvallur	Tiruvallur

3.2 GEOLOGY

Adyar river was completely filled with Gondwana as well as tertiary rocks along with alluvium soil. In east of Adyar river was associated with slope and smooth terrain. Further parts were affected due to imbalance in the environment and human interaction. The Geology map of basin is shown in Figure 3.2.

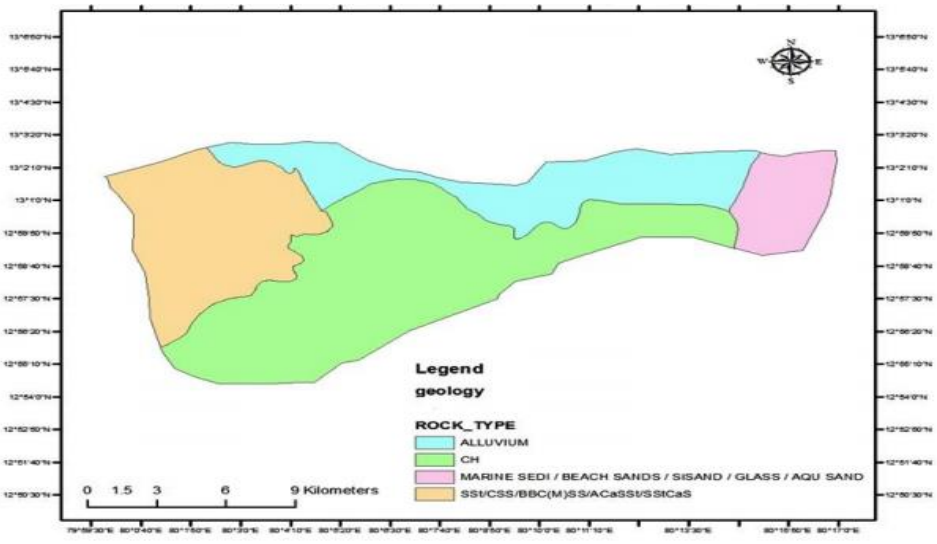

Figure 3.2 Geology Map of study area

Coastal sand occupies the centre area and sand along with silt was occupied the top layer in the Adyar river basin. Some parts are also covered with charnockites.

3.3 COLLECTION OF THE DATA

The rainfall data is very essential which is used to compute the runoff and estimate the peak discharge. Data is a factual information in digital form that can be transmitted and processed. For flood frequency analysis**,** Monthly rainfall datasets and peak flow were acquired for the period of 38 years ranging from 1980-2017.

Table 3.2 Data Collection from Different Sources

S.No	Data	Source
1	Year, Discharge of Adyar river, Yearly rainfall, Temperature, Depth of river, Discharge of Chemparambakkam	Department of Economics and Statistics, Chennai.
2	Geology map	Institute of Water Studies (IWS) Chennai.

The rainfall data has been collected from Department of Statistics and Economics, Chennai. The geology map of Adyar sub-basin was collected from Institute of Water Studies (IWS), Chennai.

3.4 ADYAR RIVER DATAS

The data's of Adyar river such as Year, Discharge of Adyar river, Yearly Rainfall, Temperature, Depth of river and Discharge of Chembarambakkam are shown in table no 3.3.

Table 3.3 Details of Adyar River data

Year	Discharge in Adyar	Yearly rainfall(mm)	Temperature	Depth of water level	Discharge in Chembaram bakkam
1980	38.11303	1483.7	22	2.5	0
1981	0	931.5	25	2	0
1982	0	792.8	28	2	0
1983	0	1479.4	23	0	0
1984	419.2598	1547.8	24	3	0
1985	2613.294	1821.5	22	5	2682.72
1986	1355.282	979.1	27	4	457.92
1987	674.2195	1222.9	23	3	0
1988	694.3101	1433.8	23	3	0
1989	0	1410.5	23	2	0
1990	0	1419	23	2	0
1991	0	1427.5	23	2	285.55
1992	0	1069.6	24	2	0
1993	0	1243.6	24	2	0
1994	0	1456.1	23	2	0
1995	879.2807	1525	22	2	0
1996	161.4322	1566.5	22	3	3829.42
1997	0	2015.6	22	2.5	1832.28
1998	0	1079.1	25	2	255.05
1999	0	1151.1	24	2	0
2000	0	1079.6	25	2	0
2001	93.58652	1625.6	22	2	0
2002	0	1399.2	23	2.5	0
2003	0	768.8	28	2	0
2004	0	1210	24	2	0
2005	0	2491.7	22	2	8985.61
2006	1255.075	1275.2	24	2	0

2007	601.8248	1309.7	23	4	292
2008	94.70084	1595.6	22	3	35.425
2009	0	1180.5	24	2.5	0
2010	0	1632.8	22	2	0
2011	0	1833.9	22	2	0
2012	0	1052.9	25	2	0
2013	0	1094	25	2	0
2014	0	1283.2	24	2	0
2015	2944.952	2135	22	2	2900.35
2016	0	975.7	28	5	0
2017	96.90654	1366.6	24	2	38.624

The above data's of Adyar River are used for flood frequency analysis in Gumbel method.

CHAPTER-4

METHODOLOGY

CHAPTER -4

METHODOLOGY

4.1 GENERAL

This section explains the detailed procedure followed for the proposed study. The entire methodology includes three major parts. The first part is to fit the data to Gumbel distribution. The second part involves in fitting observed data with theoretical data using Gumbel method. The final part of the methodology involves in the analysis of frequency of flood using ANN Model. The entire methodology for this study is described in below figure 4.1.

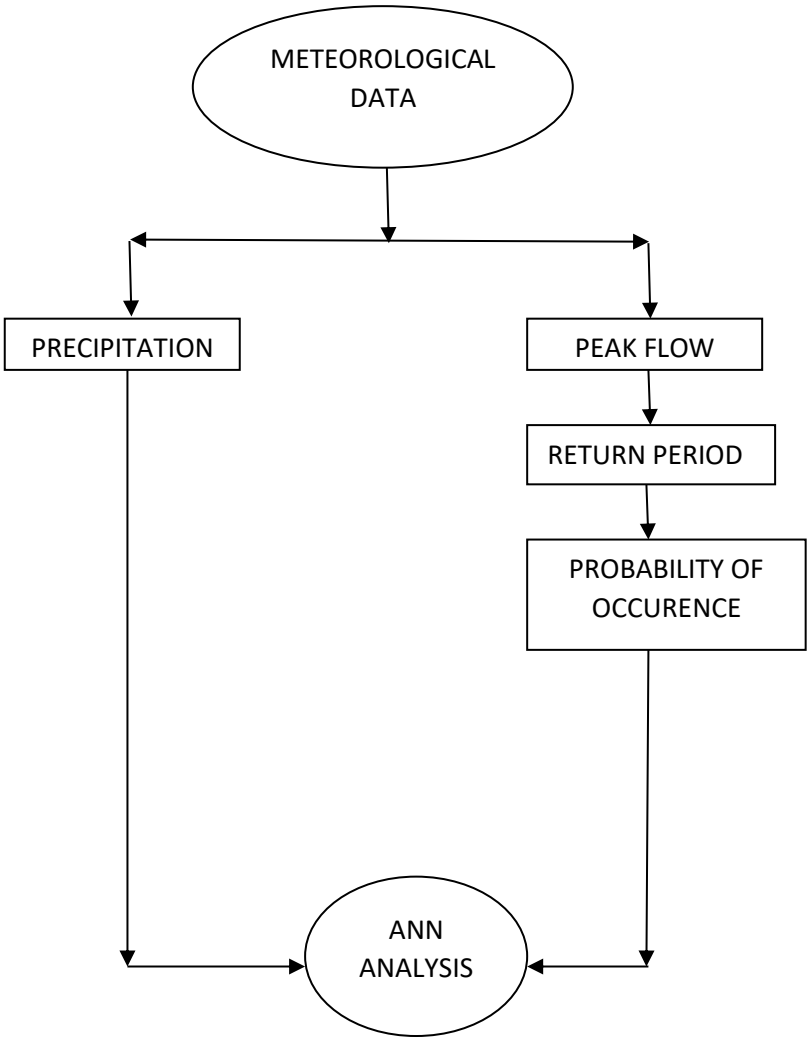

Figure 4.1 Methodology Chart

4.2 PRINCIPLE OF FREQUENCY ANALYSIS

To analyse the frequency of flood peaks by following simple method such as determination of probabilities P ($X \geq x$). The values of probabilities are found out along with values of peak floods were represented in log-probability paper. Then all points are plotted by a curve and by the process of extrapolation, extreme values were found out. Finally for calculations of desired probabilities with the proper fitting of distribution with observed data.

4.3 GUMBEL METHOD

On the basics of extreme value distribution along with appropriate use of frequency factors with theoretical distribution, the analysis of flood frequency by Gumbel method were calculated. The basic equation which was used for flood frequency analysis is given below as

$$\mathbf{x = \bar{x} + \Delta x} \qquad \textbf{(4.1)}$$

where,

x is flood magnitude of specified return period (T)or Probability (P).

$\bar{x}$ is mean value of record floods.

Δx is change in flood magnitude.

Δx based on statistical parameters, recurrence interval (T), dispersion characteristics and others.

Then the equation was shown below as $\mathbf{\Delta x = S\ K}$

where,

S is Standard Deviation

K is Frequency Factor

Therefore, the equation (4.1) was expressed as $\mathbf{x = \bar{x} + KS}$

4.3.1 Procedures for Analysis of frequency of flood

The following are the basic processes carried out in Gumbel method for analysis of flood frequency as follows:

(i) The values of magnitude of flood (x) are listed initially and they are arranged in descending form.

(ii) Next ranking 'm' is done with the greater value as m = 1 and it is continued further.

(iii) By using the Known equation for return period T= n+ 1/m and Probability of exceedance P= m/n +1 respectively. And they are found out for all respective years.

(iv) From the obtained table the values such as x^2, $\sum x$ and $\sum x^2$ were also determined.
(v) Now for the purpose of computation such as mean $\bar{x}$, squared mean $\bar{x}^2$, mean of squares x^2 and standard deviation S were obtained.
(vi) To find out the value of frequency factor from the Table 7.1 of the Gumbel method read values such that for specified sample size (n) along with available return period (T).

(vii) Now by using equation $x = \bar{x} + KS$, the magnitude of floods is determined for respective return period.

(viii) To get the frequency curve, the values of x are plotted along with P values or return period in probability paper.

Table 4.1 frequency factors for Gumbel Method

Sample size	Return priod (T) in years										
n	5	10	15	20	25	30	50	60	75	100	1,000
15	0.967	1.703	2.117	2.410	2.632	2.823	3.321	3.501	3.721	4.005	6.265
20	0.919	1.625	2.023	2.302	2.517	2.690	3.179	3.352	3.563	3.836	6.006
25	0.888	1.575	1.963	2.235	2.444	2.614	3.088	3.257	3.463	3.729	5.842
30	0.866	1.541	1.922	2.18	2.393	2.560	3.026	3.191	3.393	3.653	5.727
35	0.851	1.516	1.891	2.152	2.354	2.520	2.979	3.142	3.341	3.598	
40	0.838	1.495	1.866	2.126	2.326	2.489	2.943	3.104	3.301	3.554	5.576
45	0.829	1.478	1.847	2.104	2.303	2.464	2.913	3.078	3.268	3.520	
50	0.820	1.466	1.831	2.086	2.283	2.443	2.889	3.027	3.241	3.491	5.478
55	0.813	1.455	1.818	2.071	2.267	2.426	2.869	3.027	3.219	3.467	
60	0.807	1.455	1.818	2.071	2.267	2.426	2.869	3.008	3.219	3.467	
65	0.801	1.446	1.806	2.059	2.253	2.411	2.852	2.992	3.200	3.446	
70	0.797	1.437	1.796	2.048	2.241	2.398	2.837	2.979	3.183	3.429	
75	0.792	1.430	1.788	2.038	2.230	2.387	2.824	2.9.67	3.169	3.413	5.359
80	0.788	1.423	1.780	2.029	2.220	2.377	2.812	2.956	3.155	3.400	
85	0.785	1.413	1.767	2.020	2.212	2.368	2.802	2.946	3.145	3.387	
90	0.782	1.409	1.762	2.007	2.205	2.353	2.785	2.938	3.125	3.367	
95	0.780	1.405	1.757	2.002	2.193	2.347	2.777	2.930	3.116	3.357	
100	0.779	1.401	1.172	1.998	2.187	2.341	2.770	2.922	3.109	3.349	5.261

4.4 ARTIFICIAL NEURAL NETWORK TECHNIQUE

The Artificial Neural Network technique is a soft computing technique plays important role in predicting various events. The collection of connected nodes in ANN are known as artificial neurons. It is also known as neural networks, which is a combination of several neurons in the way to perform notable tasks. Each neuron is joined by connection to other neurons for the process of transferring a signal. The connections are also termed as edges. The figure 4.2 shows the structure of Artificial Neural Network.

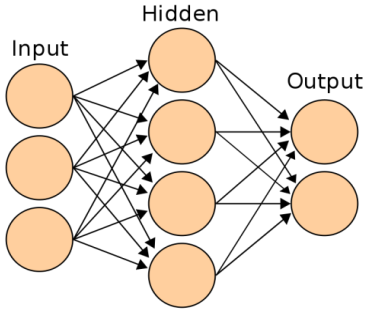

Figure 4.2 Artificial Neural Network

The network consists of three layers such as input layer, hidden layer and output layer. Initially the signals are passed from input layer then get processed in hidden layer and finally reaches output layer. During the process of transmitting signals various algorithms were used for learning process in which the weights are also adjusted. Depending on the signal strength weights may increase or decrease and sometimes neurons may reach the value of threshold in case of aggregate signal.

4.5 ELEMENTS OF ARTIFICIAL NEURAL NETWORK

The elements of Artificial Neural Networks are shown in the following:

a. Processing Elements
b. Topology
c. Learning Algorithm

4.5.1 Processing Elements

The Processing elements function as brain similar to neurons in human being. It consists of input unit, summing unit and output unit. The weighted sum of values is calculated by summing unit with n input values and also their weights.

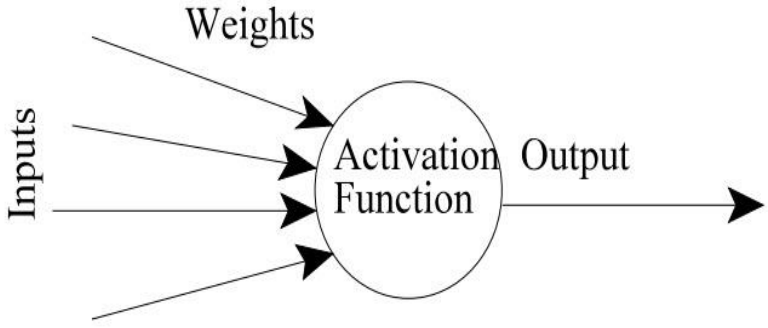

Figure 4.3 Processing Elements

The classification of positive weight or negative weight will depend on the weight of every input sign. The activation value is the value of weighted sum in the summing unit. The figure 4.3 shows the processing elements in neural network.

4.5.2 Topology

Generally, there is need of arrangement of the processing element in an appropriate manner as well as in organised pattern, it can be with their connections, inputs and outputs are called as topology. Connections can be made within same layer or between different layers of the processing units.

4.5.3 Learning Algorithm

Learning Algorithms were widely to perform specified input-output task to generate several data in order to get suitable patterns in the respective situation. It consists of supervised, unsupervised and the hybrid of both. These can be described in the form of weights of first derivative.

4.6 MATLAB

MATLAB is a mathematical programming language in which several activities to determine its solution for the specific problems in easy manner. It solves many issues regarding technical and computations especially the ones which include vector and matrix expressions, by using languages like C or FORTRAN. Such that it performs tasks like analysis of data, exploration, visualization and computation.

There has been a periodic evolution of MATLAB over the years with many users providing input. MATLAB is the better choice for development, analysis, research, and higher productivity in the industry. The main feature of MATLAB is a group of application specific solutions namely tool boxes.

4.6.1 Artificial Neural Network in MATLAB

The basic steps involved in the neural networks in MATLAB are as follows:

i. The data collection work is carried out.
ii. Creation of the neural network in the respective toolbox.
iii. The process of network configuration is performed.

iv. To get desirable results the weights as well as biases are initialized.

v. Then neural network training was done and also network validation is undertaken.

vi. If not get desired output in network1 and then use another as network 2.

CHAPTER-5

RESULTS AND DISCUSSIONS

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 GENERAL

Gumbel Method was used to analysis flood frequency curve for the period of 1980 to 2017 and ANN model was computed with temperature, depth of water level, rainfall, discharge in Chemparambakkam and discharge of Adyar river which are discussed below in detail.

5.2 FREQUENCY ANALYSIS BY GUMBEL METHOD

Gumbel's distribution is widely performed for analysis of flood frequency. To determine the frequency, the peak discharge data of Adyar river in the period of 1980-2017 were used. The procedure for determining the flood magnitude with respect to return period are in the following:

i. Arrange the Peak Discharge data in descending order initially.
ii. For every data ranking is done.
iii. After that the values of return period (T), Probability (P) and x^2 are found out.
iv. By using Gumbel's equation $x = \bar{x} + KS$, the values of flood flows with specific return periods are calculated.
v. Such that graph is plotted with the observed data of flood flows along with its return period.

TABLE 5.1 COMPUTATION OF RETURN PERIOD

YEAR	PEAK DISCHARGE Q(m^3/s)	PEAK DISCHARGE ARRANGED IN DESCENDING ORDER	RANK (M)	N+1	RETURN PERIOD (T)	PROBABILITY P(X≤x)	x^2
1980	38.11303	2944.952	1	39	39	0.025641026	8672742
1981	0	2613.294	2	39	19.5	0.051282051	6829306
1982	0	1355.282	3	39	13	0.076923077	1836789
1983	0	1255.075	4	39	9.75	0.102564103	1575213
1984	419.2598	879.2807	5	39	7.8	0.128205128	773134.5
1985	2613.294	694.3101	6	39	6.5	0.153846154	482066.5
1986	1355.282	674.2195	7	39	5.571428571	0.179487179	454571.9
1987	674.2195	601.8248	8	39	4.875	0.205128205	362193.1
1988	694.3101	419.2598	9	39	4.333333333	0.230769231	175778.8
1989	0	161.4322	10	39	3.9	0.256410256	26060.36
1990	0	96.90654	11	39	3.545454545	0.282051282	9390.877
1991	0	94.70084	12	39	3.25	0.307692308	8968.249
1992	0	93.58652	13	39	3	0.333333333	8758.437
1993	0	38.11303	14	39	2.785714286	0.358974359	1452.603
1994	0	0	15	39	2.6	0.384615385	0
1995	879.2807	0	16	39	2.4375	0.41025641	0
1996	161.4322	0	17	39	2.294117647	0.435897436	0
1997	0	0	18	39	2.166666667	0.461538462	0
1998	0	0	19	39	2.052631579	0.487179487	0
1999	0	0	20	39	1.95	0.512820513	0
2000	0	0	21	39	1.857142857	0.538461538	0
2001	93.58652	0	22	39	1.772727273	0.564102564	0
2002	0	0	23	39	1.695652174	0.58974359	0
2003	0	0	24	39	1.625	0.615384615	0
2004	0	0	25	39	1.56	0.641025641	0
2005	0	0	26	39	1.5	0.666666667	0
2006	1255.075	0	27	39	1.444444444	0.692307692	0
2007	601.8248	0	28	39	1.392857143	0.717948718	0
2008	94.70084	0	29	39	1.344827586	0.743589744	0
2009	0	0	30	39	1.3	0.769230769	0
2010	0	0	31	39	1.258064516	0.794871795	0
2011	0	0	32	39	1.21875	0.820512821	0
2012	0	0	33	39	1.181818182	0.846153846	0
2013	0	0	34	39	1.147058824	0.871794872	0
2014	0	0	35	39	1.114285714	0.897435897	0
2015	2944.952	0	36	39	1.083333333	0.923076923	0
2016	0	0	37	39	1.054054054	0.948717949	0
2017	96.90654	0	38	39	1.026315789	0.974358974	0
	Σx =	11922.23703				**$\Sigma x^{2=}$**	21216426

In the above table 5.1 the computation of return period (T), probability of exceedance P (X > x) and x^2 are calculated and the values of $\sum x$ and $\sum x^2$ are also found out.

From table 5.1 the following values of mean $\bar{x}$, squared mean $\bar{x}^2$, mean of squares x^2 and standard deviation S are also found out for the purpose of computation shown below.

mean $\bar{x}$	313.7430797
squared mean $\bar{x}^2$	98434.72008
mean of squares x^2	558326.9936
standard deviation S	687.25

Table 5.2 COMPUTATION OF DISCHARGE

RETURN PERIOD IN YEARS T	MEAN $\bar{x}$	STANDARD DEVIATION S	FREQUENCY FACTOR K	FREQUENCY FACTOR X STANDARD DEVIATION K X S	DISCHARGE $x = \bar{x} + KS$
5	313.7431	687.25	0.838	575.9155	889.6586
10	313.7431	687.25	1.495	1027.439	1341.18185
20	313.7431	687.25	2.126	1461.094	1774.8366
50	313.7431	687.25	2.943	2022.577	2336.31985
100	313.7431	687.25	3.554	2442.487	2756.2296

In the table 5.2 for various return period (T) in years say such as 5,10,20,50 and 100 by using the known standard deviation and mean such that the value of frequency factor (K) is obtained from the table 4.1 corresponding to the return period (T) and sample size (n). Finally, the discharge of floods (x) is found out.

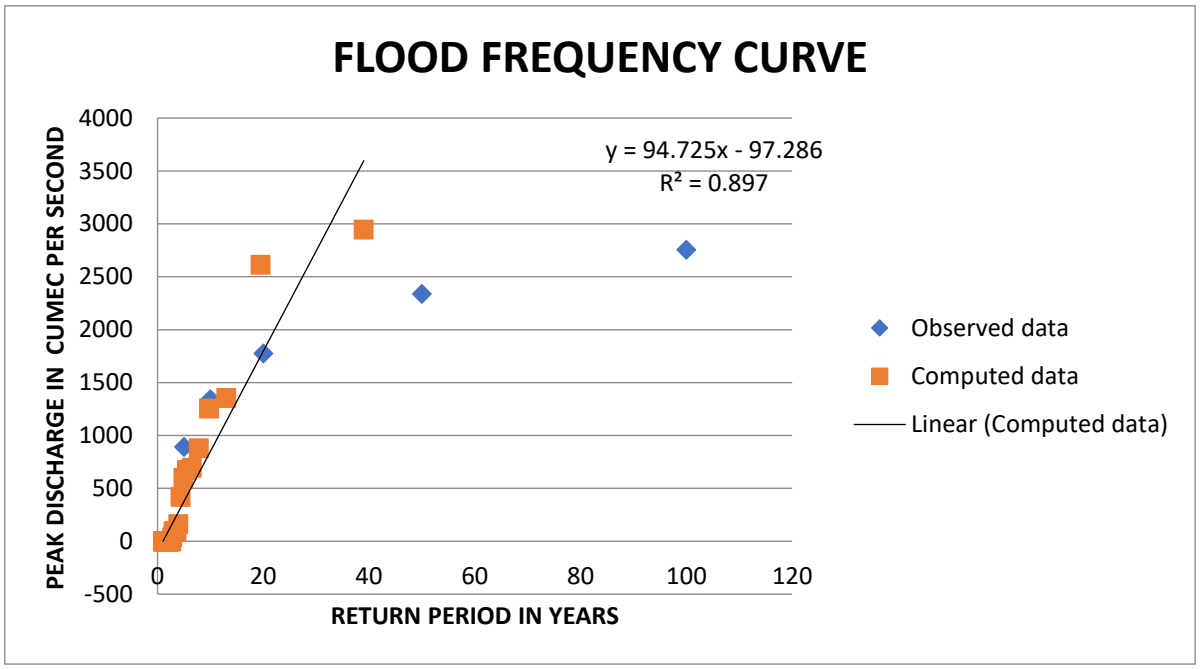

Figure 5.1 Flood frequency Curve

From figure 5.1 it clearly shows the entire observed data fitted to flood frequency curve suitably.

5.3 ANN ANALYSIS

ANN is an analyzing tool which was used for determining solutions for several problems. It solves very complex problems in easy way. Such that ANN is a parallel processing structure. To solve the given problem the peak discharge data of Adyar river for the following year 1980-2017 were taken for analysis in ANN.

The regression equation was obtained from Minitab Software. By varying four parameters such as temperature, depth of water level, rainfall and discharge in Chemparambakkam for obtaining generated dataset by using regression equation. This generated dataset was used for training input in MATLAB for ANN analysis.

5.4 PROCEDURE FOR ANN ANALYSIS

The procedure for ANN Analysis for frequency of flood in Adyar river can be performed with the process of data generation in which the equation of regression is obtained and can be used for training data in MATLAB. Then by Neural Network training with the available dataset by using suitable algorithm for learning with the number of required hidden layers in nntool box and finally the values of regression are obtained.

5.4.1 Data Generation Procedure

i. The collected data's of Adyar river as such Temperature, Depth of water level, discharge in Chembarambakkam, Rainfall and Discharge of Adyar river are present in excel sheet.
ii. Now open the Minitab Software in which all the data's presented in the excel sheet are copied and paste it on worksheet in the Minitab.
iii. Then click the stat option in which regression is selected, then again regression is chosen and finally fit regression model.
iv. A box of regression will open in that the responses and continuous predictors are assigned and click ok.
v. Finally, the Regression equation is obtained after analysed in Minitab Software.
vi. This equation can be incorporated in simple "if why" statement to generate number of data's by varying input parameters such as temperature, depth of water level, rainfall and discharge in

Chembarambakkam. The generated data were used for training purpose in MATLAB.

vii. The collected data's of Adyar river are used for testing purpose in MATLAB.

5.4.2 Analysis by ANN Toolbox in MATLAB

1.Open the workspace in MATLAB Software.

2.Create a new folder and provide the name as training input, test input and target output.

3.Copy the data such as training input, test input and target output from Excel and paste it in variables folder and transpose it.

4.In Command window, type nntool and enter it. So that, Neural Network data manager dialog box will open.

5.Click import menu, in these variables are selected as input data and target data. These data are imported to data manager.

6. To create the network, click new file option in neural network data manager by varying training algorithms. The Levenberg- Marquardt algorithm was used in this analysis. After clicking it will open tab called create network/data, it consists of various options like Network type, Training functions and number of neurons can be modified.

7.In create neural network dialog box chosen input data as training input and target data as target output and click the create option. Then new network is added to data manager.

8.Now double click the network in nntool and then network dialog box opens. So, that network is created. The created network is shown in below figure 5.2.

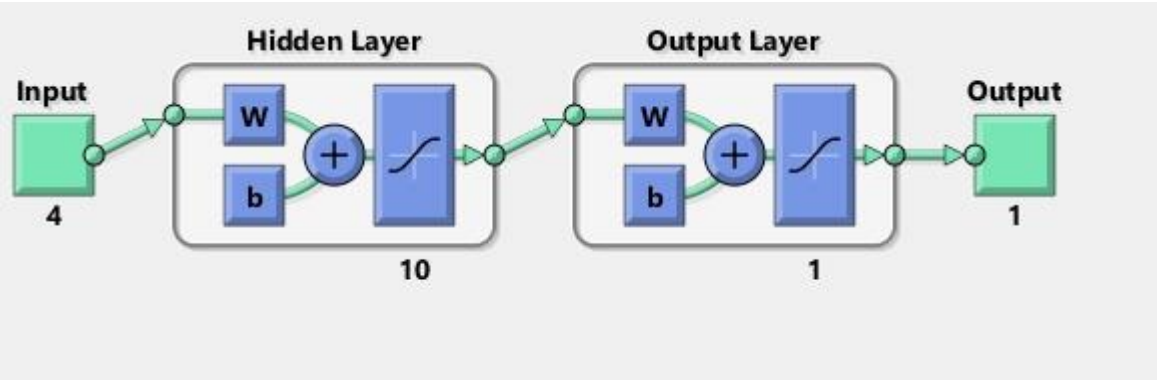

Figure 5.2 Network Processing Diagram

9.Now click the train option, feed the training input data as training input and target data as target output and click the train network option, then Neural network training (nntraintool) box opens and it starts train the network. The figure 5.3 shows the Algorithms and training progress of Neural Network in MATLAB.

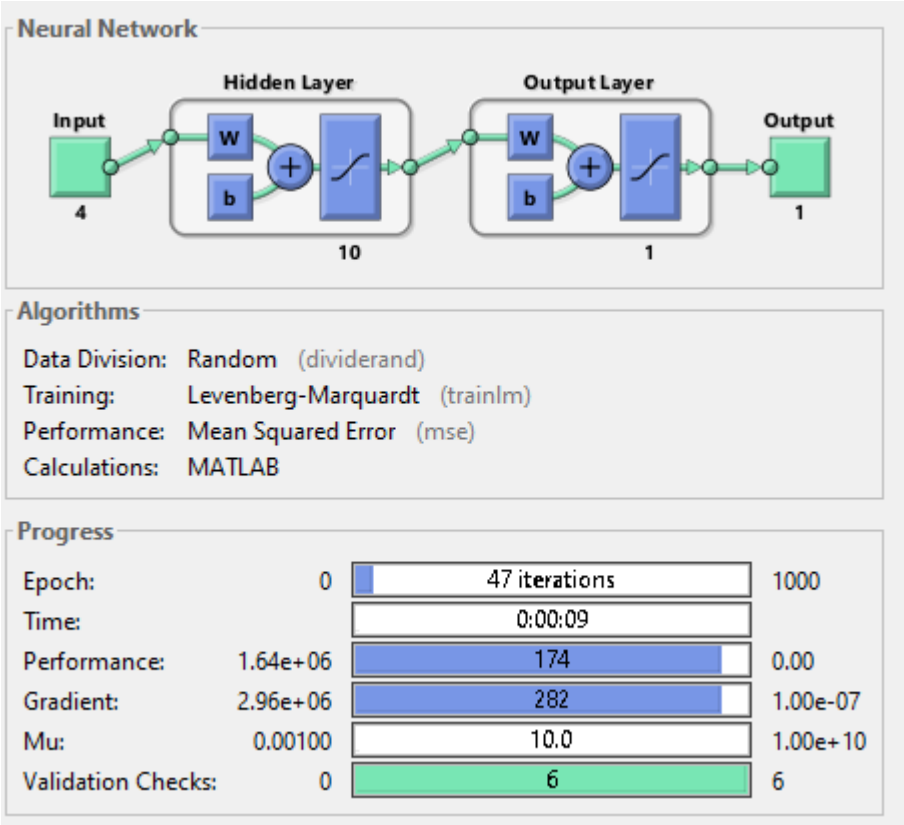

Figure 5.3 Neural Network

10.Once the training process gets completed, now the value of regression plot is obtained.

11.In the plots now click the regression to validate the created network and a dialog box opens such that it contains the value of R in training, test, validation and combination of all.

12.Need to train the network, until get the optimize value of regression (R).

13.If did not get optimized value of regression (R), in order to get optimized value, need to change the transfer function in nntool box. Create new network and train it, repeat the cycle until get the optimized value. The plots of regression value were obtained as shown in figure 5.4.

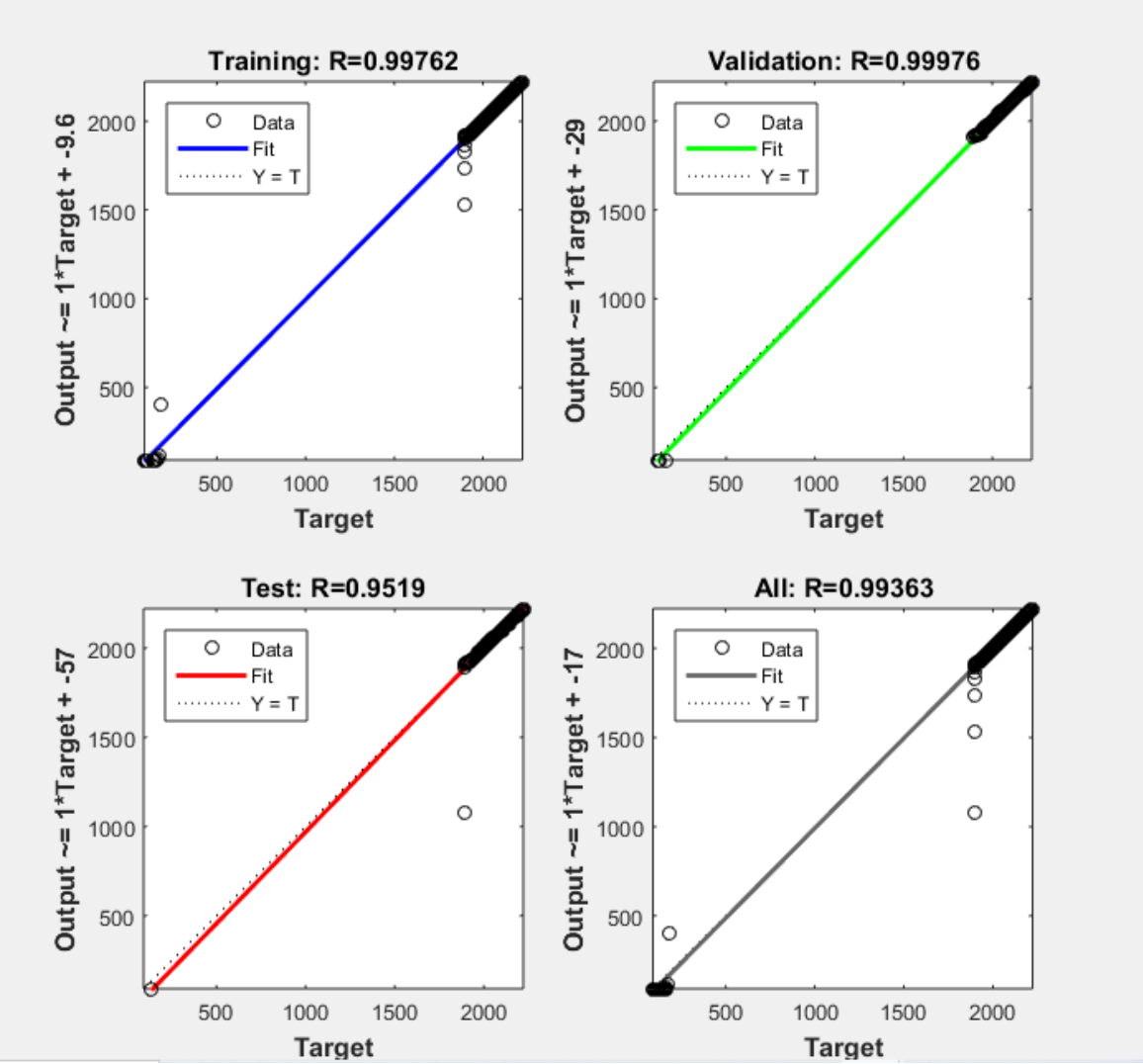

Figure 5.4 ANN Analysis

In ANN toolbox in MATLAB, the maximum regression R=0.99 value was obtained from Levenberg Marquardt (LM)Training Algorithm and the neurons in the hidden layer was 10. The regression value R=0.89 was obtained from Gumbel method. So that regression value (R) obtained from ANN analysis is more accurate than regression value (R) obtained from Gumbel method.

CHAPTER-6
CONCLUSION

CHAPTER- 6
CONCLUSION

6.1 CONCLUSION

The main objective was to assess the flood frequency curve by Gumbel method and to analyse frequency of flood using soft computing technique ANN tool box using MATLAB. This study has been limited to meteorological drought-based rainfall and peak discharge data. This study analysed meteorological variables to assess flood frequency in Adyar river basin.

To analyze the frequency of flood, ANN models were created. The results show that the selected ANN models are appropriate. The study also confirms ANN models was a better analyzing capability for value of regression (R).

Based on the study and results from Gumbel method and ANN Analysis, the following results were drawn.

i. Flood frequency curves can be defined mathematically from records containing annual flood discharge and frequency curve computed using Gumbel method shows that observed data fits the computed data satisfactorily.
ii. In this Study ANN used for predicting the river discharge, based on different parameters such as rainfall, temperature and depth of water level.
iii. To enable sustainable water resource planning in Adyar river basin, ANN models were developed for planning of flood prevention.
iv. The computed ANN results were more accurate when compared to the results of Gumbel Method.

Probability of exceedance plays significant role for climatologists in early detection of climate forecasting and climate trends. These data are widely used for the purpose of safety and planning of economy due to raise in number of storms and changing climatic conditions. Such that it gives information to governments, planners, communities, hydrologists, insurers and homeowners for risk reduction purpose.

6.2 SCOPE FOR FUTURE STUDY

To design hydraulic structures namely bridges, waterworks, dams, highways sewage disposal plants and industrial building to determine recurrence of flood events for frequency analysis. Applying statistical tools for estimation of flood frequency, to optimize specification in designing of hydraulic structures as well as to protect under-designing and over designing of structures.

Flood frequency estimation plays important role for flood zoning, flood insurance along with design of hydraulic structures. It also beneficial for identifying damages caused because of flood with respective to particular time period along with giving the various parameters for measurement. The flood frequency analysis estimation not only design hydraulic structure and also protect economic losses.

The ANN analysis was carried out only for seasonal rainfall and peak discharge data. These analyses can also carry out further monthly and annual rainfall data. The study was carried out further in determining quality of water and concentration of sediment phenomena. To find out values of water level and discharge, such that morphology of river bed can also considered in future. The techniques of ANN, can also be related with various other techniques such as neuro-fuzzy and fuzzy for determination of flood frequency.

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