Deanship of Graduate Studies
Al- Quds University

West Bank Rainfall Modeling

Ahmad Mahmoud Mousa Awad

M.Sc. Thesis

Jerusalem – Palestine

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Prepared by:
Ahmad Mahmoud Mousa Awad

B.Sc.: Physics (Bethlehem University) (Palestine)

Supervisor: Dr. Amer Marei

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Faculty of Science and Technology Al- Quds University

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Prepared By: Ahmad Mahmoud Mousa Awad
Registration No: 20311589

Supervisor: Dr. Amer Marei

Master thesis submitted and accepted, Date:
The names and signatures of the examining committee members are as follows:

1-Head of Committee: Dr. Amer Marei Signature: ………..

2-Internal Examiner: Dr. Adnan Lahham Signature: ………..

3-External Examiner: Dr. Ziad Mimi Signature: ………..

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Dedication

To the finest soul of the hero martyr Mahmoud Awad whose pure blood fully watered our beloved home land and to the entire Palestinian Martyrs, I gift my thesis.

Ahmad Mahmoud Mousa Awad

Declaration

I certify that this thesis submitted for the degree of Master, is the result of my own research, except where otherwise acknowledged, and that this thesis (or any part of the same) has not been submitted for a higher degree to any other university or institution.

Signed

Ahmad Mahmoud Mousa Awad

Date:

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My sincere thanks and gratitude to Dr. Amer Marei for his supervision, endless support, expertise, and guidance. Without his encouragement I could not embark on my work.

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Acronyms

- **ARIMA**: Autoregressive Integrated Moving Average.
- **AIC**: Akaike Information Criterion.
- **DCM**: Decomposition Model
- **DMA**: Double Moving Average
- **LSM**: Least Square Method
- **RA**: Regression Analysis
- **SS_R**: Regression Sum of Squares
- **SMA**: Simple Moving Average
- **SESM**: Single Exponential Smoothing Model
- **WSA**: Weighted Simple Averages
- **WM**: Winters Method

Abstract

Palestine suffers from water shortage because of many reasons, firstly Palestine has Mediterranean climate characterized by long, hot and dry summers, and short, cool and rainy winters. Secondly, political reason, this leads to Israeli – Palestinian conflict.
The Israelis and the Palestinians each blame the other and each side consider it self as a victim. The Palestinian water authority in the West Bank said that in summer months Macarot Israeli Water Company reduces the supply of water to the Palestinian areas, for instance, the 300,000 inhabitants who live in Hebron need 25,000 cubic meters of water daily, However Macarot supplies this area with 5,500 cubic meters only.
(Environmental Profile for the West Bank, ARIJ, 1997).

Water scarcity in addition leads to many other problems such that bad water distribution, water management problems and environmental quality problems. These problems had enhanced experts to study these problems in details.
Rainfall is a major factor for planning and management of irrigation projects and agricultural production, such as reservoir operation, irrigation area, and irrigation water requirements. The rainfall changes especially the reduction in annual rainfall may have a great effect on the effectiveness and accuracy on planning of irrigation project. (Kwanyuen, 2000).

In view of this, rainfall records over the West Bank have been analyzed and modeled to predict the future fluctuations in rainfall. To do this, in this research, rainfall data collected from six stations in the West Bank. The length of each record differs from one station to another, analyzing and modeling these rainfall records were developed using time series analysis to estimate precipitations trends in future. Many trials were used to assign the best model. First the analyzing and predicting method used is the autoregressive integrated moving average (ARIMA), the parameter of the model estimated by the least square method using E-views software. Second we used a nonlinear mathematical model mimic's reality which is angle Cosine, the parameter of the model estimated by the least square method using SPSS software.

In general it has been found that rainfall will decrease in all regions in the West Bank by the two models ARIMA and Nonlinear where. The decrease in rainfall will be linearly through up coming years for most selected station. The result of time series analysis for the selected stations in West Bank indicates the present of gradual climatic changes toward aridity especially in the central highlands.

Chapter One

Introduction

Rains are the main source of water in the West Bank. It is the feeder of groundwater aquifers, surface water, and valleys. In addition, they are used for irrigating wide areas of agricultural lands especially dry lands. However, the rainwater amount falling in the West Bank is changeable from year to another and from area to another according to the

1- Topographical conditions
2- Elevation and conditions of area locations.

Rainfall occurs during period between October and April; they reach the climax in the period between December and March in each year. In the Jordan Valley area, the average of rainwater varies between 100 and 300 millimeters. However, it varies between 500 and 600 millimeters in the Western falls. In the Eastern falls the rainwater amount varies between 100 and 450 millimeters (Environmental Profile for the West Bank, ARIJ, 1997).
The total volume of rainwater amount falling in the West Bank varies between 2700 and 2900 Million m^3. (Environmental Profile for the West Bank, ARIJ, 1997).

1.1 Problem Identification

The Palestinian daily consumption of water is 35 to 50 liters per capita, while the daily consumption of the Jewish settlers is 280 to 350 liters per capita (Environmental Profile for the West Bank, ARIJ, 1997).
If the annual water supplies drop below 1700 cubic meters per capita, the country is said to be experiencing water stress. When annual water supplies drop below 1,000 cubic meters per capita the country faces water scarcity (Hinrichsen, 2008).
Since Palestinian receives less than 80 liters per capita per day, West Bank and Gaza represents a good model of water scarcity.

1.2 Importance of the Study

Since rainfall represents the major resource of fresh water in Palestine, rainfall forecasting plays an important role.
- It helps decision makers to make proper decisions with minimum risk.
- It gives an idea about future problems of water resource and distribution in Palestine.
- Another importance of forecasting rainfall series, is in agriculture sector, agriculturists all over the world and especially for who live in semi-arid regions have long recognizing the importance of seasonal and annual variability of precipitation, which have a direct effect on their livelihood. (Woolhiser and Roldan, 1986).

1.3 Objective of the Study

The main objective of this study is to estimate precipitations in the future by developing a time series model for each selected stations in the West Bank.
Other objectives to be considered is to analyze rainfall data and identifying the basic statistical characteristics of rainfall series (mean, standard deviation, maximum and minimum).

1.4 Hypothesis

The main hypothesis of this research will be:

1- The expected rainfall for the coming years could depend on the previous records.
2- The environmental impact could be significantly affected by the expected rainfall.

1.5 Previous Studies

Rainfall is a key component of the hydrological cycle. It is the major means by which fresh water is made available (Srinivas, P. and Thayumanavan, 2000).
The main parameters defining the rainfall are duration, depth of precipitation and frequency of occurrence. Several investigators have proposed stochastic models for describing both precipitation occurrence and the distribution of precipitation at a point in space. (Kwanyuen, 2000).

- Palestinian hydrology group (1995) analyzed secondary rainfall data for the northern West Bank for the years 1952 to 1993. For each station the average and standard deviation of each individual month have been calculated. It is shown that the highest average of rainfall occurs in the months of January and December. An advanced stochastic modeling was carried out for monthly rainfall data. The develop Auto Regressive Integrated Moving Average (ARIMA) models shows higher order regressive terms for most of the stations, which affects the reliability of estimating these parameters. The study used multiple linear statistical models to find values of annual rainfall for each station. Finally the relationship between rainfall and runoff in one hydrology catchments was investigated; it was found that the ratio of runoff to rainfall ranges from 0.1 % to 16.2 %.

- Ssrinivas and Thayumanavans, (2000) analyzed rainfall for Saidapet Rain Gauges Station in Chennai for the years 1901 – 2000. Analyzing and modeling rainfall records were developed. They used time series analysis to estimate precipitation trend in future to this region. The ARMA (2, 2) model was selected as the best fit from the analysis.

- Dahabiyeh, (2002) analyzed rainfall for Jordan for the years 1938 – 1999. The study area was divided into three main geographical regions: the Jordan Valley region, the Hilly region and the Badia region, analyzing and modeling rainfall records were developed. The study used time series analysis through computer software (SAS) to estimate precipitation trend in future to these regions. Estimations of rainfall data of different selected stations suggest a general trend of gradual climatic changes toward aridity along the southeast – northeast direction. This general pattern of decreasing rainfall is combined with a cyclic pattern of fluctuation in the northern and northwest parts of Jordan. In the southern and eastern parts of Jordan rainfall were expected to decrease linearly. The conclusion of the research is that. It has been found that the Salinization hazard will increase in the Jordan Valley, the stresses on the natural vegetations cover and crops grown will increase in the Hilly region, however in the Badia region no more extensive soil degradation is expected.

- Landsea et al. (1998) analyzed June to September seasonal rainfall of three regions in North Africa; they used Least Absolute Deviation (LAD) regression method for the years 1950 – 1997. Statistical forecast for the year 1998 rainfall were predicted. The study shows that a linear decrease in the rainfall for the year 1998.

- Mattes and Mason (1998) used quadratic discriminate analysis model for evaluating seasonal rainfall forecasts in Namibia from 1950 – 1990. the country is divided into a northern and southern region, then six month rainfall indices for each of these two regions are related to the principal components of see – surface temperatures, in the Indian south Atlantic and Pacific oceans. Results have suggested that useful forecasts could be released operationally before the start of the summer rains.

- AL – Omari (1997) studied rainfall in the Jordanian Badia by using (ARIMA) model to forecast the annual rainfall. Result showed that annual rainfall decrease in the study area.

- Baroul, (1993) studied the relationship between the location of the upper air bed which takes place in October, and the annual amount of rainfall in Jordan. The study revealed that the location of the upper air cold bed of the Mediterranean beside other variables effect the annual average of rainfall over the country.

1.6 Measurement of Precipitation

Precipitation is physics process forms the third stage in the hydrological cycle, preceded by the initial stage of evaporation and the second stage of condensation.

The term precipitation as used in the science of climatology refers to cloud droplets falling to the ground (Anthus, 1992). Most precipitation starts off as snow as the temperature at which the cloud exists is usually below freezing.

There are tow main objectives of precipitation measurements; the first is to ensure that the gauge collects the same amount of rain or snow that would have reached the ground.

The second is to estimate accurately the precipitation over an extensive natural area, by means of gauges at a number of locations (Brutsaert1982).

The knowledge of the amount and distribution of precipitation with respect to time and space is an essential element of water and energy balance studies in hydrology and climatology. Moreover, precipitation data also are an important input to various engineering design computations. Precipitation data can be obtained by different means. The oldest and the most common method is a point measurement using can-type precipitation gauges. (Sevruk, and Klemm, 1989). Other methods of obtaining precipitation data are based on modern remote sensing techniques.

Chapter Two

Study Area

2.1 Description of Study Area

2.1.1 Topography

The high morphological diversity of the West Bank affects greatly the distribution of agricultural patterns. The agricultural patterns vary from irrigated agriculture in the Jordan Valley, the lowest area in the world to rain fed farming in the mountains. It also affects the distribution of population, the maximum concentrations of built-up areas being found in the mountains where the climate is more suitable for human life than the hot climate of the Jordan Valley. (Environmental Profile for the West Bank, ARIJ, 1997).
In general there are three topographic regions; they are:

1- **Hebron Mountains**: The Hebron Mountains form the southern rim of the West Bank Mountains. They are located south of Jerusalem and extend to the Negev. On average, they are 850 meters high, with the highest point at 1020 meters above sea level near Halhoul, to the north of Hebron. Despite the numerous wadis among these mountains on both Eastern and Western sides, they are relatively barer than other mountains areas in the West Bank. This is principally due to the closeness of the Hebron Mountains to the Negev Desert in the south and the Dead Sea in the east, where and conditions prevail.
(Environmental Profile for the West Bank, ARIJ, 1997).

2- **Nablus Mountains**: The Nablus Mountains extend from Marij Ben Amer in the north to Jerusalem Mountains in the south. The Nablus Mountains can be divided into three areas: the eastern slopes, the mountains crests, and the western slopes.
The eastern slopes are located between the Jordan Valley and the mountains. They are characterized by steep slopes that contribute to forming young wadis such as Wadi el Badan. Elevation of the mountains ranges on average between 750 and 800 meters above sea level. The Western slopes, have an elevation that ranges between 250 and 500 meters above sea level.

3- **Jordan Valley**: The Jordan Rift forms the eastern boundary of Palestine, running along the edge of the country from north to south separating it from Jordan. The Jordan Valley is located between the Jordan River and the Eastern slopes, with elevation ranging between 350 meters below sea level and 100 meters above sea level. Its widest point in the West Bank reaches 16 Km and is located in the northern part of the valley.
The Valley narrows gradually to 7 Km in the south. (Environmental Profile for the West Bank, ARIJ, 1997).

2.1.2 Climate

The West Bank lies within the zone of the Mediterranean, thus this area experiences the Mediterranean characteristics of winter rain and summer drought. Only the lower Jordan Valley has a different transitional climate, between dry steppe and the extreme desert conditions of the Dead Sea regions. Rainfall is limited to the winter and spring months, mostly between November and April, summer is completely dry. Snow and hail, although uncommon, may occur anywhere in the area, especially over the highlands.

The mountainous areas in the West Bank extend from north to south and serve as barrier to the passage of moist air coming from the westerly direction, that is, air from the Mediterranean Sea, the only sea with an influence on the climatic conditions in the West Bank. The marine influence reaches to all of the Tulkarm and Jenin districts. It also affects the Western edges of the Nablus, Ramallah, Jerusalem, Bethlehem and Hebron districts, but it does not go deep into these districts due to the presence of highlands that stop the flow of wind. To the south of Jerusalem, the marine influence decreases because the Mediterranean shore bends to the southwest thus increasing the distance between the sea and the West Bank. In the north, there are no hills to block the sea winds, so the marine influence passes easily across the open lands of the Marj Ben Amer, the plain between the Jordan Valley.

This explains the increased quantity of rain in the northern Jordan Valley despite the fact that most it is below sea level. The climate of the West Bank, especially in the south, is influenced by the vast nearby deserts, the Negev and Arabian deserts. Especially during the spring and early summer, desert storms move through with hot winds full of sand and dust, (the khamaseen). These storms cause increases in temperature and a decrease in humidity.

In general there are three climatic regions in the West Bank. These are defined as follows:

1- The Jordan Valley Region: This region extends along the western Bank of the Jordan River. It is area (up to 375m below sea level), with semi – tropical climate with 400 Km^2. Characterized by hot summers and warm winters. Rainfall is low in this eco – region, averaging 158 mm per year.

2- The Central Highlands Region: This region includes a range of mountains and their western slope area. This range extends over the length of the central parts of the West Bank, from Jenin in the north to Hebron in the south. The central highlands region constitutes a major part of the West Bank, covering an area of approximately 3500 Km^2. This predominantly mountainous region ranges in elevation from 400 m to more than 1000 m above sea level. This region is the main catchments area of rainwater which replenishes the West Bank underground water aquifers.

3- The Semi – Coasted Region: It is the smallest of the West Bank region with an area of approximately 400 Sq. Km. it comprises the northwestern part of the West Bank, including parts of the Jenin and Tulkarim districts. In terms of climate, this region is considered an extension of the Mediterranean coasted region with elevation varying between 100 – 400 m above sea level. The semi – coasted region is characterized by extensive plains, which are highly cultivated with vegetables and field crops (Environmental Profile for the West Bank, ARIJ, 1997).

2.2 Distribution of Meteorological Network in the West Bank

Before 1967, when the West Bank was under Jordanian administration, five weather stations, called agricultural stations, were installed for agricultural purposes. These stations were located in El Arroub, Maythaliun, Beit Qad, Tulkarm and Al Far'a. The Jerusalem, Hebron and Jericho meteorological stations were established and controlled by the Jordanian Ministry of Transportation. While the weather stations recorded data for rainfall, temperature, humidity, wind and sunshine, the meteorological stations made full observations and had records of rainfall, evaporation, relative humidity, sunshine, wind direction and speed, maximum and minimum temperature and air pressure. These data were compiled from the Palestinian Ministry of Agriculture. When the West Bank was occupied by Israel in 1967, Israel installed the Nablus meteorological station, whereas the Jerusalem, Hebron and Jericho meteorological stations, which were established before 1967 by the Jordanian Ministry of Transportation, came under the control of the Israeli meteorological Service of the Ministry of Transport until the period of Palestinian autonomy.

In this work data from six meteorological stations will be collected they are Hebron station, Rammallah, Nablus, Tulkarem, Jenin, and Jericho station.
Table (2.1) gives selected station name, location and altitude. And figure (2.1) shows location of studied rainfall station in the West Bank.

Table 2.1: Selected Stations (name, location X-Y coordinate, and altitude)

Station	East Location	North Location	Altitude (m)
Rammallah	169.0	145.5	874
Hebron	159.7	104.0	1005
Jericho	194.0	140.2	-260
Nablus	175.0	180.0	533
Jenin	178.5	207.5	138
Tulkarem	152.5	191.0	65

(Environmental Profile for the West Bank, ARIJ, 1997).

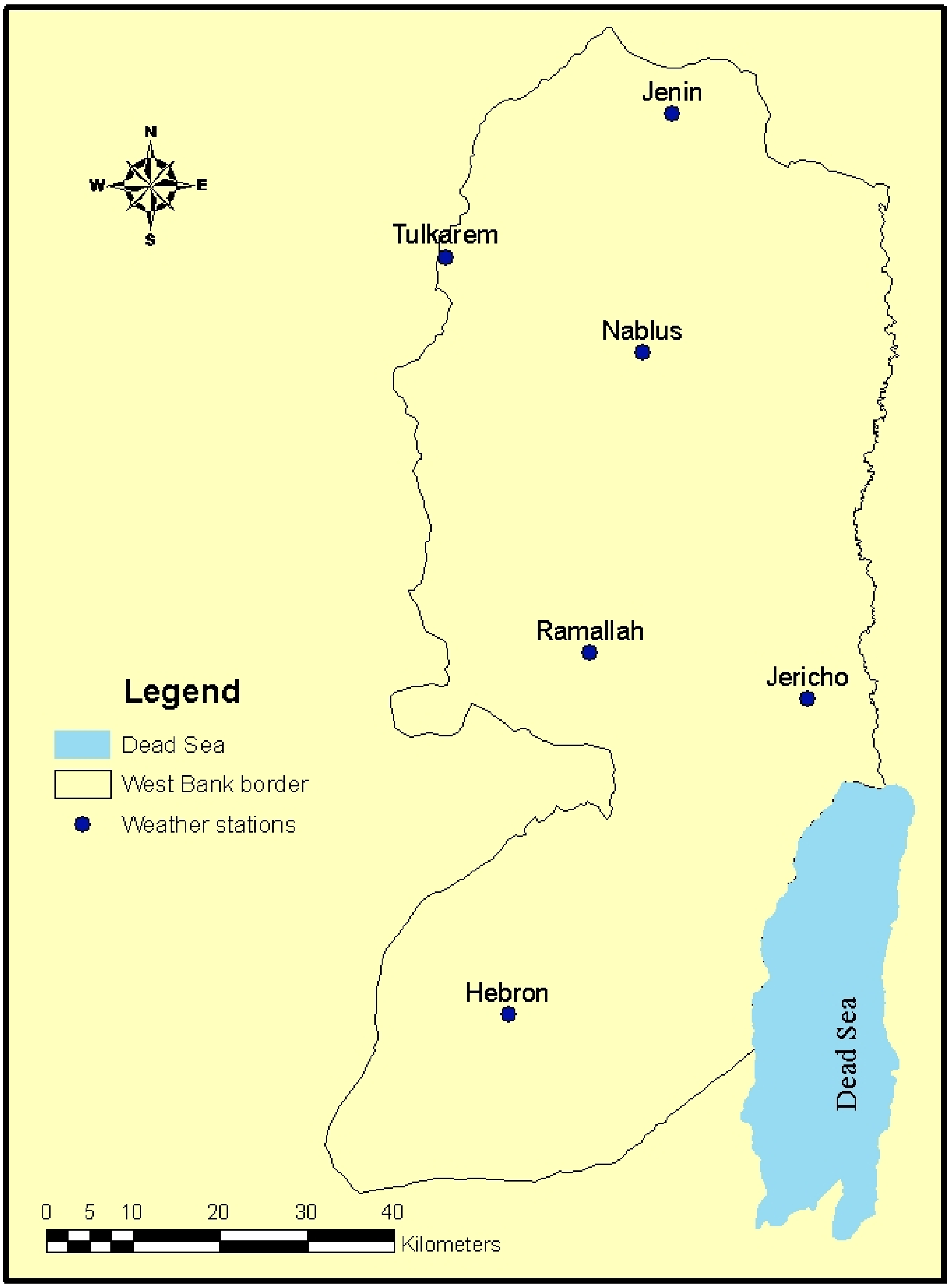

Fig 2.1: Locations of the selected rainfall stations in the West Bank

Chapter Three

Statistical Background

3.1 Describing Time Series

Time series is a set of observations measured at successive points in time, over successive periods of a time series data. It is used past data as the basis for estimating future results (Chatfield, 1980).
Time series is composed of a number of component parts which are in some way related to one another or the whole, these components parts are trend (T), cyclical (C), Seasonal (S), and irregular (I) (Chatfield, 1980).

3.1.1 Trend Component (T)

In time series the measurement may be taken every hour, day, week, month, year or any other regular interval. Although time series data is generally exhibit random fluctuation, the time series may still show gradual shifts or movement to relatively higher or lower value over a longer period of time, this gradual shifting of the time series due to long term factor is referred to as the trend (Chatfield, 1980).

3.1.2 Cyclic component (S)

Cycles are indicated by the runs of observations above and below the trend line (Chatfield, 1980).

3.1.3 Seasonal Component

The seasonal component represents any repeating pattern that is less than one year in duration (Chatfield, 1980).

3.1.4 Irregular Component (I)

It is the residual or catchall factor that accounts for the deviation of the actual time series value from what we would expect if the trend, cyclical and seasonal components completely explained the time series. It is account for the random variability in the time series and it is unpredictable (Anderson et, 1990).
There are various types of time series models some of them are, Single Exponential Smoothing model (SESM), Auto Regressive Moving Average model (ARMA), Auto Regressive Integrated Moving Average model (ARIMA), Decomposition model (DCM), and Winters method (WM).

3.2 Exploration of Data

To analyze a time series, the first step is to plot the observations against time, the plot of the time series contains fluctuations, these fluctuations that appear in the time series plot are due to the four components trend (T), cyclic (C) seasonal (S) and irregular variations (I). In addition to these four sources of variation, the graph enables us to look for extreme observations like turning points where an upward trend suddenly changes to a downward trend (Chatfield, 1980).

3.3 Averaging Techniques

The method of Moving Average is one of the simplest approaches to modeling and forecasting a time series. Moving average is helpful in looking for patterns in data when the underlying signal is obscured by noise. In this sense Moving Average are smoothers in that systemically reduce the noise in the observations, thus making the underlying pattern easy to detect (Douglas et al, 1990).
Some of the following statistics such Simple Average (SA), Single Moving Average (SMA), and Double Moving Average (DMA) can be used to smooth a time series.
(Yaffe and Mcgee, 2000).

3.3.1 The Simple Average

Simple average (SA) gives each observation an equal weight and it describe a series that does not exhibit a trend and it may be helpful in comparing the general levels of different series, each of which may have a constant mean without trend, Weighted Simple Averages (WSA) can also be used where more recent observations are given higher weights than remote observations (Yaffe and Mcgee, 2000).

3.3.2 The Single Moving Average

It is a moving mean of a fixed number of observations. It is based on the same number of observations in a sliding time span that moves its point of origin one time span at a time from the beginning to the most recent observation. The single Moving Average is defined as:

$$M_T = \frac{X_T + X_{T-1} + X_{T-2} + ... + X_{T-N+1}}{N} \quad ....[1]$$

(Yaffe and Mcgee, 2000).

Where X_T is observation at time T, and N is the number of observations.
For instance, the six – period moving average is:

$$M_6 = \frac{X_6 + X_5 + X_4 + X_3 + X_2 + X_1}{6} \quad .... [2]$$

The end effect of single moving average is to smooth out irregular fluctuations in the time series (Yaffe and Mcgee, 2000).

3.3.3 Double Moving Average

When the time series exhibits a linear trend over time, Double Moving Average is used for smoothing not the original series rather the series of Single Moving Averages. I.e. it is a moving average of the moving average, the N-Period double moving average is:

$$M_T^{[2]} = \frac{M_T + M_{T-1} + ... + M_{T-N+1}}{N} \quad ....[3]$$

Where the bracketed superscript [2] denotes a second – order statistics not a squared quantity. (Yafee and Mcgee, 2000).

3.4 Modeling Techniques of Rainfall Time Series

The purpose of this study is to present quantitative procedure to be usefully used in forecasting systems that routinely predict values important in decision processes.
These statistical methods analyze historical data in order to provide estimates of the future. In this research we used two forecasting methods which are widely used; these methods are: Autoregressive Integrated Moving Average (ARIMA) and Nonlinear Regression Model.

3.4.1 Autoregressive Integrated Moving Average of order (*P, d, q*)

Autoregressive Integrated Moving Average (ARIMA) time series models (Box and Jenkins model) form a general class of linear models that are widely used for modeling and forecasting time series.
This model is one of the most sophisticated of all time series techniques as it is capable of handling almost any pattern of data. It usually provides the most accurate short rang forecasts of any model and even enables statistical tests to be applied.
The non – seasonal (ARIMA) (P, d, q) models for a time series [x_1,x_2 ...] is defined as:

$$\phi_{\rho}(\beta)\omega_t = \delta + \theta_q(\beta)\varepsilon_t \quad \ldots\ldots [4]$$

Where:

$$\omega_t = \begin{cases} \nabla^d X_t & d > 0 \\ X_t & d = 0 \end{cases} \quad \ldots\ldots [5]$$

And where:
p: order of non – seasonal autoregressive term.
d: order of non – seasonal differencing.
q: order of non – seasonal moving- average term.

(β) is the backward shift operator where:

$\beta X_t = X_{t-1}$

$\beta^m X_t = X_{t-m}$
(Abraham ang Ledolter, 1983).

And $\nabla X_t = (1 - \beta)X_t = X_t - X_{t-1}$ is the backward difference operator, (ϕ_i) and (θ_j) the autoregressive and moving average parameters.
Of order i = 1, 2, 3… p and j = 1, 2, 3… q, (δ) is constant, and (ε_t) white noise with mean equaled zero and constant variance (σ^2): WN (0, σ^2)
ARIMA (P, d, q) models are combinations of an autoregressive part AR (p).

$$\phi_p(\beta) = 1 - \phi_1\beta - \phi_2\beta^2 - \ldots - \phi_p\beta^p \quad \ldots\ldots [6]$$

And moving average MA (q) part:

$$\theta_q(\beta) = 1 - \theta_1\beta - \phi_2\beta^2 - .... - \theta_q\beta^q \text{ ....……… [7]}$$

(Abraham and Ledolter, 1983).

For illustration of ARIMA modeling of non – seasonal time series we consider the ARIMA (1, 0, 1) process:

$$\phi_1(\beta)X_t = \theta_1(\beta)\varepsilon_t \text{ ……………………………………….…… [8]}$$

$$X_t = \phi_1 X_{t-1} - \theta_1\varepsilon_{t-1} + \varepsilon_t$$

In this model current observation (X_t) depends on the observation (X_{t-1}) (immediately proceeding) and on past and current errors in the series (Montgomery and Johnson, 1976).

The order of the model will be estimated by Least Square Method (LSM).

Because ARIMA model is applicable to stationary time series, the parameters ($ø_i$ (i = 1, 2, …..p) and (θ_j (j = 1, 2, …..q)) are chosen in order to maintain stationary, stationary means that the mean and variance do not change over time or position. Time series is called stationary if it satisfies:

1- $E(X_t)$ = constant ……………………………………………..[9]

2- $\mathrm{Cov}(X_t, X_s) = \begin{cases} \text{constant } = \nu_0 \ \forall s, \forall t, t = s \\ f(|s-t|), \forall s, \forall t, t \neq s \end{cases}$ …..…………[10]

Where E (X_t) and Cov(X_t, X_s) are the mean and variance of the series respectively.
And (X_s), (X_t) are the observations at time s and t respectively.

3.4.2 Mathematical Modeling (Nonlinear Regression)

Mathematical modeling is the process of creating a mathematical representation of some phenomenon in order to gain a better understanding of that phenomenon.
It is a process that attempts to match observation with symbolic statement.
During the process of building a mathematical model, the modeler will decide what factors are relevant to the problem and what factors can be de-emphasized.
Once a model has been developed and used to answer questions, it should be critically examined and often modified to obtain a more accurate reflection of the observed reality of that phenomenon. In this way, mathematical modeling is an evolving process; as new insight is gained, the process begins again as additional factors are considered. "Generally the success of a model depends on how easily it can be used and how accurate are its predictions" (Edwards and Hamson, 1994).

In this study we develop nonlinear model which is cosine function model for each station in the West Bank.

Nonlinear regression is a method of finding a nonlinear model of the relationship between the dependent variable and a set of independent variables. Unlike traditional linear regression, which is restricted to estimating linear models, nonlinear regression can estimate models with arbitrary relationships between independent and dependent variables.

Cosine function describes a wave; a wave can be described as a disturbance that travels through a medium from one location to another location. The main components of a wave are amplitude, wavelength, and the frequency.
The amplitude is the height of the wave**.** The wavelength is the distance from one wave top, or crest, to the next. The frequency of a wave refers to how often the particles of the medium vibrate when a wave passes through the medium. To present oscillation in the series the model can be described by the equation:

$$Y(t) = a + b \times \cos\alpha \qquad [11]$$

Where Y (t) is the observed value at any time (t), a, b are constant will be estimated by the SPSS software using regression analysis. (a) Is chosen based on the maximum correlation coefficient between actual and estimated rainfall. (α) = (c $\times$r +d) where r is the radian measure of the angle where the initial value of the angle equal 0° at month January 1975 at the beginning of the series, 1° at month February, and so on. c and d are constant.

It is easy to convert between degree measurement and radian measurement. The circumference of the entire circle is 2π (π is about 3.14159), so it follows that 360° equals 2π radians. Hence, 1° equals $\pi/180$ radians and 1 radian equal $180/\pi$ degrees.

3.5 Regression Analysis

Regression Analysis (RA) is a statistical technique for modeling and investigation the relationship between tow or more variables. Furthermore, regression analysis is often useful as a forecasting technique. (Douglas et al, 1990).

3.5.1 Simple Linear Regression

If we wish to determine the relationship between independent variable (X) and dependent variable (Y) and if we assume that the relation between these variables is a straight line and that the observed value of (Y) at any time (T) is a random variable, then we may write the expected value of (Y) for each value of (X) as:

$$E(Y / X) = b_0 + b_1 Y \qquad [12]$$

(Douglas et al, 1990).

Where the intercept b_0 and slope b_1 are unknown constant.

The observed value of (Y) can be described by:

$$Y = b_0 + b_1 X + \varepsilon \qquad [13]$$

Where (ε_t) is a random error or noise component.

3.5.2 Least -square methods

The least Square Methods (LSM) are probably the most popular technique in statistics. This is due to several factors:

First, most common estimators can be casted within this framework.
Second, the mathematical tools and algorithms involved in (LSM) have been well studied for a relatively long time.

There are many techniques that could be used to estimate the unknown parameters b_0 and b_1 in equation (11). A method used quite frequently is Least Square, in which estimates of b_0 and b_1 are chosen to minimize the error or residual sum of squares.

Suppose that there are (n) observation available, say $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$.The model written in terms of these observation is (Douglas et al, 1990):

$$Y_i = b_0 + b_1 X_i + \varepsilon_i \qquad [14]$$

Where $i = 1, 2, \ldots n$

And the errors sum of squares or least-square function is (Douglas et al, 1990):

$$l(b_0, b_1) = \sum_{i=1}^{n} (y_i - b_o - b_1 x_i)^2 \qquad [15]$$

To estimate b_0 and b_1 by the method of least squares, we must choose b_0 and $b_1$to minimize equation. Therefore it is necessary that b_0 and b_1 satisfy

$$\left.\frac{\partial \ell}{\partial b_0}\right|_{\hat{b}_0, \hat{b}_1} = \left.\frac{\partial \ell}{\partial b_1}\right|_{\hat{b}_0, \hat{b}_1} = 0 \qquad [16]$$

This results in the following equations:

$$\left.\frac{\partial \ell}{\partial b_0}\right|_{\hat{b}_0, \hat{b}_1} = -2 \sum_{i=1}^{n} (y_i - \hat{b}_0 - \hat{b}_1 x_i) = 0 \qquad [17]$$

$$\left.\frac{\partial \ell}{\partial b_1}\right|_{\hat{b}_0, \hat{b}_1} = -2 \sum_{i=1}^{n} (y_i - \hat{b}_0 - \hat{b}_1 x_i) x_i = 0 \qquad [18]$$

Equations (17) and (18) may be rewritten as:

$$\hat{b}_0 n + \hat{b}_1 \sum_{i=1}^{n} x_i = \sum_{i=1}^{n} y_i \qquad [19]$$

$$\hat{b}_0 \sum_{i=1}^{n} x_i + \hat{b}_1 \sum_{i=1}^{n} x_i^2 = \sum_{i=1}^{n} y_i x_i \quad \text{........................ [20]}$$

Equations (19) and (20) are called the least-squared normal equations. The solution to the normal equations are the least-squares estimators for b_0 and b_1, or

$$\hat{b}_1 = \frac{\sum_{i=1}^{n} x_i y_i - \left(\sum_{i=1}^{n} x_i\right)\left(\sum_{i=1}^{n} y_i\right) \big/ n}{\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2 \big/ n} = \frac{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)\left(y_i - \bar{y}\right)}{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2} = \frac{S_{xy}}{S_{xx}} \quad \text{.. [21]}$$

$$\hat{b}_0 = \bar{y} - \hat{b}_1 \bar{x} \quad \text{... [22]}$$

Where $\bar{y} = 1/n \sum_{i=1}^{n} yi$ and $\bar{x} = 1/n \sum_{i=1}^{n} xi$.

Note the definitions of the corrected sum of products (S_{xy}) and the corrected sum of squares (S_{xx}) implicate in equation [19].

The fitted simple linear regression model is:

$$\hat{y} = \hat{b}_0 + \hat{b}_1 x \quad \text{... [23]}$$

And the fitted values $\hat{y}$ corresponding to the observed x_i, Where i=1, 2, ….. n

$$\hat{y}_i = \hat{b}_0 + \hat{b}_1 x_i \quad \text{... [24]}$$

i = 1, 2, ….. n

The difference between the ith fitted value and the observed value X_i is called a residual, say

$$r_i = y_i - \hat{y}_i \quad \text{... [25]}$$

i = 1, ..., n

The coefficient of determination (R^2) is defined by:

$$R^2 = \frac{SS_R}{S_{xx}} \quad \text{... [26]}$$

Where (SS_R) is the regression sum of squares computed as

$$SS_R = \hat{b}_1 S_{xy} \quad [27]$$

Is called the coefficient of determination, and it is often used to judge the adequacy of a regression model (Douglas et al, 1990).
We have only considered the problem of fitting a straight line to paired data. More generally, the method of least squares can also be used to fit other kinds of curves and also to derive predicting equations in more than tow unknowns. Of the many equations that can be used to express relationships among than tow variables, the form:

$$\hat{y} = c_1 + c_2 x_1 + c_3 x_2 + c_4 x_3 + \ldots \quad [28]$$

In which ($\hat{y}$) is the variable to be predicted and the x's (which may be several) are the known variables selected during past time on which the predictions are to be based.
The numerical constants of this equation were obtained by method of least squares.
In a situation like this, the least squares methods requires the solution of as many normal equation as there are variables, so it required powerful machine programs for their solutions (Douglas et al, 1990).

3.6 Tests for time series before and after modeling

3.6.1 Test of stationary

Because Box – Jenkins ARIMA method is applicable to stationary time series, it's first necessary to test whether the series is stationary or not, non – stationary time series behavior could be a result of random walk or trend. Dickey – Fuller test (1970) is used to perform stationary test. (Salas et al., 1997).

The null hypothesis of this test is that the process is non – stationary and its alternative hypothesis is that the time series is stationary; rejection of the null hypothesis concludes stationary. Three forms of this test are available, one form for non – stationary in mean another for non – stationary in trend, and the third form test for non – stationary in both mean and trend (Dahabiyeh, H. M., 2002).

3.6.2 Akaike Information Criterion (AIC)

This criterion is designed to determine the number of parameters (i.e. p and q) in the ARIMA model. Let (N) denotes the number of observation in a time series and (K) denotes the number of ARIMA parameters (i.e. K = p + q) to be estimated.
The Akaike Information Criterion (AIC) were developed by Hirotsugu in 1971, is a measure of the goodness of fit of an estimated statistical model. The AIC is an operational way of trading off the complexity of an estimated model against how well the model fits the data.

Akaike (AIC) is given by:

$$AIC(K) = N.\ln(\sigma^2_{\varepsilon}) + 2K \quad (29)$$

Where ($\sigma^2{}_{\varepsilon}$) is the maxim likelihood estimate of the residual variance, Akaike suggested such criterion to select a good candidate model among competing ARIMA models. Under this criterion the models which gives the minimum AIC is the one to be selected and fitted (Salas et al. 1997).

3.7 Methodology

3.7.1 Methods that used in Building a ARIMA Model

Rainfall records of 6 meteorological stations, distributed over three climatic regions were obtained from Palestinian Metrological Department. These data records were collected as monthly rainfall in millimeter (*mm*) and they covered different durations of studied period (series length). Fitting time series models using ARIMA time series proceeds systematically as follows:

Step (1.a): plotting the series versus time.

Step (1.b): mean and variance of the series are calculated where maximum and minimum values are identified.

Step (1.c): Estimation of parameters and coefficients in equation (4), this is done by the following steps:

Step (2.a): determine the order of the model, (the values of p and q) using (E- views) software.

Step (2.b): Test of goodness of fit of the selected model, after model parameters are estimated, model goodness of fit is tested by the R-square, and Akaike Information Criterion (AIC**)** the best fitted model is selected based on the minimum value of the Akaike Information Criterion (AIC**)** measure. After the correct model is adopted, the next step is to employ it for forecasting purposes.

3.7.2 Methods that used in Building a Mathematical Model

The following steps outline a general approach to the mathematical modeling process:

1. Identify the problem, define the terms in your problem, and draw diagrams where appropriate.
2. Begin with a simple model, stating the assumptions that you make as you focus on particular aspects of the phenomenon.
3. Identify important variables and constants and determine how they relate to each other. This done by using SPSS software by least square method.
4. Develop the equation(s) that express the relationships between the variables and constants.

After the correct model is adopted, the next step is to employ it for forecasting purposes.

3.8 Time Series Forecasting

When we have a set of observations measured at successive points in time or over successive periods, so we have a time series data. Forecasting is projection or prediction of future values of time series that means it is the process of obtaining information from time series data for forecasting purpose. Forecasting method can be classifies as quantitative or qualitative. Quantitative forecasting methods are based on an analysis of historical data concerning a time series. Qualitative forecasting methods applied when there is no historical data available (Franses, 1998). This research applies quantitative forecasting methods.

Chapter Four

Statistical Analysis of the Selected Station

4.1 Forecasting Monthly Rainfall Implementing Nonlinear Regression Model

The nonlinear regression model has been applied to monthly records for the six stations in the West Bank. The modeling has been carried out by applying regression analysis using statistical software package (SPSS), in order to estimate the best variable based on equation (11)

$$Y(t) = a + b \times \cos\alpha$$

In general rainfall will decrease in future for most of the selected stations in the West Bank since the average of the expected rainfall less than the average of actual rainfall where:

For Tulkarem station: This station is located at longitude 35.03°, latitude 32.31° and at 65 m above sea level.
Data series were collected for the period between 1975 to 2005. The hydrological year divided into 7 month from October to April.
The Basic characteristic of the series are:

(a) It contains (211) observations with mean (89) mm, and standard deviation (87).

(b) Maximum rainfall value is (436) mm in December 1991, while the minimum is (0) mm.
In general rainfall will decrease in future. The average of expected annual rainfall for 13 upcoming years from 2008/2009 to 2020/2021 will be about 521 mm, where the average of actual annual rainfall of the series is 620 mm. Data analysis in Fig. 4.1 shows that the decrease in rainfall will be linearly.
The forecasting equation for Tulkarem Station:

$$X_t = 79.02 + 15.36 \times \cos(52.43 \times r + .73) \qquad \text{(mm)}$$

For Jenin station: This station is located at longitude 35.29°, latitude32.45° and at 138 m above sea level.
Data series were collected for the period between 1975 to 2005.
The Basic characteristic of the series are:

(a) It contains (211) observations with mean (64) mm, and standard deviation (67).

(b) Maximum rainfall value is (367) mm in February 1992, while the minimum is (0)

The average of expected annual rainfall for 13 upcoming years from 2008/2009 to 2020/2021 will be about 420 mm, where the average of actual annual rainfall of the series is 444 mm. Data analysis in Fig.4.2 shows that there will be a slight increase in rainfall but less than annual rainfall
The forecasting equation for Jenin Station:

$$X_t = 52.60 - 5.05 \times \cos(160.58\, r - 255.44) \quad \text{(mm)}$$

For Jericho station: This station is located at longitude 35.45°, latitude 31.86° and at -260 m below sea level.
Data series were collected for the period between 1975 to 2005.
The Basic characteristic of the series are:

(a) It contains (211) observations with mean (21) mm, and standard deviation (22).

(b) Maximum rainfall value is (112) mm in February 1992, while the minimum is (0)

The average of expected annual rainfall for 13 upcoming years from 2008/2009 to 2020/2021 will be about 131 mm, where the average of actual annual rainfall of the series is 127 mm. Data analysis in Fig.4.3 shows that a steady in rainfall in future but less than average.
The forecasting equation for Jericho Station:

$$X_t = 18.42 - 2.84 \times \cos(47.13r + 45.027) \quad \text{(mm)}$$

For Rammallah station: This station is located at longitude 35 .12°, latitude31 .54° and at 874 m above sea level.
Data series were collected for the period between 1975 to 2005.
The Basic characteristic of the series are:

(a) It contains (211) observations with mean (89) mm, and standard deviation (89).

(b) Maximum rainfall value is (611) mm in February 1992, while the minimum is (0).

. The average of expected annual rainfall for 13 upcoming years from 2008/2009 to 2020/2021 will be about 495.8 mm, where the average of actual annual rainfall of the series is 514.2 mm. Data analysis in Fig.4.4 shows that there will be fluctuation in rainfall but less than average.
The forecasting equation for Rammallah Station:

$$X_t = 75.54 + 16.14 \times \cos(61.91r + 256.37) \quad \text{(mm)}$$

For Nablus station: This station is located at longitude 35.25°, latitude32.22° and at 533 m above sea level.
Data series were collected for the period between 1975 to 2005.
The Basic characteristic of the series are:

(a) It contains (211) observations with mean (94) mm, and standard deviation (92).

(b) Maximum rainfall value is (472) mm in December1991, while the minimum is (0)

The average of expected annual rainfall for 13 upcoming years from 2008/2009 to 2020/2021 will be about 637mm, where the average of actual annual rainfall of the series is 655 mm. Data analysis in Fig.4.5 shows that there will be a slight increase in rainfall but less than annual rainfall.

The forecasting equation for Nablus Station:

$$X_t = 75.83 + 18.87 \times \cos(51.46\,r + 4.01) \qquad \text{(mm)}$$

For Hebron station: This station is located at longitude 35.10°, latitude 31.53° and at 1005 m above sea level.
Data series were collected for the period between 1975 to 2005.
The Basic characteristic of the series are:

(a) It contains (211) observations with mean (80) mm, and standard deviation (77).

(b) Maximum rainfall value is (335) mm in February 1991, while the minimum is (0)

In general rainfall will decrease in future. The average of expected annual rainfall for 13 upcoming years from 2008/2009 to 2020/2021 will be about 436 mm, where the average of actual annual rainfall of the series is 556 mm. Data analysis in Fig. 4.6 shows that the decrease in rainfall will be linearly.

The forecasting equation for Hebron Station:

$$X_t = 75.47 - 14.93 \times \cos(50.46\,r + 1.76)$$

These formulas were applied for forecasting purpose, forecasting monthly rainfall for each station using nonlinear regression model from 1975/6 to 2020/21 were given in Appendix (A1). Comparison between the sum of forecasted and actual values for annual rainfall for each station were given in Appendix (A2).

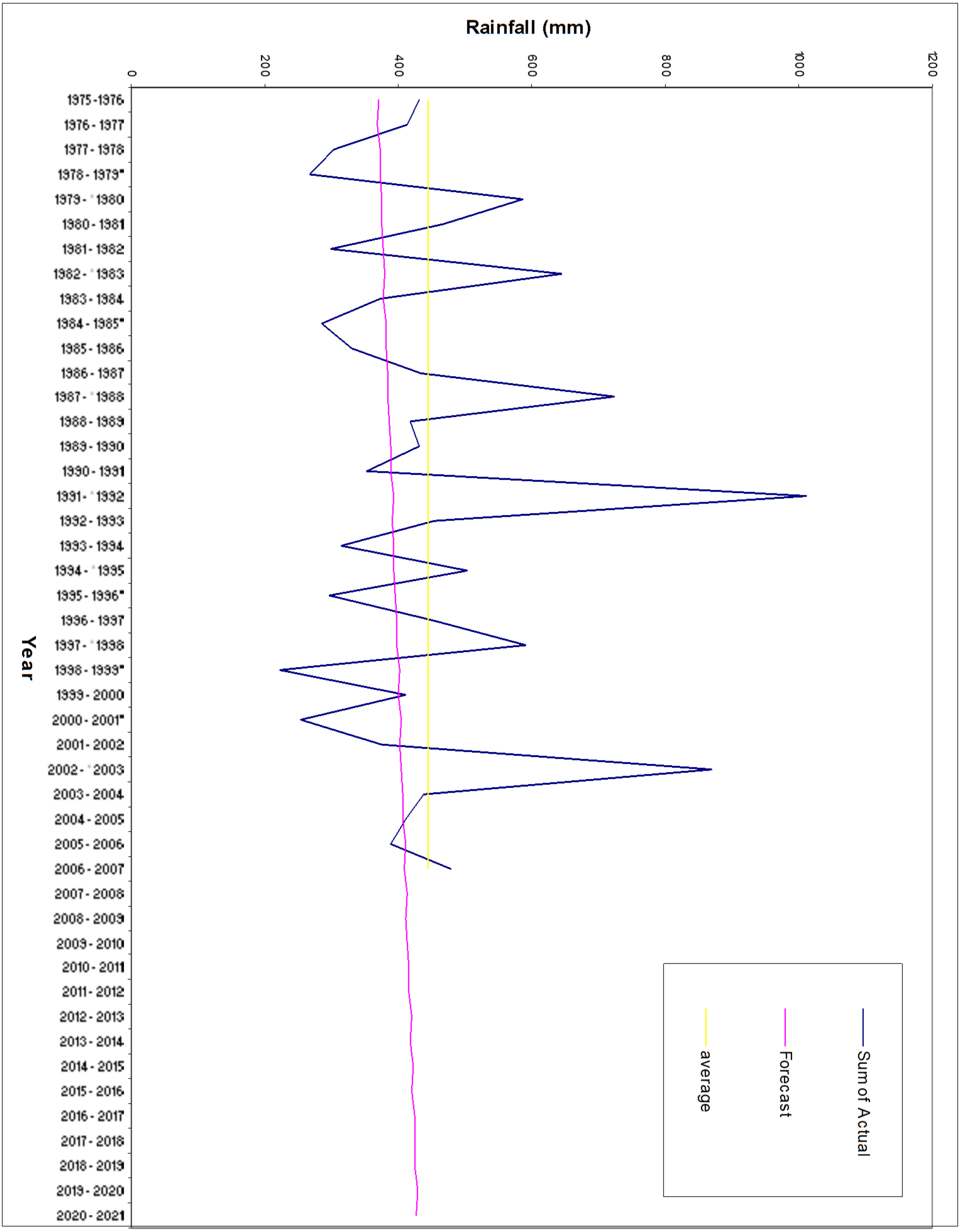

Figure 4.1: Sum of actual and forecast rainfall values implementing nonlinear model for years 1975-2021 for Tulkarem station

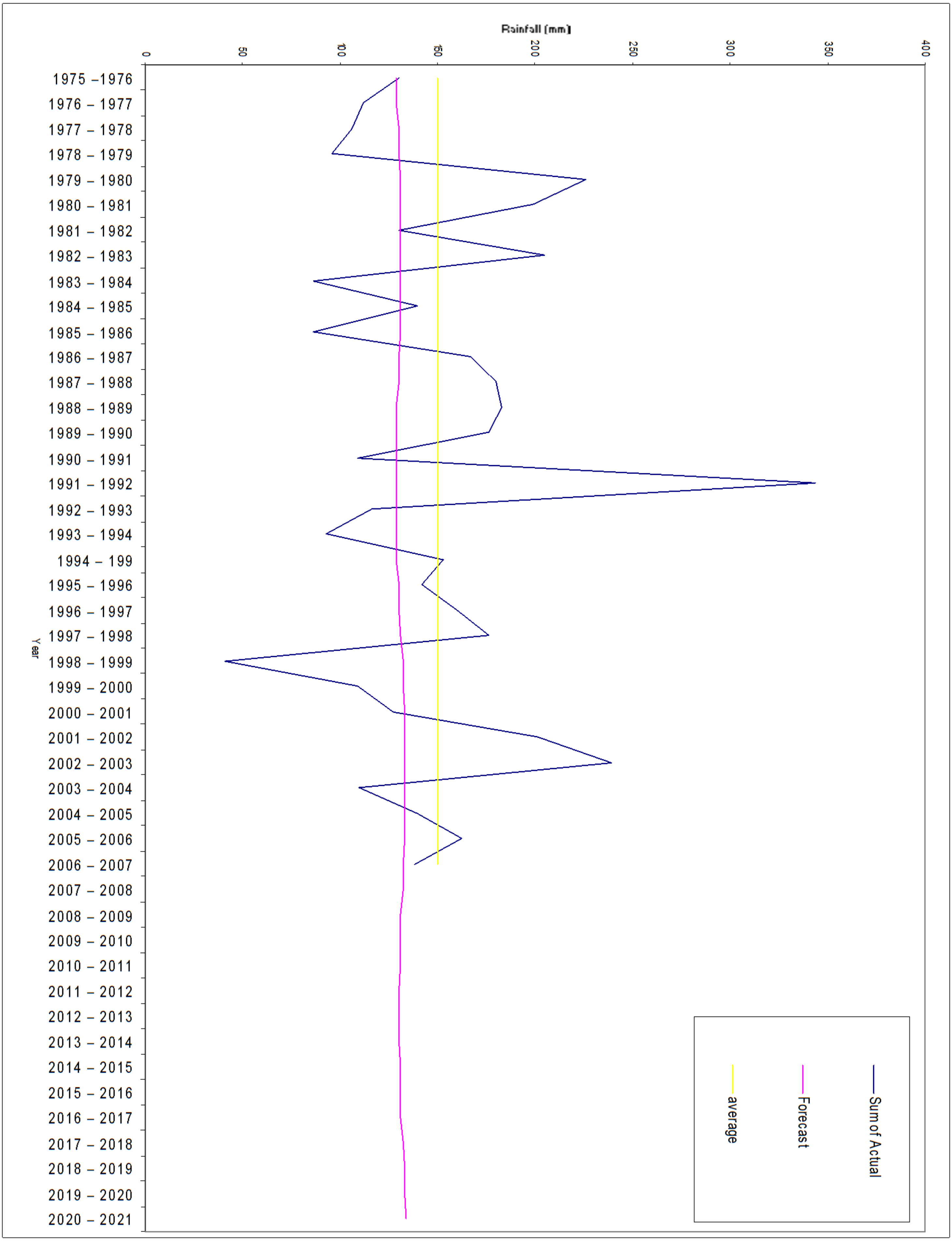

Figure 4.3: Sum of actual and forecast rainfall values implementing nonlinear model for years 1975-2021 for Jericho station

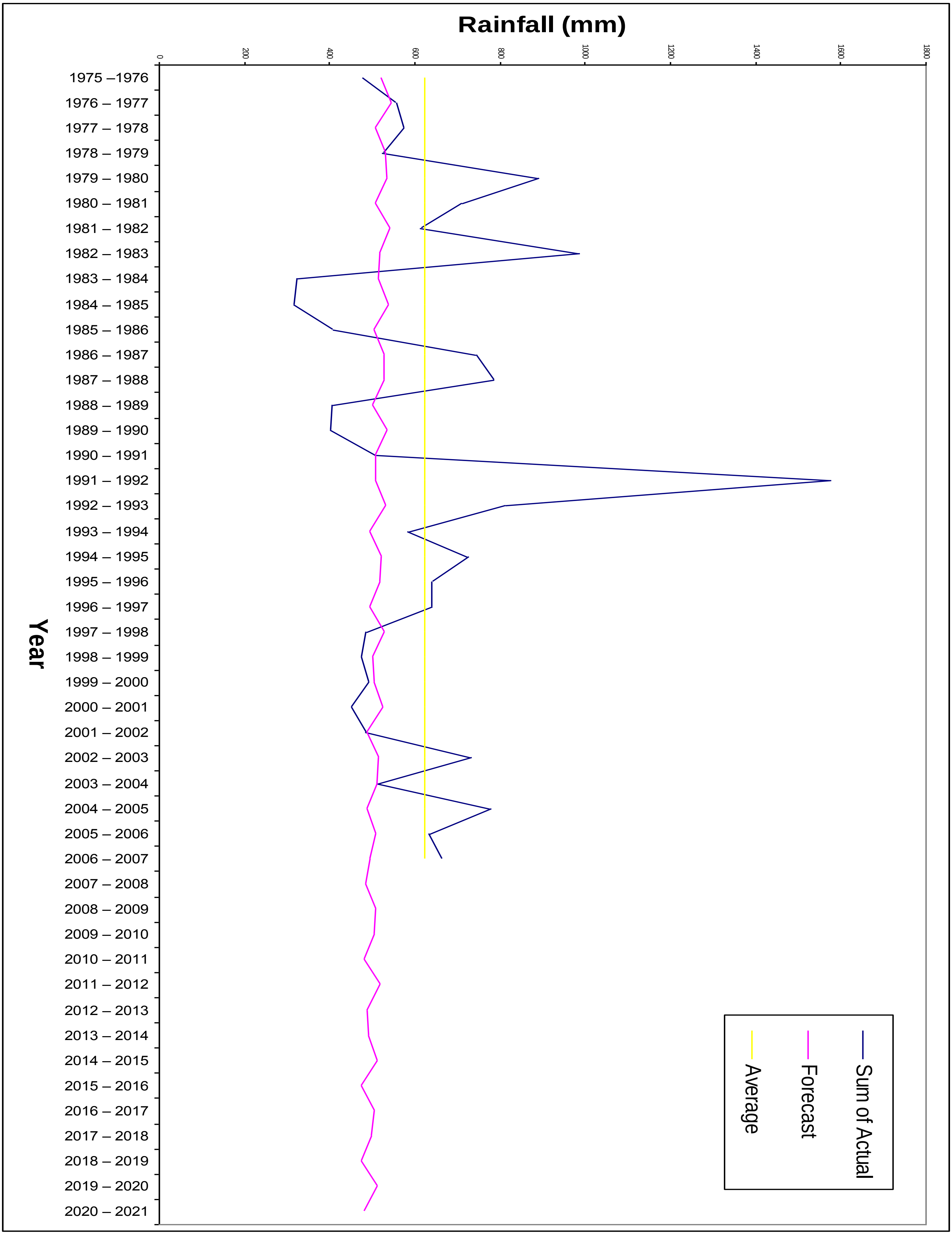

Figure 4.4: Sum of actual and forecast rainfall values implementing nonlinear model for years 1975-2021 for Rammallah station

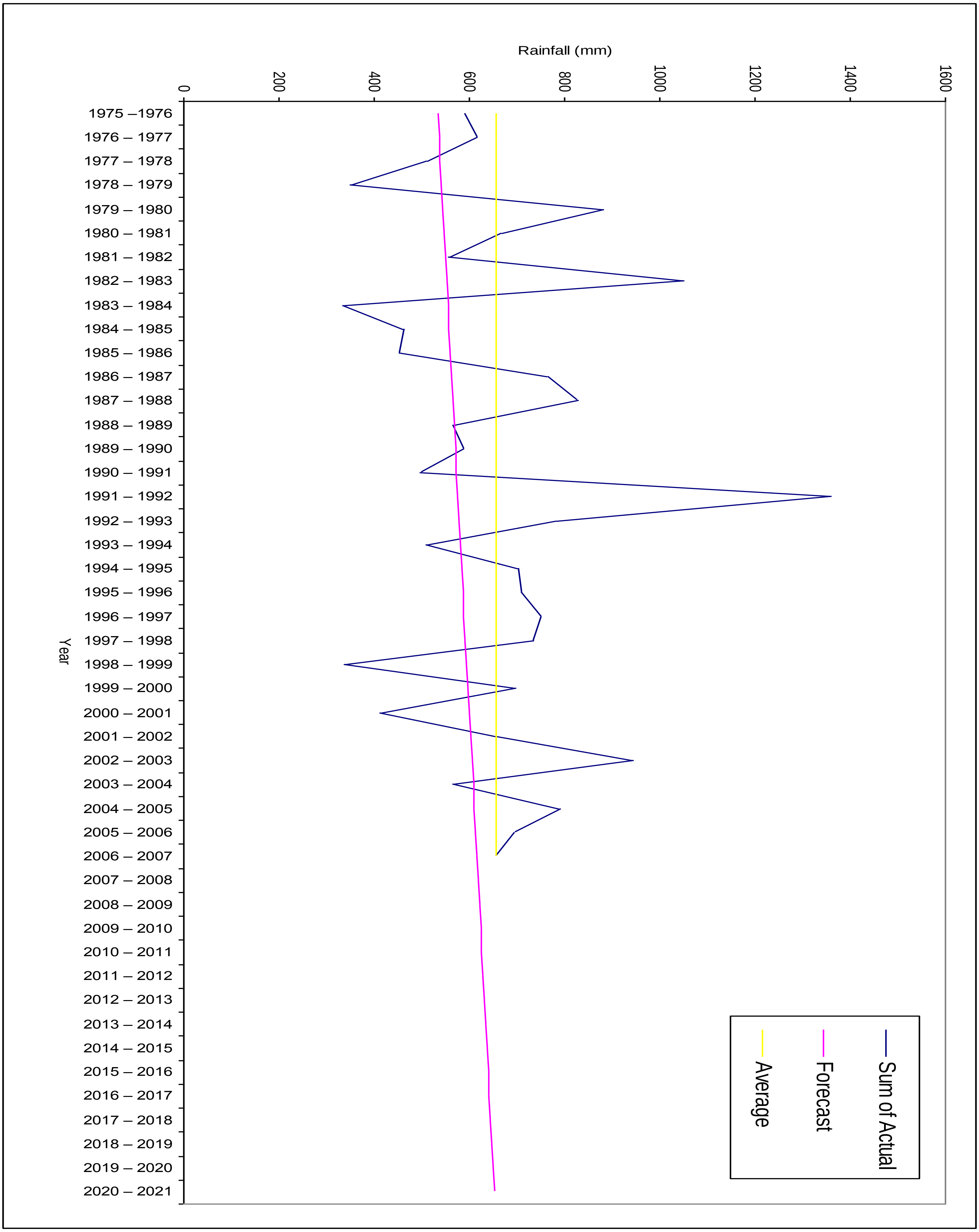

Figure 4.5: Sum of actual and forecast rainfall values implementing nonlinear model for years 1975-2021 for Nablus station

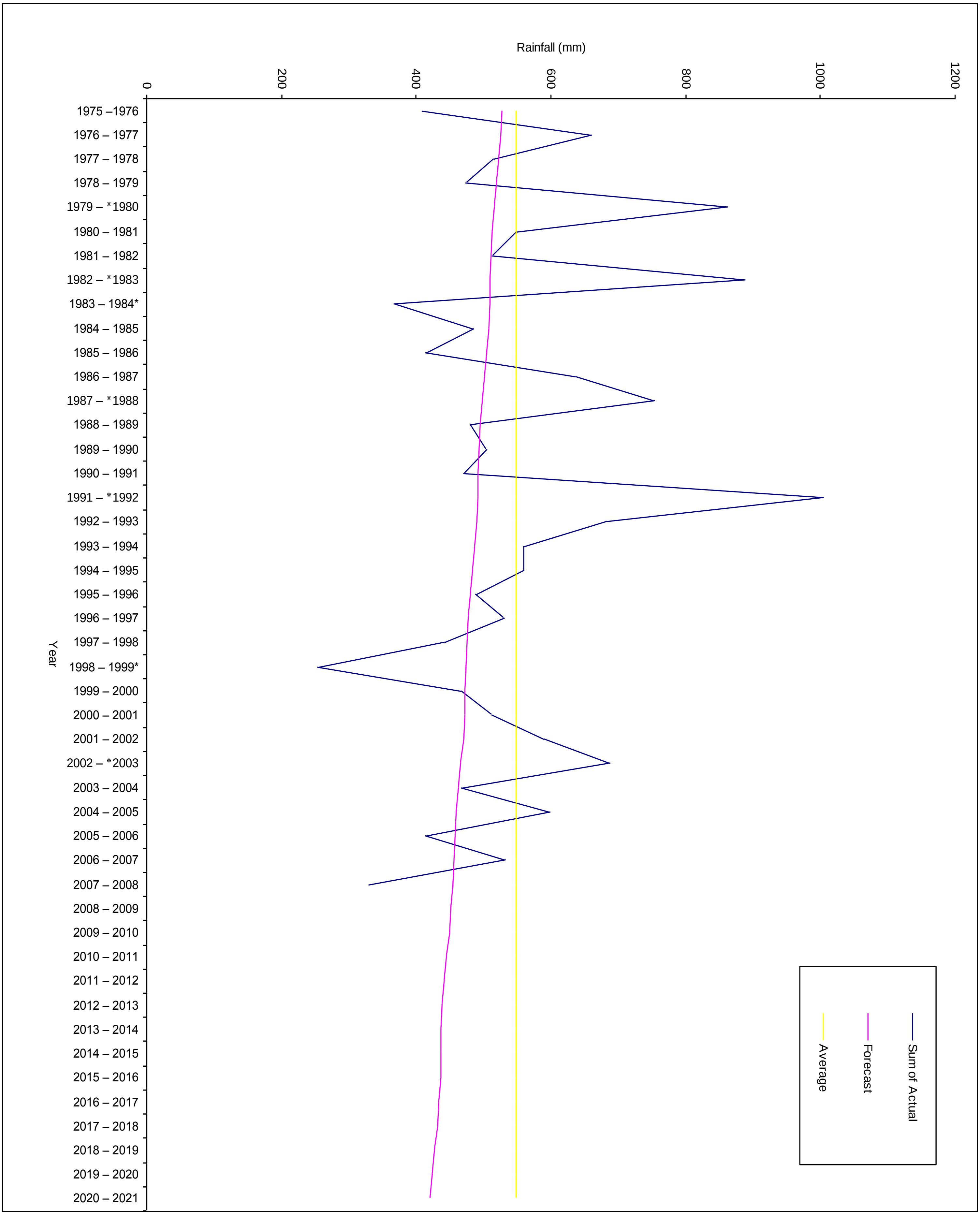

Figure 4.6: Sum of actual and forecast rainfall values implementing nonlinear model for years 1975-2021 for Hebron station

4.2 Forecasting Monthly Rainfall Implementing ARIMA Model

The ARIMA model has been applied to monthly records for the six stations in the West Bank. The modeling has been carried out using sophisticated statistical software package (E-views), from equation (4)

$$\phi_{\rho}(\beta)\omega_t = \delta + \theta_q(\beta)\varepsilon_t$$

In general rainfall will decrease in future for all most of the selected stations in the West Bank since the average of the expected rainfall less than the average of actual rainfall where:

For Tulkarem station the average of expected annual rainfall for 3 upcoming years from 2007/2008 to 2009/2010 will be about 457 mm, where the average of actual annual rainfall is 614 mm from 1981/82 to 2004/5.
Many trials were used to assign the best model based on minimum Akaike Information Criterion. Data analysis in Fig. 4.7 shows that the decrease in rainfall will be linearly.
The forecasting equation for Tulkarem Station:

$$X_t = 0.13 - 0.98\sqrt{X_{t-1}} - 0.018\sqrt{X_{t-5}} + 0.96\sqrt{X_{t-12}} + 0.94\varepsilon_{t-12} \text{ (mm).}$$

For Jenin station: the average of expected annual rainfall for 3 upcoming years from 2007/2008 to 2009/2010 will be about 431 mm, where the average of actual annual rainfall is 452.8 mm from 1981/82 to 2006/7. Data analysis in Fig.4.8 shows that there will be a slight increase in rainfall but less than annual rainfall
The forecasting equation for Jenin station:

$$X_t = -0.025 - 0.97\sqrt{X_{t-1}} - 0.0002\sqrt{X_{t-2}} + 0.032\sqrt{X_{t-11}} + 0.95\sqrt{X_{t-12}} + 0.94\,\varepsilon_{t-12} \text{ (mm).}$$

For Jericho station: the average of expected annual rainfall for 3 upcoming years from 2007/2008 to 2009/2010 will be about 127 mm, where the average of actual annual rainfall is 150 mm from 1981/82 to 2006/7. Data analysis in Fig. 4.9 shows that the decrease in rainfall will be linearly. The forecasting equation for Jericho station:

$$X_t =- 0.08 - 0.99\sqrt{X_{t-1}} + 0.017\sqrt{X_{t-5}} + 0.97\sqrt{X_{t-12}} - 0.95\varepsilon_{t-12} \text{ (mm).}$$

For Rammallah station: the average of expected annual rainfall for 3 upcoming years from 2007/2008 to 2009/2010 will be about 440 mm, where the average of actual annual rainfall is 620 mm from 1981/82 to 2006/7. Data analysis in Fig. 4.10 shows that the decrease in rainfall will be linearly. The forecasting equation for Rammallah station:

$$X_t = 0.36 + 0.22\sqrt{X_{t-1}} - 0.31\sqrt{X_{t-3}} + 0.557\sqrt{X_{t-11}} - 0.54\sqrt{X_{t-12}} + 0.39\varepsilon_{t-12} \text{ (mm).}$$

For Nablus station: the average of expected annual rainfall for 3 upcoming years from 2007/2008 to 2009/2010 will be about 385 mm, where the average of actual annual rainfall is 669 mm from 1981/82 to 2006/7. Data analysis in Fig.4.11 shows that a steady in rainfall in future but less than average.

The forecasting equation for Nablus station:

$$X_t = 0.179 - 0.96\sqrt{X_{t-1}} - 0.027\sqrt{X_{t-2}} - 0.019\sqrt{X_{t-8}} + 0.026\sqrt{X_{t-11}} + 0.94\sqrt{X_{t-12}} + 0.94\varepsilon_{t-12} \text{ (mm).}$$

For Hebron station: the average of expected annual rainfall for 3 upcoming years from 2007/2008 to 2009/2010 will be about 388 mm, where the average of actual annual rainfall is 556 mm from 1981/82 to 2006/7. Data analysis in Fig. 4.12 shows that the decrease in rainfall will be linearly. The forecasting equation for Hebron station:

$$X_t = -0.064 - 0.96\sqrt{X_{t-1}} - 0.003\sqrt{X_{t-2}} + 0.045\sqrt{X_{t-11}} + 0.93\sqrt{X_{t-12}} - 0.944\varepsilon_{t-1} \text{ (mm).}$$

These formulas were applied for forecasting purpose, forecasting monthly rainfall for each station using ARIMA model from 1981/82 to 2009/10 were given in Appendix (B1). Comparison between the sum of forecasted and actual values for annual rainfall for each station were given in Appendix (B2).

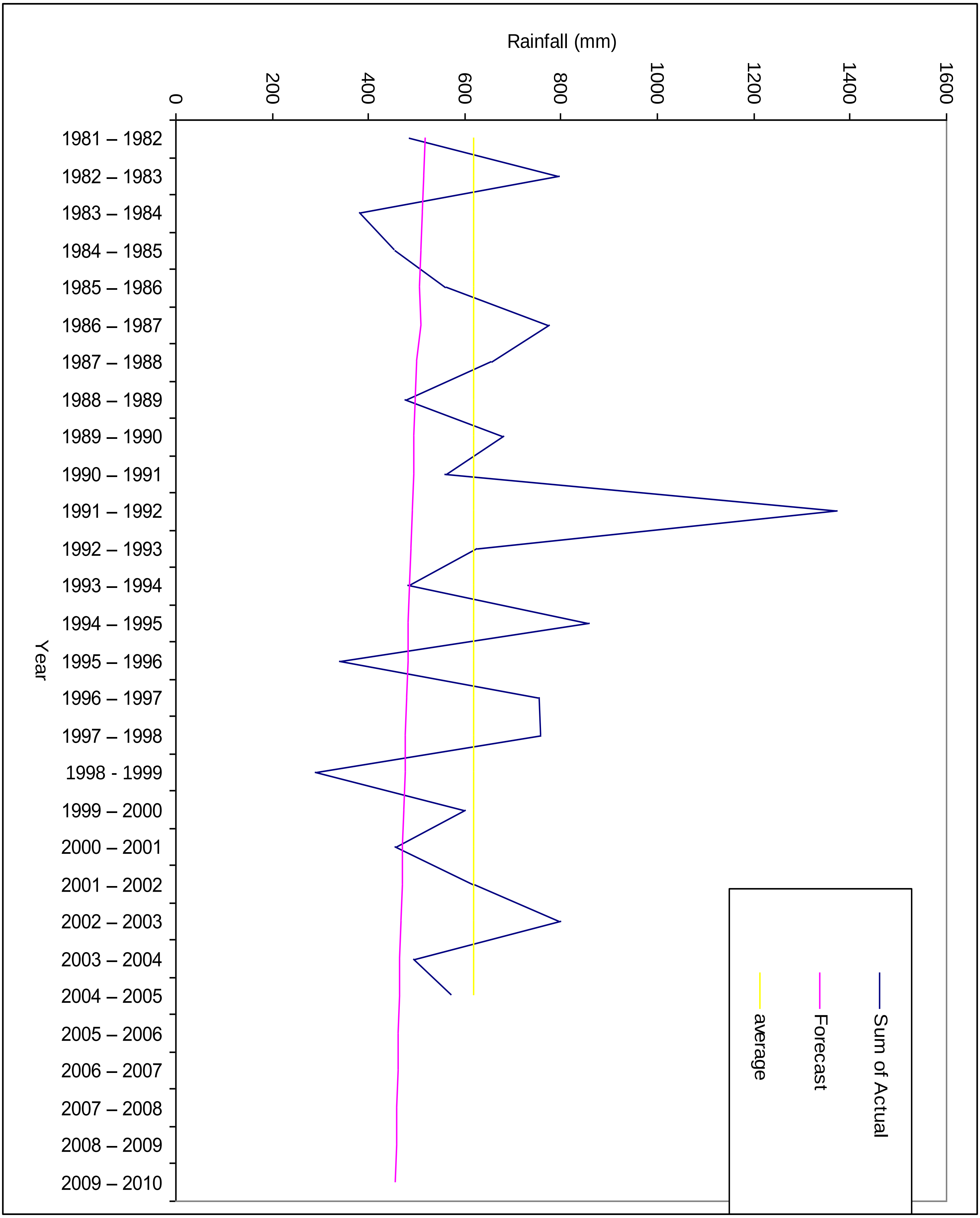

Figure 4.7: Sum of actual and forecast rainfall values implementing ARIMA model for years 1981-2010 for Tulkarem station

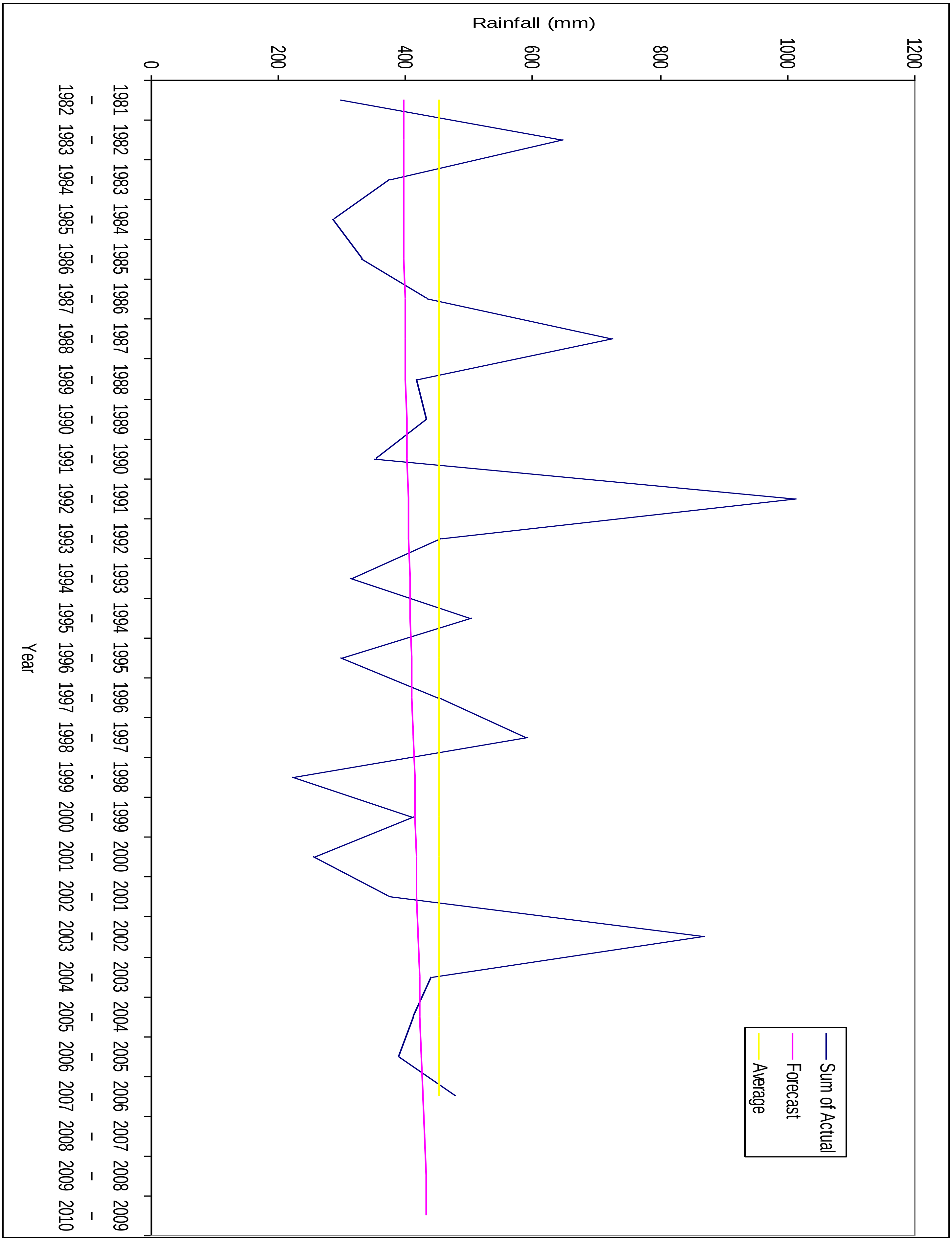

Figure 4.8: Sum of actual and forecast rainfall values implementing ARIMA model for years 1981-2010 for Jenin station

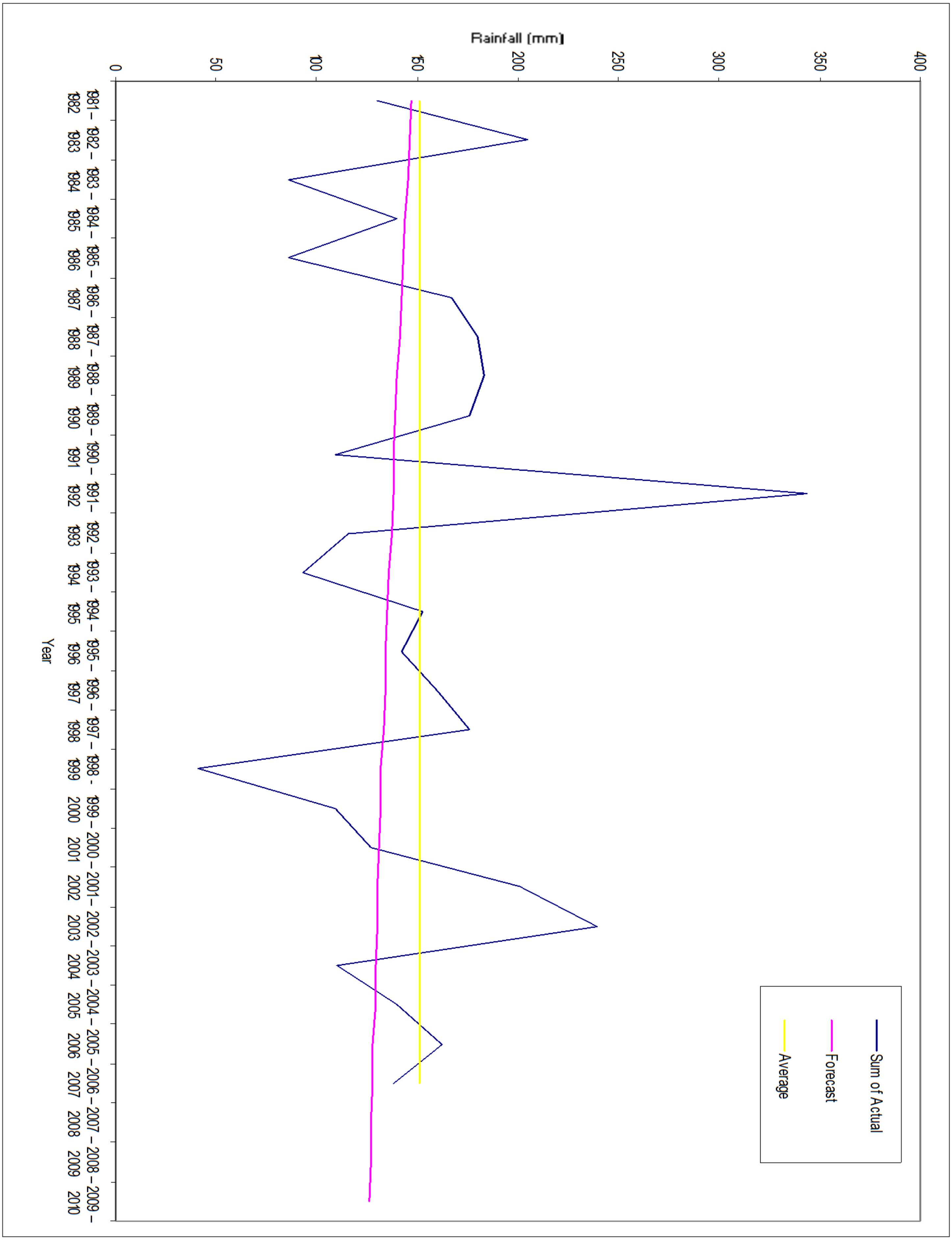

Figure 4.9: Sum of actual and forecast rainfall values implementing ARIMA Model for years 1981-2010 for Jericho station

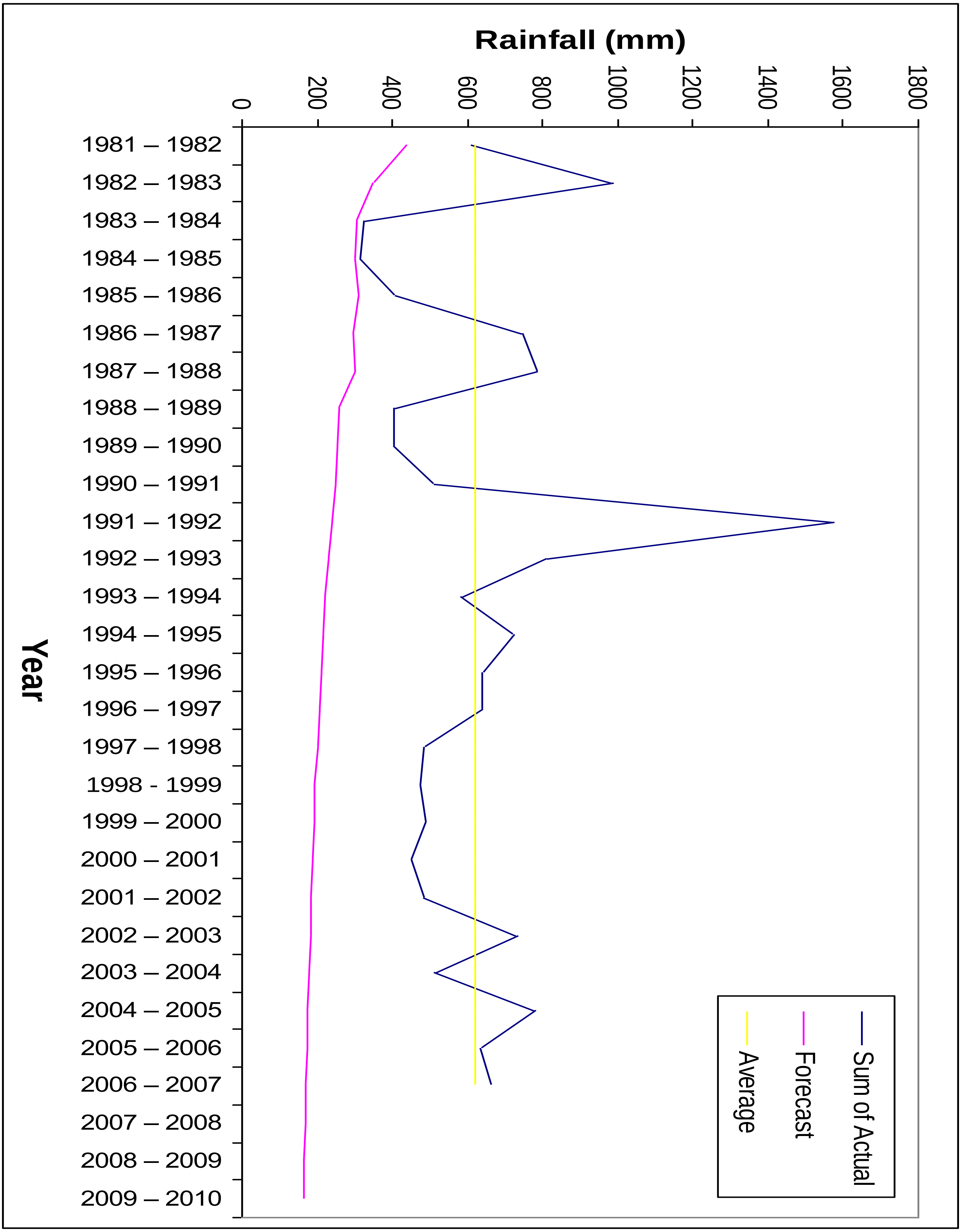

Figure 4.10: Sum of actual and forecast rainfall values implementing ARIMA model for years 1981-2010 for Rammallah station

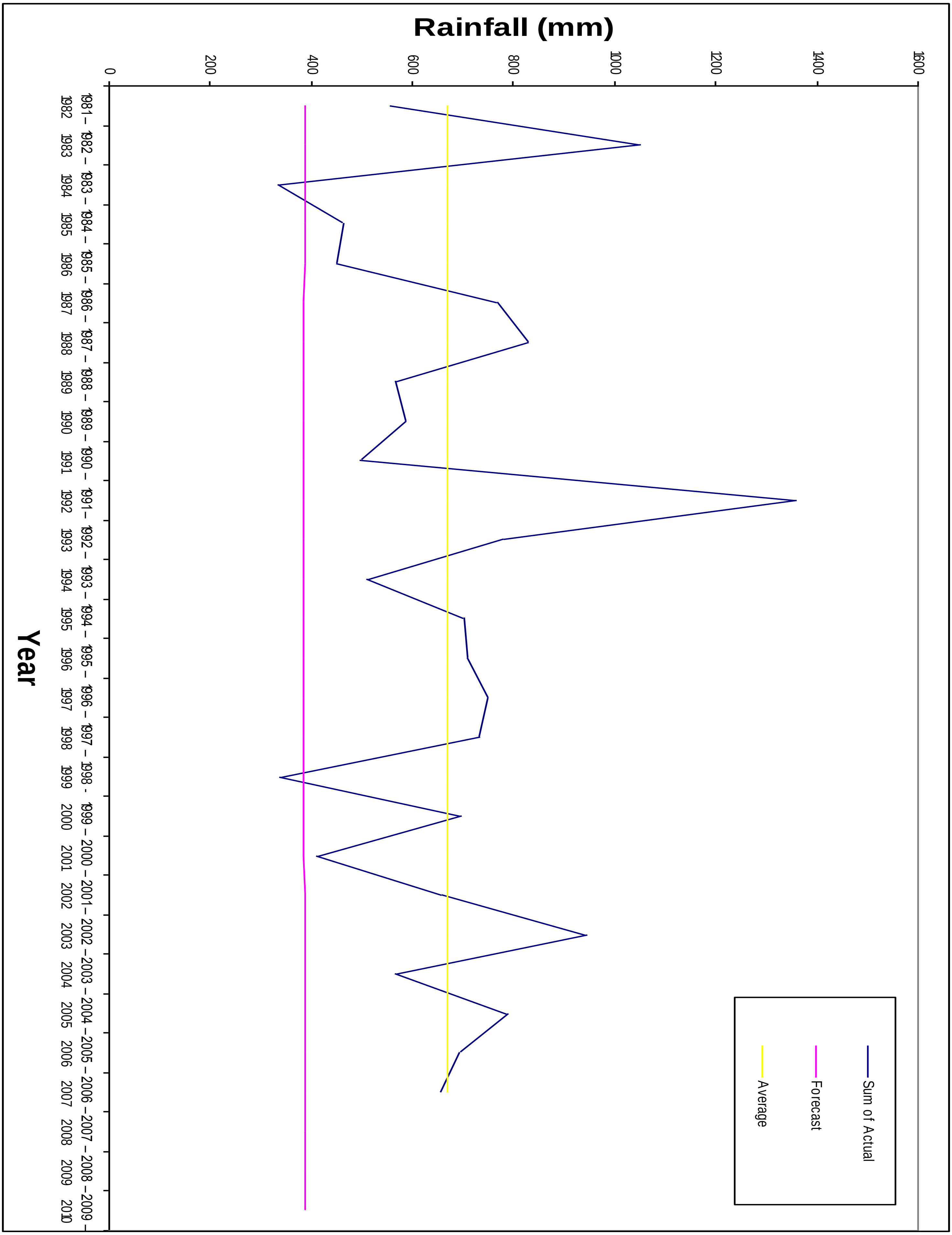

Figure 4.11: Sum of actual and forecast rainfall values implementing ARIMA model for years1981 – 2010 for Nablus station

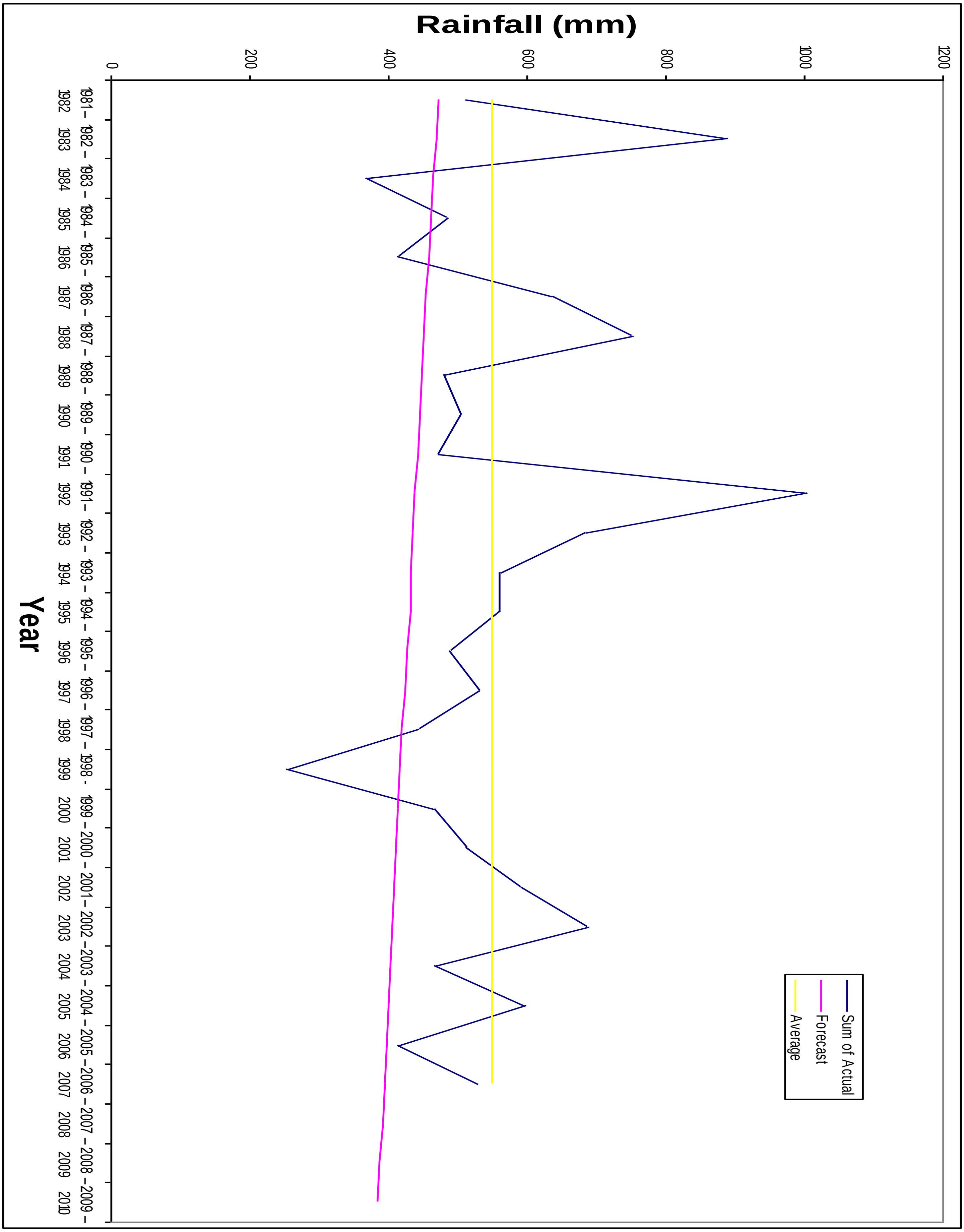

Figure 4.12: Sum of actual and forecast rainfall values implementing ARIMA model for years 1981 – 2010 for Hebron station

Chapter Five

Conclusions and Recommendations

5.1 Conclusions

1- In general it has been found that rainfall will decrease in all region in West Bank by the two models ARIMA and Nonlinear where:
   a. The Semi – Coasted Region: There is convergence between the results obtained by the two methods ARIMA and nonlinear regression but ARIMA model shows more decrees in rainfall in future.
   b. The Jordan Valley Region: We can see that in general expected rainfall very close to actual rainfall for most of the years. There is convergence between the results obtained by the tow methods ARIMA and nonlinear regression but ARIMA model shows more decrees in rainfall in future.
   c. The Central Highlands Region: there will be decrease in rainfall by ARIMA model. Nonlinear regression more suitable in forecasting rainfall in The Central Highlands Region than ARIMA model where there are large fluctuations in rainfall so that it not follow linear model.

2- The decrease in rainfall will be linearly through up coming years for Tulkarem, Jericho, Rammallah, and Hebron stations, where there will be slight increase in rainfall for Nablus and Jenin stations but rainfall will be less than the average annual rainfall.

3- The result of time series analysis for the selected stations in the West Bank indicated the present of gradual climatic changes toward aridity especially in the central highlands.

4- Rainfall measurements at different stations in the Mediterranean basin show similar declines in most regions of the basin this result agree with the analysis result in this study.

5- Several authors detected a decrease in precipitation in the last decades; primarily in the center and north of the country. Paz in 1998 detected a decrease in precipitation in the most stations in Palestine during 1950 to 1990.

6- Decreased annual rainfall and lengthened intervals between rains, coupled with increased temperatures and evaporation, will reduce plant productivity and crops growth.

5.2 Recommendations

1- In this study rainfall data were used to forecast future precipitation, other studies in future may used other parameters beside rainfall (such as temperature, humidity, and pressure), that will reduce the residual values and give better understanding of the fluctuation movement.

2- Few studies were done on distribution, cause and variation of rainfall in the West Bank; it will be useful to gather these studies in on report.

3- This study provides analysis of rainfall data to six stations in the West bank for the past three decades. Other studies should be extended to cover other stations over the longest possible historic period for which data is present to identify the best model that simulates the spatial distribution of precipitation in the West bank.

4- The need to collect and save water for drought years will increase. Yet, only a large-scale solution may provide sufficient adaptation, through better use of recycled water and use of new water resources, like reservoir construction.

5- Since the climate of Palestine changes to ward aridity and because the lack of water it recommended to construct wastewater plants in different cities and use treated wastewater in irrigation.

6- Better management of aquifer recharge through water-sensitive urban planning may reduce surface runoff.

7- Reduces surface runoff by dam construction it is an inefficient but expensive solution.

8- The government should adopt like these studies and encourage other studies to use them in any future negotiation.

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Appendices

Appendix A.1: Forecast and Actual Monthly Rainfall Implementing Nonlinear Model

Table A1.1: Predicted and actual monthly rainfall for Tulkarem station using nonlinear regression and their residual

Year	Month	Actual	Forecast	Residual
1975 – 1976	10	16	87.570	-71.57
	11	35	94.270	-59.27
	12	161	88.990	72.01
	1	71	75.850	-4.85
	2	95	65.090	29.91
	3	89	65.110	23.89
	4	21	75.870	-54.87
1976 – 1977	10	39	94.170	-55.17
	11	230	87.390	142.61
	12	100	73.920	26.08
	1	113	64.270	48.73
	2	65	65.950	-0.95
	3	169	77.650	91.35
	4	86	90.220	-4.22
1977 – 1978	10	92	85.660	6.34
	11	1	72.070	-71.07
	12	265	63.660	201.34
	1	94	66.990	27.01
	2	97	79.450	17.55
	3	74	91.290	-17.29
	4	12	93.260	-81.26
1978 – 1979	10	36	70.310	-34.31
	11	11	63.280	-52.28
	12	126	68.210	57.79
	1	92	81.230	10.77
	2	25	92.170	-67.17
	3	45	92.470	-47.47
	4	4	81.900	-77.90
1979 – 1980	10	18	63.140	-45.14
	11	104	69.590	34.41
	12	358	82.980	275.02
	1	75	92.840	-17.84
	2	177	91.470	85.53
	3	79	79.920	-0.92
	4	31	67.200	-36.20
1980 – 1981	10	5	71.100	-66.10
	11	6	84.650	-78.65
	12	172	93.300	78.70
	1	309	90.270	218.73
	2	85	77.930	7.07
	3	37	65.890	-28.89

Year	Month	Actual	Forecast	Residual
	4	29	63.550	-34.55
1981 – 1982	10	1	86.230	-85.23
	11	148	93.520	54.48
	12	38	88.890	-50.89
	1	94	75.940	18.06
	2	125	64.770	60.23
	3	75	64.100	10.90
	4	3	74.430	-71.43
1982 – 1983	10	0	93.520	-93.52
	11	138	87.350	50.65
	12	137	73.990	63.01
	1	183	63.860	119.14
	2	200	64.860	135.14
	3	120	76.190	43.81
	4	19	89.000	-70.00
1983 – 1984	10	3	85.660	-82.66
	11	71	72.100	-1.10
	12	25	63.160	-38.16
	1	122	65.820	56.18
	2	40	77.980	-37.98
	3	93	90.150	2.85
	4	27	92.800	-65.80
1984 – 1985	10	23	70.300	-47.30
	11	25	62.690	-37.69
	12	78	66.960	11.04
	1	123	79.770	43.23
	2	172	91.110	80.89
	3	6	92.100	-86.10
	4	27	81.980	-54.98
1985 – 1986	10	50	62.450	-12.45
	11	76	68.280	7.72
	12	107	81.540	25.46
	1	175	91.870	83.13
	2	108	91.190	16.81
	3	22	80.020	-58.02
	4	23	67.070	-44.07
1986 – 1987	10	71	69.730	1.27
	11	260	83.240	176.76
	12	177	92.410	84.59
	1	109	90.070	18.93
	2	37	78.030	-41.03
	3	119	65.690	53.31
	4	2	62.670	-60.67
1987 – 1988	10	44	84.870	-40.87
	11	13	92.730	-79.73
	12	235	88.760	146.24
	1	102	76.040	25.96

Year	Month	Actual	Forecast	Residual
	2	167	64.490	102.51
	3	87	63.120	23.88
	4	7	72.990	-65.99
	10	27	92.820	-65.82
	11	59	87.280	-28.28
	12	151	74.070	76.93
1988 – 1989	1	100	63.490	36.51
	2	57	63.790	-6.79
	3	83	74.730	8.27
	4	0	87.750	-87.75
	10	32	85.650	-53.65
	11	95	72.150	22.85
	12	189	62.700	126.30
1989 – 1990	1	150	64.670	85.33
	2	155	76.510	78.49
	3	27	88.970	-61.97
	4	31	92.300	-61.30
	10	7	70.310	-63.31
	11	10	62.130	-52.13
	12	20	65.740	-45.74
1990 – 1991	1	251	78.310	172.69
	2	88	90.010	-2.01
	3	144	91.700	52.30
	4	38	82.040	-44.04
	10	8	61.800	-53.80
	11	221	66.990	154.01
	12	436	80.090	355.91
1991 – 1992	1	278	90.860	187.14
	2	390	90.870	299.13
	3	30	80.110	-50.11
	4	8	66.970	-58.97
	10	0	68.390	-68.39
	11	51	81.820	-30.82
	12	310	91.490	218.51
1992 – 1993	1	122	89.830	32.17
	2	78	78.140	-0.14
	3	61	65.520	-4.52
	4	2	61.820	-59.82
	10	19	83.480	-64.48
	11	18	91.910	-73.91
	12	22	88.600	-66.60
1993 – 1994	1	229	76.140	152.86
	2	93	64.240	28.76
	3	92	62.180	29.82
	4	8	71.560	-63.56
1994 – 1995	10	34	92.090	-58.09
	11	309	87.190	221.81

Year	Month	Actual	Forecast	Residual
	12	259	74.160	184.84
	1	73	63.160	9.84
	2	123	62.760	60.24
	3	40	73.280	-33.28
	4	21	86.480	-65.48
1995 – 1996	10	2	85.620	-83.62
	11	95	72.210	22.79
	12	63	62.280	0.72
	1	24	63.560	-39.56
	2	145	75.050	69.95
	3	12	87.760	-75.76
	4	0	91.760	-91.76
1996 – 1997	10	48	70.340	-22.34
	11	7	61.620	-54.62
	12	99	64.550	34.45
	1	138	76.840	61.16
	2	257	88.880	168.12
	3	195	91.250	103.75
	4	11	82.100	-71.10
1997 – 1998	10	39	61.180	-22.18
	11	81	65.730	15.27
	12	183	78.630	104.37
	1	199	89.810	109.19
	2	58	90.520	-32.52
	3	190	80.200	109.80
	4	6	66.890	-60.89
1998 – 1999	10	4	67.070	-63.07
	11	3	80.390	-77.39
	12	60	90.530	-30.53
	1	127	89.570	37.43
	2	37	78.240	-41.24
	3	34	65.380	-31.38
	4	26	61.020	-35.02
1999 – 2000	10	4	82.080	-78.08
	11	18	91.040	-73.04
	12	43	88.410	-45.41
	1	390	76.250	313.75
	2	88	64.030	23.97
	3	56	61.280	-5.28
	4	0	70.150	-70.15
2000 – 2001	10	107	91.320	15.68
	11	17	87.070	-70.07
	12	124	74.250	49.75
	1	89	62.860	26.14
	2	116	61.770	54.23
	3	0	71.840	-71.84
	4	2	85.180	-83.18

Year	Month	Actual	Forecast	Residual
2001 – 2002	10	6	85.570	-79.57
	11	124	72.290	51.71
	12	205	61.890	143.11
	1	232	62.480	169.52
	2	55	73.590	-18.59
	3	0	86.530	-86.53
	4	0	91.190	-91.19
2002 – 2003	10	12	70.380	-58.38
	11	33	61.140	-28.14
	12	124	63.400	60.60
	1	100	75.380	24.62
	2	337	87.720	249.28
	3	161	90.770	70.23
	4	32	82.140	-50.14
2003 – 2004	10	6	60.610	-54.61
	11	43	64.500	-21.50
	12	92	77.170	14.83
	1	241	88.720	152.28
	2	89	90.120	-1.12
	3	18	80.270	-62.27
	4	6	66.840	-60.84
2004 – 2005	10	3	65.770	-62.77
	11	127	78.940	48.06
	12	63	89.530	-26.53
	1	219	89.260	129.74
	2	140	78.330	61.67
	3	17	65.260	-48.26
	4	5	60.250	-55.25
2005 – 2006	10		90.130	
	11		88.190	
	12		76.350	
	1		63.840	
	2		60.420	
	3		68.750	
	4		82.310	
2006 – 2007	10		86.930	
	11		74.350	
	12		62.590	
	1		60.820	
	2		70.400	
	3		83.850	
	4		90.650	
2007 – 2008	10		72.370	
	11		61.540	
	12		61.440	
	1		72.130	
	2		85.260	

Year	Month	Actual	Forecast	Residual
	3		90.570	
	4		83.890	
2008 – 2009	10		60.700	
	11		62.270	
	12		73.910	
	1		86.520	
	2		90.250	
	3		82.170	
	4		68.580	
2009 – 2010	10		63.300	
	11		75.700	
	12		87.610	
	1		89.700	
	2		80.330	
	3		66.810	
	4		59.690	
2010 – 2011	10		77.49	
	11		88.500	
	12		88.920	
	1		78.420	
	2		65.180	
	3		59.530	
	4		65.870	
2011 – 2012	10		89.190	
	11		87.940	
	12		76.450	
	1		63.690	
	2		59.600	
	3		67.370	
	4		80.920	
2012 – 2013	10		86.750	
	11		74.460	
	12		62.360	
	1		59.900	
	2		68.980	
	3		82.500	
	4		89.900	
2013 – 2014	10		72.470	
	11		61.230	
	12		60.430	
	1		70.690	
	2		83.970	
	3		89.910	
	4		83.850	
2014 – 2015	10		60.300	
	11		61.180	
	12		72.450	

Year	Month	Actual	Forecast	Residual
	1		85.300	
	2		89.680	
	3		82.170	
	4		68.620	
2015 – 2016	10		62.130	
	11		74.240	
	12		86.460	
	1		89.230	
	2		80.380	
	3		66.810	
	4		59.100	
2016 – 2017	10		76.030	
	11		87.430	
	12		88.550	
	1		78.500	
	2		65.120	
	3		58.840	
	4		64.560	
2017 – 2018	10		88.200	
	11		87.650	
	12		76.550	
	1		63.560	
	2		58.820	
	3		66.010	
	4		79.510	
2018 – 2019	10		86.540	
	11		74.560	
	12		62.170	
	1		59.030	
	2		67.580	
	3		81.140	
	4		89.100	
2019 – 2020	10		72.570	
	11		60.950	
	12		59.460	
	1		69.250	
	2		82.660	
	3		89.210	
	4		83.780	
2020 – 2021	10		59.940	
	11		60.120	
	12		70.990	
	1		84.040	
	2		89.080	
	3		82.160	
	4		68.670	

Table A.1.2: Predicted and actual monthly rainfall for Jenin station using nonlinear regression and their residual

Year	Month	Actual	Forecast	Residual
1975 – 1976	10	8	57.23	-49.23
	11	33	47.73	-14.73
	12	106	57.71	48.29
	1	81	48.48	32.52
	2	104	56.01	47.99
	3	72	51.13	20.87
	4	27	52.89	-25.89
1976 – 1977	10	0	49.76	-49.76
	11	108	57.21	50.79
	12	62	48.03	13.97
	1	14	58.00	-44.00
	2	47	48.47	-1.47
	3	116	56.56	59.44
	4	67	50.91	16.09
1977 – 1978	10	0	54.31	-54.31
	11	0	50.35	-50.35
	12	140	57.16	82.84
	1	63	48.36	14.64
	2	31	58.24	-27.24
	3	61	48.49	12.51
	4	9	57.09	-48.09
1978 – 1979	10	0	54.24	-54.24
	11	14	54.06	-40.06
	12	102	50.96	51.04
	1	61	57.08	3.92
	2	16	48.73	-32.73
	3	71	58.45	12.55
	4	3	48.56	-45.56
1979 – 1980	10	0	50.54	-50.54
	11	12	54.90	-42.90
	12	233	53.81	179.19
	1	99	51.59	47.41
	2	112	56.96	55.04
	3	103	49.15	53.85
	4	27	58.61	-31.61
1980 – 1981	10	0	58.05	-58.05
	11	11	50.38	-39.38
	12	109	55.55	53.45
	1	191	53.56	137.44
	2	77	52.24	24.76
	3	71	56.81	14.19
	4	8	49.60	-41.60
1981 – 1982	10	0	48.82	-48.82
	11	64	58.47	5.53
	12	28	50.26	-22.26

Year	Month	Actual	Forecast	Residual
	1	31	56.19	-25.19
	2	121	53.31	67.69
	3	55	52.90	2.10
	4	0	56.64	-56.64
1982 – 1983	10	0	58.80	-58.80
	11	80	49.01	30.99
	12	96	58.86	37.14
	1	162	50.17	111.83
	2	183	56.80	126.20
	3	125	53.06	71.94
	4	0	53.57	-53.57
1983 – 1984	10	0	50.61	-50.61
	11	68	58.84	9.16
	12	32	49.24	-17.24
	1	109	59.20	49.80
	2	47	50.10	-3.10
	3	78	57.40	20.60
	4	40	52.83	-12.83
1984 – 1985	10	0	56.23	-56.23
	11	23	51.16	-28.16
	12	49	58.84	-9.84
	1	63	49.52	13.48
	2	120	59.51	60.49
	3	8	50.08	-42.08
	4	22	57.97	-35.97
1985 – 1986	10	0	54.92	-54.92
	11	56	56.01	-0.01
	12	42	51.74	-9.74
	1	95	58.80	36.20
	2	103	49.84	53.16
	3	14	59.77	-45.77
	4	21	50.09	-29.09
1986 – 1987	10	0	52.40	-52.40
	11	157	55.59	101.41
	12	105	55.77	49.23
	1	72	52.34	19.66
	2	19	58.72	-39.72
	3	81	50.20	30.80
	4	0	59.99	-59.99
1987 – 1988	10	0	59.01	-59.01
	11	15	52.21	-37.21
	12	211	56.26	154.74
	1	181	55.52	125.48
	2	225	52.96	172.04
	3	92	58.62	33.38
	4	0	50.60	-50.60
1988 – 1989	10	0	50.23	-50.23

Year	Month	Actual	Forecast	Residual
	11	60	59.49	0.51
	12	164	52.05	111.95
	1	86	56.92	29.08
	2	31	55.27	-24.27
	3	77	53.61	23.39
	4	0	58.48	-58.48
1989 – 1990	10	0	60.30	-60.30
	11	58	50.37	7.63
	12	98	59.93	38.07
	1	118	51.91	66.09
	2	91	57.56	33.44
	3	47	55.01	-8.01
	4	20	54.26	-34.26
1990 – 1991	10	0	51.51	-51.51
	11	11	60.39	-49.39
	12	10	50.54	-40.54
	1	156	60.33	95.67
	2	60	51.81	8.19
	3	115	58.18	56.82
	4	0	54.77	-54.77
1991 – 1992	10	0	58.13	-58.13
	11	137	52.02	84.98
	12	254	60.44	193.56
	1	216	50.76	165.24
	2	367	60.69	306.31
	3	38	51.73	-13.73
	4	0	58.79	-58.79
1992 – 1993	10	0	55.60	-55.60
	11	49	57.93	-8.93
	12	239	52.56	186.44
	1	68	60.45	7.55
	2	68	51.02	16.98
	3	27	61.01	-34.01
	4	4	51.69	-47.69
1993 – 1994	10	0	54.30	-54.30
	11	40	56.28	-16.28
	12	6	57.70	-51.70
	1	152	53.13	98.87
	2	54	60.43	-6.43
	3	55	51.32	3.68
	4	7	61.28	-54.28
1994 – 1995	10	0	59.92	-59.92
	11	192	54.08	137.92
	12	162	56.95	105.05
	1	33	57.47	-24.47
	2	88	53.72	34.28
	3	28	60.37	-32.37

Year	Month	Actual	Forecast	Residual
	4	0	51.67	-51.67
1995 – 1996	10	0	51.73	-51.73
	11	91	60.44	30.56
	12	33	53.89	-20.89
	1	130	57.62	72.38
	2	28	57.22	-29.22
	3	15	54.34	-39.34
	4	0	60.27	-60.27
1996 – 1997	10	0	61.71	-61.71
	11	3	51.80	-48.80
	12	43	60.92	-17.92
	1	154	53.72	100.28
	2	156	58.28	97.72
	3	85	56.97	28.03
	4	10	54.97	-44.97
1997 – 1998	10	42	52.48	-10.48
	11	49	61.86	-12.86
	12	150	51.92	98.08
	1	115	61.38	53.62
	2	73	53.57	19.43
	3	144	58.93	85.07
	4	17	56.72	-39.72
1998 – 1999	10	0	59.99	-59.99
	11	0	52.94	-52.94
	12	35	61.97	-26.97
	1	78	52.08	25.92
	2	35	61.79	-26.79
	3	54	53.45	0.55
	4	21	59.56	-38.56
1999 – 2000	10	0	56.29	-56.29
	11	4	59.82	-55.82
	12	46	53.43	-7.43
	1	254	62.03	191.97
	2	52	52.28	-0.28
	3	53	62.17	-9.17
	4	3	53.37	-50.37
2000 – 2001	10	55	56.23	-1.23
	11	0	56.96	-56.96
	12	61	59.62	1.38
	1	65	53.96	11.04
	2	67	62.06	4.94
	3	6	52.53	-46.53
	4	1	62.50	-61.50
2001 – 2002	10	9	60.76	-51.76
	11	33	55.99	-22.99
	12	121	57.63	63.37
	1	164	59.40	104.60

Year	Month	Actual	Forecast	Residual
	2	48	54.52	-6.52
	3	0	62.05	-62.05
	4	0	52.82	-52.82
2002 – 2003	10	0	53.30	-53.30
	11	41	61.32	-20.32
	12	192	55.77	136.23
	1	67	58.31	8.69
	2	357	59.17	297.83
	3	174	55.10	118.90
	4	39	62.00	-23.00
2003 – 2004	10	3	63.05	-60.05
	11	42	53.32	-11.32
	12	100	61.86	38.14
	1	176	55.57	120.43
	2	95	58.98	36.02
	3	8	58.93	-50.93
	4	15	55.71	-40.71
2004 – 2005	10	0	53.51	-53.51
	11	86	63.25	22.75
	12	44	53.38	-9.38
	1	116	62.36	53.64
	2	142	55.39	86.61
	3	20	59.65	-39.65
	4	3	58.68	-55.68
2005 – 2006	10	21.7	61.81	-40.11
	11	44.4	53.92	-9.52
	12	75.1	63.42	11.68
	1	87.6	53.48	34.12
	2	73.8	62.82	10.98
	3	10.2	55.23	-45.03
	4	76.2	60.30	15.9
2006 – 2007	10	25.9	56.99	-31.09
	11	50.3	61.66	-11.36
	12	100.4	54.37	46.03
	1	109.1	63.54	45.56
	2	125.8	53.63	72.17
	3	57.5	63.25	-5.75
	4	10.3	55.11	-44.81
2007 – 2008	10		58.17	
	11		57.65	
	12		61.50	
	1		54.85	
	2		63.62	
	3		53.81	
	4		63.64	
2008 – 2009	10		61.56	
	11		57.93	

Year	Month	Actual	Forecast	Residual
	12		58.31	
	1		61.30	
	2		55.37	
	3		63.67	
	4		54.04	
2009 – 2010	10		54.94	
	11		62.15	
	12		57.69	
	1		58.99	
	2		61.09	
	3		55.92	
	4		63.67	
2010 – 2011	10		64.30	
	11		54.91	
	12		62.73	
	1		57.46	
	2		59.66	
	3		60.87	
	4		56.49	
2011 – 2012	10		54.63	
	11		64.57	
	12		54.92	
	1		63.27	
	2		57.26	
	3		60.34	
	4		60.63	
2012 – 2013	10		63.57	
	11		54.98	
	12		64.79	
	1		54.96	
	2		63.78	
	3		57.07	
	4		61.01	
2013 – 2014	10		57.71	
	11		63.46	
	12		55.38	
	1		64.97	
	2		55.05	
	3		64.26	
	4		56.90	
2014 – 2015	10		60.13	
	11		58.35	
	12		63.33	
	1		55.81	
	2		65.11	
	3		55.18	
	4		64.70	

Year	Month	Actual	Forecast	Residual
2015 – 2016	10		62.31	
	11		59.88	
	12		59.01	
	1		63.17	
	2		56.28	
	3		65.21	
	4		55.35	
2016 – 2017	10		56.65	
	11		62.94	
	12		59.63	
	1		59.67	
	2		62.99	
	3		56.78	
	4		65.27	
2017 – 2018	10		65.47	
	11		56.57	
	12		63.54	
	1		59.39	
	2		60.34	
	3		62.79	
	4		57.32	
2018 – 2019	10		55.82	
	11		65.80	
	12		56.53	
	1		64.12	
	2		59.16	
	3		61.02	
	4		62.56	
2019 – 2020	10		65.26	
	11		56.11	
	12		66.08	
	1		56.52	
	2		64.68	
	3		58.94	
	4		61.70	
2020 – 2021	10		58.47	
	11		65.21	
	12		56.45	
	1		66.32	
	2		56.55	
	3		65.20	
	4		58.75	

Table A.1.3: Predicted and actual monthly rainfall for Jericho station using nonlinear regression and their residual

Year	Month	Actual	Forecast	Residual
1975 – 1976	10	0	17.21	-17.21
	11	40.0	15.72	24.28
	12	24.0	15.97	8.03
	1	14.0	17.80	-3.80
	2	23.0	20.04	2.96
	3	25.0	21.26	3.74
	4	4.0	20.68	-16.68
1976 – 1977	10	0.	16.52	-16.52
	11	17.0	15.60	1.40
	12	12.0	16.51	-4.51
	1	27.0	18.65	8.35
	2	11.0	20.67	-9.67
	3	17.0	21.27	-4.27
	4	28.0	20.07	7.93
1977 – 1978	10	0.	16.00	-16.00
	11	1.0	15.73	-14.73
	12	52.0	17.21	34.79
	1	8.0	19.49	-11.49
	2	25.0	21.11	3.89
	3	20.0	21.04	-1.04
	4	0.	19.32	-19.32
1978 – 1979	10	0.	15.70	-15.70
	11	5.0	16.11	-11.11
	12	40.0	18.03	21.97
	1	21.0	20.24	0.76
	2	13.0	21.32	-8.32
	3	17.0	20.58	-3.58
	4	0.	18.50	-18.50
1979 – 1980	10	0.	15.64	-15.64
	11	55.0	16.69	38.31
	12	54.0	18.89	35.11
	1	39.0	20.83	18.17
	2	34.0	21.27	12.73
	3	41.0	19.93	21.07
	4	3.0	17.67	-14.67
1980 – 1981	10	0.	15.84	-15.84
	11	1.0	17.44	-16.44
	12	87.0	19.72	67.28
	1	57.0	21.21	35.79
	2	11.0	20.98	-9.98
	3	37.0	19.16	17.84
	4	6.0	16.92	-10.92
1981 – 1982	10	0	16.27	-16.27
	11	10	18.27	-8.27
	12	2	20.43	-18.43

Year	Month	Actual	Forecast	Residual
	1	30	21.36	8.64
	2	37	20.47	16.53
	3	36	18.32	17.68
	4	15	16.30	-1.30
1982 – 1983	10	0	16.89	-16.89
	11	29	19.13	9.87
	12	20	20.97	-0.97
	1	62	21.25	40.75
	2	54	19.78	34.22
	3	39	17.51	21.49
	4	1	15.88	-14.88
1983 – 1984	10	0	17.66	-17.66
	11	12	19.93	-7.93
	12	6	21.30	-15.30
	1	32	20.90	11.10
	2	4	18.99	-14.99
	3	28	16.78	11.22
	4	4	15.70	-11.70
1984 – 1985	10	0	18.51	-18.51
	11	9	20.61	-11.61
	12	8	21.39	-13.39
	1	21	20.35	0.65
	2	66	18.15	47.85
	3	26	16.21	9.79
	4	10	15.77	-5.77
1985 – 1986	10	0	19.36	-19.36
	11	17	21.11	-4.11
	12	23	21.22	1.78
	1	9	19.63	-10.63
	2	27	17.35	9.65
	3	3	15.85	-12.85
	4	7	16.08	-9.08
1986 – 1987	10	0	20.14	-20.14
	11	83	21.38	61.62
	12	17	20.82	-3.82
	1	27	18.82	8.18
	2	20	16.66	3.34
	3	20	15.72	4.28
	4	0	16.61	-16.61
1987 – 1988	10	0	20.78	-20.78
	11	1	21.40	-20.40
	12	49	20.21	28.79
	1	42	17.98	24.02
	2	69	16.14	52.86
	3	19	15.85	3.15
	4	0	17.32	-17.32
1988 – 1989	10	0	21.23	-21.23

Year	Month	Actual	Forecast	Residual
	11	10	21.17	-11.17
	12	86	19.47	66.53
	1	31	17.20	13.80
	2	25	15.83	9.17
	3	31	16.22	14.78
	4	0	18.13	-18.13
	10	0	21.44	-21.44
	11	15	20.72	-5.72
	12	20	18.65	1.35
1989 – 1990	1	56	16.55	39.45
	2	26	15.76	10.24
	3	39	16.80	22.20
	4	20	18.99	1.01
	10	0	21.40	-21.40
	11	4	20.08	-16.08
	12	1	17.82	-16.82
1990 – 1991	1	54	16.07	37.93
	2	22	15.95	6.05
	3	27	17.54	9.46
	4	1	19.82	-18.82
	10	0	21.11	-21.11
	11	58	19.30	38.70
	12	104	17.06	86.94
1991 – 1992	1	57	15.82	41.18
	2	112	16.37	95.63
	3	12	18.37	-6.37
	4	1	20.53	-19.53
	10	0	20.61	-20.61
	11	25	18.47	6.53
	12	35	16.44	18.56
1992 – 1993	1	17	15.82	1.18
	2	27	17.00	10.00
	3	12	19.23	-7.23
	4	0	21.09	-21.09
	10	0	19.93	-19.93
	11	18	17.66	0.34
	12	4	16.02	-12.02
1993 – 1994	1	34	16.06	17.94
	2	20	17.76	2.24
	3	14	20.03	-6.03
	4	3	21.42	-18.42
	10	0	19.14	-19.14
	11	66	16.93	49.07
	12	52	15.83	36.17
1994 – 1995	1	2	16.54	-14.54
	2	28	18.61	9.39
	3	4	20.72	-16.72

Year	Month	Actual	Forecast	Residual
	4	1	21.51	-20.51
1995 – 1996	10	0	18.30	-18.30
	11	6	16.35	-10.35
	12	21	15.89	5.11
	1	46	17.20	28.80
	2	13	19.46	-6.46
	3	48	21.22	26.78
	4	8	21.35	-13.35
1996 – 1997	10	0	17.50	-17.50
	11	6	15.98	-9.98
	12	21	16.19	4.81
	1	53	18.00	35.00
	2	43	20.24	22.76
	3	35	21.50	13.50
	4	2	20.96	-18.96
1997 – 1998	10	31	16.80	14.20
	11	11	15.85	-4.85
	12	45	16.72	28.28
	1	34	18.85	15.15
	2	17	20.89	-3.89
	3	38	21.53	16.47
	4	0	20.36	-20.36
1998 – 1999	10	0	16.27	-16.27
	11	0	15.97	-15.97
	12	1	17.42	-16.42
	1	12	19.69	-7.69
	2	14	21.34	-7.34
	3	11	21.31	-10.31
	4	3	19.62	-16.62
1999 – 2000	10	0	15.96	-15.96
	11	2	16.33	-14.33
	12	8	18.23	-10.23
	1	55	20.45	34.55
	2	17	21.56	-4.56
	3	27	20.86	6.14
	4	0	18.80	-18.80
2000 – 2001	10	18	15.89	2.11
	11	1	16.90	-15.90
	12	36	19.09	16.91
	1	31	21.05	9.95
	2	32	21.53	10.47
	3	2	20.22	-18.22
	4	7	17.97	-10.97
2001 – 2002	10	0	16.07	-16.07
	11	15	17.64	-2.64
	12	49	19.92	29.08
	1	78	21.45	56.55

Year	Month	Actual	Forecast	Residual
	2	25	21.25	3.75
	3	20	19.45	0.55
	4	14	17.21	-3.21
2002 – 2003	10	20	16.48	3.52
	11	21	18.47	2.53
	12	50	20.64	29.36
	1	35	21.61	13.39
	2	70	20.75	49.25
	3	40	18.62	21.38
	4	3	16.58	-13.58
2003 – 2004	10	1	17.10	-16.10
	11	1	19.33	-18.33
	12	44	21.20	22.80
	1	30	21.51	8.49
	2	23	20.08	2.92
	3	9	17.81	-8.81
	4	2	16.15	-14.15
2004 – 2005	10	8	17.86	-9.86
	11	26	20.13	5.87
	12	30	21.54	8.46
	1	43	21.18	21.82
	2	18	19.29	-1.29
	3	13	17.07	-4.07
	4	2	15.95	-13.95
2005 – 2006	10	0.5	18.71	-18.21
	11	12.9	20.82	-7.92
	12	28.8	21.64	7.16
	1	31.4	20.63	10.77
	2	16.9	18.45	-1.55
	3	0.7	16.49	-15.79
	4	70.3	16.00	54.3
2006 – 2007	10	9.5	19.56	-10.06
	11	5.8	21.33	-15.53
	12	36.8	21.49	15.31
	1	23.5	19.92	3.58
	2	22.5	17.65	4.85
	3	31.4	16.11	15.29
	4	8.2	16.30	-8.1
2007 – 2008	10	0.2	20.35	-20.15
	11	19.9	21.62	-1.72
	12	14.5	21.10	-6.6
	1	53.3	19.12	34.18
	2	34.3	16.95	17.35
	3	0	15.97	-15.97
	4	0	16.82	-16.82
2008 – 2009	10		21.00	
	11		21.66	

Year	Month	Actual	Forecast	Residual
	12		20.51	
	1		18.28	
	2		16.41	
	3		16.09	
	4		17.52	
2009 – 2010	10		21.45	
	11		21.44	
	12		19.77	
	1		17.50	
	2		16.09	
	3		16.44	
	4		18.33	
2010 – 2011	10		21.68	
	11		21.00	
	12		18.95	
	1		16.83	
	2		16.01	
	3		17.01	
	4		19.19	
2011 – 2012	10		21.66	
	11		20.37	
	12		18.12	
	1		16.34	
	2		16.18	
	3		17.74	
	4		20.02	
2012 – 2013	10		21.39	
	11		19.60	
	12		17.35	
	1		16.08	
	2		16.59	
	3		18.57	
	4		20.74	
2013 – 2014	10		20.89	
	11		18.77	
	12		16.73	
	1		16.06	
	2		17.20	
	3		19.43	
	4		21.31	
2014 – 2015	10		20.22	
	11		17.95	
	12		16.29	
	1		16.29	
	2		17.96	
	3		20.24	
	4		21.66	

Year	Month	Actual	Forecast	Residual
2015 – 2016	10		19.44	
	11		17.22	
	12		16.08	
	1		16.75	
	2		18.81	
	3		20.93	
	4		21.76	
2016 – 2017	10		18.60	
	11		16.63	
	12		16.12	
	1		17.41	
	2		19.66	
	3		21.44	
	4		21.62	
2017 – 2018	10		17.80	
	11		16.25	
	12		16.41	
	1		18.19	
	2		20.45	
	3		21.74	
	4		21.24	
2018 – 2019	10		17.09	
	11		16.10	
	12		16.93	
	1		19.05	
	2		21.10	
	3		21.78	
	4		20.65	
2019 – 2020	10		16.55	
	11		16.20	
	12		17.62	
	1		19.89	
	2		21.57	
	3		21.58	
	4		19.92	
2020 – 2021	10		16.22	
	11		16.55	
	12		18.43	
	1		20.65	
	2		21.80	
	3		21.14	
	4		19.10	

Table A.1.4: Predicted and actual monthly rainfall for Rammallah station using nonlinear regression and their residual

Year	Month	Actual	Forecast	Residual
1975 – 1976	10	1	67.12	-66.12
	11	41	83.72	-42.72
	12	99	91.57	7.43
	1	83	82.35	0.65
	2	128	65.81	62.19
	3	110	59.43	50.57
	4	17	69.95	-52.95
1976 – 1977	10	6	91.01	-85.01
	11	61	79.23	-18.23
	12	54	63.34	-9.34
	1	158	60.13	97.87
	2	52	72.99	-20.99
	3	137	88.30	48.70
	4	89	89.83	-0.83
1977 – 1978	10	87	61.34	25.66
	11	16	61.44	-45.44
	12	229	76.13	152.87
	1	51	89.85	-38.85
	2	75	88.07	-13.07
	3	97	72.66	24.34
	4	18	59.90	-41.90
1978 – 1979	10	62	79.22	-17.22
	11	26	90.82	-64.82
	12	156	85.80	70.20
	1	149	69.45	79.55
	2	31	59.07	-28.07
	3	89	65.62	23.38
	4	12	82.16	-70.16
1979 – 1980	10	42	83.10	-41.10
	11	217	66.48	150.52
	12	208	58.88	149.12
	1	141	68.33	72.67
	2	154	84.81	69.19
	3	118	90.87	27.13
	4	10	80.08	-70.08
1980 – 1981	10	0	59.32	-59.32
	11	46	71.30	-25.30
	12	254	87.07	166.93
	1	180	89.94	90.06
	2	112	76.85	35.15
	3	104	61.64	42.36
	4	13	60.39	-47.39
1981 – 1982	10	0	88.84	-88.84
	11	119	88.40	30.60
	12	28	73.54	-45.54

Year	Month	Actual	Forecast	Residual
	1	147	59.97	87.03
	2	168	62.03	105.97
	3	147	77.54	69.46
	4	4	90.06	-86.06
	10	22	70.28	-48.28
	11	102	58.88	43.12
	12	106	64.18	41.82
1982 – 1983	1	253	80.55	172.45
	2	310	90.66	219.34
	3	176	83.79	92.21
	4	18	67.20	-49.20
	10	0	66.75	-66.75
	11	36	83.33	-47.33
	12	15	90.62	-75.62
1983 – 1984	1	110	80.88	29.12
	2	40	64.41	-24.41
	3	100	58.62	41.38
	4	22	69.62	-47.62
	10	33	89.94	-56.94
	11	21	77.72	-56.72
	12	26	62.02	-36.02
1984 – 1985	1	37	59.44	-22.44
	2	153	72.69	80.31
	3	25	87.74	-62.74
	4	22	88.65	-66.65
	10	28	60.13	-32.13
	11	5	60.86	-55.86
	12	54	75.83	-21.83
1985 – 1986	1	86	89.19	-3.19
	2	158	86.78	71.22
	3	28	71.14	-43.14
	4	49	58.80	-9.80
	10	45	78.91	-33.91
	11	278	90.04	187.96
	12	105	84.42	20.58
1986 – 1987	1	146	67.97	78.03
	2	51	58.09	-7.09
	3	115	65.22	49.78
	4	6	81.80	-75.80
	10	39	81.65	-42.65
	11	15	65.05	-50.05
	12	238	58.02	179.98
1987 – 1988	1	140	67.98	72.02
	2	205	84.38	120.62
	3	107	89.85	17.15
	4	39	78.58	-39.58
1988 – 1989	10	8	58.59	-50.59

Year	Month	Actual	Forecast	Residual
	11	32	70.99	-38.99
	12	115	86.55	28.45
	1	100	88.80	11.20
	2	90	75.33	14.67
	3	60	60.38	-0.38
	4	0	59.77	-59.77
1989 – 1990	10	5	88.23	-83.23
	11	54	87.15	-33.15
	12	22	72.02	-50.02
	1	130	58.82	71.18
	2	80	61.51	18.49
	3	50	77.23	-27.23
	4	62	89.33	-27.33
1990 – 1991	10	0	68.78	-68.78
	11	49	57.86	-8.86
	12	9	63.75	-54.75
	1	208	80.21	127.79
	2	96	89.81	6.19
	3	134	82.37	51.63
	4	15	65.75	-50.75
1991 – 1992	10	29	66.38	-37.38
	11	143	82.93	60.07
	12	498	89.65	408.35
	1	219	79.40	139.60
	2	611	63.03	547.97
	3	63	57.83	5.17
	4	13	69.31	-56.31
1992 – 1993	10	120	88.85	31.15
	11	310	76.21	233.79
	12	187	60.73	126.27
	1	129	58.77	70.23
	2	50	72.40	-22.40
	3	0	87.17	-87.17
	4	14	87.44	-73.44
1993 – 1994	10	39	58.94	-19.94
	11	33	60.30	-27.30
	12	203	75.53	127.47
	1	142	88.51	53.49
	2	142	85.47	56.53
	3	23	69.63	-46.63
	4	0	57.72	-57.72
1994 – 1995	10	267	78.58	188.42
	11	256	89.24	166.76
	12	40	83.03	-43.03
	1	113	66.50	46.50
	2	48	57.13	-9.13
	3	0	64.83	-64.83

Year	Month	Actual	Forecast	Residual
	4	0	81.42	-81.42
1995 – 1996	10	92	80.19	11.81
	11	45	63.64	-18.64
	12	200	57.19	142.81
	1	59	67.65	-8.65
	2	218	83.94	134.06
	3	26	88.80	-62.80
	4	0	77.07	-77.07
1996 – 1997	10	18	57.87	-39.87
	11	88	70.69	17.31
	12	167	86.02	80.98
	1	188	87.63	100.37
	2	146	73.80	72.20
	3	21	59.15	-38.15
	4	12	59.17	-47.17
1997 – 1998	10	50	87.59	-37.59
	11	165	85.89	79.11
	12	127	70.50	56.50
	1	77	57.70	19.30
	2	47	61.01	-14.01
	3	18	76.92	-58.92
	4	0	88.57	-88.57
1998 – 1999	10	18	67.29	-49.29
	11	23	56.85	-33.85
	12	164	63.33	100.67
	1	87	79.86	7.14
	2	177	88.93	88.07
	3	3	80.93	-77.93
	4	4	64.31	-60.31
1999 – 2000	10	19	66.03	-47.03
	11	21	82.52	-61.52
	12	283	88.65	194.35
	1	82	77.91	4.09
	2	85	61.66	23.34
	3	1	57.07	-56.07
	4	0	68.99	-68.99
2000 – 2001	10	12	87.73	-75.73
	11	153	74.69	78.31
	12	100	59.45	40.55
	1	148	58.13	89.87
	2	9	72.10	-63.10
	3	11	86.58	-75.58
	4	20	86.21	-66.21
2001 – 2002	10	6	55.22	-49.22
	11	95	57.77	37.23
	12	41	59.76	-18.76
	1	248	75.23	172.77

Year	Month	Actual	Forecast	Residual
	2	67	87.80	-20.80
	3	29	84.15	-55.15
	4	0	68.12	-68.12
2002 – 2003	10	5	78.25	-73.25
	11	25	88.42	-63.42
	12	250	81.62	168.38
	1	107	65.03	41.97
	2	137	56.20	80.80
	3	175	64.45	110.55
	4	33	81.04	-48.04
2003 – 2004	10	2	78.72	-76.72
	11	42	62.24	-20.24
	12	159	56.38	102.62
	1	183	67.32	115.68
	2	98	83.48	14.52
	3	24	87.73	-63.73
	4	2	75.56	-73.56
2004 – 2005	10	4	57.18	-53.18
	11	211	70.39	140.61
	12	50	85.47	-35.47
	1	222	86.45	135.55
	2	235	72.28	162.72
	3	42	57.93	-15.93
	4	15	58.59	-43.59
2005 – 2006	10	19.5	74.85	-55.35
	11	57.7	86.93	-29.23
	12	118.2	84.60	33.6
	1	137	68.98	68.02
	2	111.1	56.59	54.51
	3	11.1	60.53	-49.43
	4	179.1	76.61	102.49
2006 – 2007	10	47.8	65.81	-18.01
	11	24	55.87	-31.87
	12	144	62.93	81.01
	1	167.3	79.50	87.8
	2	130.4	88.04	42.36
	3	144.6	79.48	65.12
	4	5	62.88	-57.88
2007 – 2008	10	1	56.62	-55.62
	11	106.5	59.24	47.26
	12	57.5	74.93	-17.43
	1	216.7	87.08	129.62
	2	144.4	82.80	61.6
	3	1.5	66.62	-65.12
	4	.7	55.64	-54.94
2008 – 2009	10		77.91	
	11		87.57	

Year	Month	Actual	Forecast	Residual
	12		80.20	
	1		63.58	
	2		55.29	
	3		64.09	
	4		80.64	
2009 – 2010	10		77.24	
	11		60.85	
	12		55.59	
	1		67.00	
	2		83.00	
	3		86.64	
	4		74.05	
2010 – 2011	10		56.51	
	11		70.09	
	12		84.90	
	1		85.25	
	2		70.75	
	3		56.74	
	4		58.02	
2011 – 2012	10		86.25	
	11		83.29	
	12		67.47	
	1		55.51	
	2		60.06	
	3		76.28	
	4		87.00	
2012 – 2013	10		64.33	
	11		54.91	
	12		62.54	
	1		79.13	
	2		87.12	
	3		78.02	
	4		61.46	
2013 – 2014	10		65.35	
	11		81.65	
	12		86.59	
	1		74.91	
	2		58.97	
	3		55.62	
	4		68.39	
2014 – 2015	10		85.43	
	11		71.64	
	12		56.96	
	1		56.90	
	2		71.52	
	3		85.33	
	4		83.70	

Year	Month	Actual	Forecast	Residual
2015 – 2016	10		55.49	
	11		58.73	
	12		74.62	
	1		86.33	
	2		81.45	
	3		65.13	
	4		54.63	
2016 – 2017	10		77.57	
	11		86.70	
	12		78.76	
	1		62.14	
	2		54.41	
	3		63.73	
	4		80.23	
2017 – 2018	10		75.75	
	11		59.48	
	12		54.82	
	1		66.69	
	2		82.51	
	3		85.53	
	4		72.53	
2018 – 2019	10		55.86	
	11		69.80	
	12		84.31	
	1		84.02	
	2		69.23	
	3		55.57	
	4		57.48	
2019 – 2020	10		85.55	
	11		81.97	
	12		65.96	
	1		54.46	
	2		59.61	
	3		75.96	
	4		86.18	
2020 – 2021	10		62.87	
	11		53.97	
	12		62.16	
	1		78.75	
	2		86.17	
	3		76.56	
	4		60.06	

Table A.1.5: Predicted and actual monthly rainfall for Nablu station using nonlinear regression and their residual

Year	Month	Actual	Forecast	Residual
1975 – 1976	10	3.8	64.68	-60.88
	11	47.2	57.25	-10.05
	12	108.3	64.04	44.26
	1	93.1	79.98	13.12
	2	152.0	93.08	58.92
	3	159.1	93.50	65.60
	4	27.0	80.96	-53.96
1976 – 1977	10	32.7	57.58	-24.88
	11	90.1	64.44	25.66
	12	46.6	80.39	-33.79
	1	158.5	93.44	65.06
	2	73.1	93.79	-20.69
	3	128.2	81.21	46.99
	4	85.7	65.22	20.48
1977 – 1978	10	82.6	64.83	17.77
	11	2.9	80.80	-77.90
	12	192.6	93.81	98.79
	1	79.2	94.09	-14.89
	2	60.0	81.47	-21.47
	3	82.8	65.49	17.31
	4	8.2	58.24	-50.04
1978 – 1979	10	20.1	81.21	-61.11
	11	6.7	94.18	-87.48
	12	104.2	94.39	9.81
	1	116.7	81.72	34.98
	2	20.4	65.76	-45.36
	3	75.7	58.57	17.13
	4	5.0	65.62	-60.62
1979 – 1980	10	39.7	94.55	-54.85
	11	158.9	94.69	64.21
	12	226.5	81.97	144.53
	1	113.8	66.02	47.78
	2	165.4	58.90	106.50
	3	155.5	66.01	89.49
	4	21.8	82.03	-60.23
1980 – 1981	10	15.0	94.98	-79.98
	11	8.9	82.23	-73.33
	12	192.7	66.29	126.41
	1	211.3	59.23	152.07
	2	147.5	66.41	81.09
	3	67.3	82.44	-15.14
	4	23.1	95.28	-72.18
1981 – 1982	10	0.	82.48	-82.48
	11	135.1	66.56	68.54
	12	19.9	59.57	-39.67

Year	Month	Actual	Forecast	Residual
	1	92.6	66.80	25.80
	2	171.2	82.85	88.35
	3	129.6	95.65	33.95
	4	7.0	95.58	-88.58
1982 – 1983	10	10.3	66.83	-56.53
	11	0.	59.90	-59.90
	12	215.8	67.20	148.60
	1	267.0	83.26	183.74
	2	322.9	96.01	226.89
	3	219.9	95.87	124.03
	4	14.8	82.98	-68.18
1983 – 1984	10	0.	60.23	-60.23
	11	70.4	67.59	2.81
	12	24.2	83.67	-59.47
	1	155.2	96.38	58.82
	2	85.2	96.17	-10.97
	3	0.	83.24	-83.24
	4	0.	67.37	-67.37
1984 – 1985	10	21.5	67.99	-46.49
	11	29.6	84.08	-54.48
	12	58.5	96.74	-38.24
	1	65.5	96.46	-30.96
	2	245.3	83.49	161.81
	3	20.1	67.64	-47.54
	4	23.2	60.90	-37.70
1985 – 1986	10	19.9	84.49	-64.59
	11	47.1	97.11	-50.01
	12	42.9	96.76	-53.86
	1	93.0	83.74	9.26
	2	163.2	67.91	95.29
	3	48.7	61.23	-12.53
	4	36.8	68.78	-31.98
1986 – 1987	10	52.4	97.47	-45.07
	11	249.6	97.05	152.55
	12	141.4	83.99	57.41
	1	130.0	68.18	61.82
	2	62.3	61.56	0.74
	3	129.0	69.18	59.82
	4	1.9	85.31	-83.41
1987 – 1988	10	52.9	97.35	-44.45
	11	23.2	84.25	-61.05
	12	224.0	68.45	155.55
	1	126.9	61.90	65.00
	2	306.9	69.57	237.33
	3	94.9	85.72	9.18
	4	0.	98.20	-98.20
1988 – 1989	10	16.0	84.50	-68.50

Year	Month	Actual	Forecast	Residual
	11	55.8	68.72	-12.92
	12	236.7	62.23	174.47
	1	96.3	69.97	26.33
	2	46.6	86.13	-39.53
	3	114.2	98.57	15.63
	4	0.	97.94	-97.94
1989 – 1990	10	9.9	68.99	-59.09
	11	94.9	62.57	32.33
	12	125.3	70.37	54.93
	1	131.6	86.54	45.06
	2	98.9	98.93	-0.03
	3	72.9	98.23	-25.33
	4	53.0	85.00	-32.00
1990 – 1991	10	3.5	62.90	-59.40
	11	24.3	70.76	-46.46
	12	9.5	86.95	-77.45
	1	251.4	99.29	152.11
	2	74.3	98.52	-24.22
	3	103.8	85.26	18.54
	4	30.1	69.53	-39.43
1991 – 1992	10	12.7	71.16	-58.46
	11	153.5	87.36	66.14
	12	472.2	99.66	372.54
	1	261.1	98.82	162.28
	2	384.7	85.51	299.19
	3	69.7	69.80	-0.10
	4	4.7	63.58	-58.88
1992 – 1993	10	0.	87.77	-87.77
	11	84.9	100.02	-15.12
	12	360.9	99.11	261.79
	1	142.3	85.76	56.54
	2	117.7	70.07	47.63
	3	68.7	63.91	4.79
	4	5.8	71.96	-66.16
1993 – 1994	10	14.7	100.38	-85.68
	11	21.6	99.40	-77.80
	12	28.7	86.01	-57.31
	1	192.5	70.35	122.15
	2	114.0	64.25	49.75
	3	129.1	72.36	56.74
	4	9.0	88.59	-79.59
1994 – 1995	10	20.6	99.69	-79.09
	11	263.5	86.27	177.23
	12	186.0	70.62	115.38
	1	57.9	64.59	-6.69
	2	95.4	72.75	22.65
	3	43.1	89.00	-45.90

Year	Month	Actual	Forecast	Residual
	4	35.3	101.11	-65.81
1995 – 1996	10	1.8	86.52	-84.72
	11	118.8	70.89	47.91
	12	59.2	64.92	-5.72
	1	229.8	73.15	156.65
	2	35.9	89.41	-53.51
	3	228.7	101.47	127.23
	4	33.4	100.28	-66.88
1996 – 1997	10	34.1	71.16	-37.06
	11	16.4	65.26	-48.86
	12	85.4	73.55	11.85
	1	158.2	89.81	68.39
	2	199.0	101.83	97.17
	3	233.1	100.57	132.53
	4	22.7	87.02	-64.32
1997 – 1998	10	16.3	65.60	-49.30
	11	59.9	73.95	-14.05
	12	167.4	90.22	77.18
	1	148.2	102.19	46.01
	2	91.9	100.86	-8.96
	3	244.5	87.27	157.23
	4	5.0	71.71	-66.71
1998 – 1999	10	1.6	74.35	-72.75
	11	1.7	90.63	-88.93
	12	54.4	102.55	-48.15
	1	154.2	101.15	53.05
	2	66.8	87.52	-20.72
	3	40.1	71.98	-31.88
	4	20.6	66.28	-45.68
1999 – 2000	10	5.8	91.04	-85.24
	11	16.3	102.91	-86.61
	12	39.4	101.44	-62.04
	1	471.0	87.78	383.22
	2	84.7	72.26	12.44
	3	79.1	66.62	12.48
	4	4.	75.15	-74.75
2000 – 2001	10	63.7	103.27	-39.57
	11	3.5	101.73	-98.23
	12	123.9	88.03	35.87
	1	85.1	72.53	12.57
	2	122.5	66.96	55.54
	3	9.3	75.55	-66.25
	4	3.6	91.86	-88.26
2001 – 2002	10	20.8	102.02	-81.22
	11	75.1	88.28	-13.18
	12	161.6	72.80	88.80
	1	157.8	67.30	90.50

Year	Month	Actual	Forecast	Residual
	2	56.6	75.95	-19.35
	3	151.9	92.27	59.63
	4	34.1	103.99	-69.89
2002 – 2003	10	2.6	88.53	-85.93
	11	32.1	73.08	-40.98
	12	130.4	67.64	62.76
	1	73.7	76.35	-2.65
	2	416.4	92.67	323.73
	3	236.6	104.35	132.25
	4	50.9	102.60	-51.70
2003 – 2004	10	2.6	73.35	-70.75
	11	32.1	67.98	-35.88
	12	130.4	76.75	53.65
	1	230.0	93.08	136.92
	2	136.2	104.70	31.50
	3	24.2	102.89	-78.69
	4	11.1	89.03	-77.93
2004 – 2005	10	4.	68.32	-67.92
	11	152.8	77.15	75.65
	12	82.6	93.49	-10.89
	1	239.8	105.06	134.74
	2	267.6	103.18	164.42
	3	37.3	89.29	-51.99
	4	9.4	73.90	-64.50
2005 – 2006	10	10.5	77.55	-67.05
	11	55.9	93.90	-38
	12	170.8	105.42	65.38
	1	152.3	103.46	48.84
	2	154.9	89.54	65.36
	3	20.6	74.18	-53.58
	4	128	69.00	59
2006 – 2007	10	98.6	94.30	4.3
	11	28.5	105.78	-77.28
	12	123	103.75	19.25
	1	105.6	89.79	15.81
	2	174.9	74.45	100.45
	3	116.6	69.34	47.26
	4	8.2	78.35	-70.15
2007 – 2008	10	0	106.13	-106.13
	11	85.3	104.04	-18.74
	12	78.4	90.04	-11.64
	1	157.7	74.73	82.97
	2	104.7	69.69	35.01
	3	6	78.75	-72.75
	4	.1	95.12	-95.02
2008 – 2009	10		104.33	
	11		90.29	

Year	Month	Actual	Forecast	Residual
	12		75.00	
	1		70.03	
	2		79.15	
	3		95.53	
	4		106.85	
2009 – 2010	10		90.54	
	11		75.28	
	12		70.37	
	1		79.55	
	2		95.93	
	3		107.20	
	4		104.90	
2010 – 2011	10		75.56	
	11		70.71	
	12		79.95	
	1		96.34	
	2		107.56	
	3		105.19	
	4		91.05	
2011 – 2012	10		71.06	
	11		80.35	
	12		96.75	
	1		107.92	
	2		105.47	
	3		91.30	
	4		76.11	
2012 – 2013	10		80.76	
	11		97.15	
	12		108.27	
	1		105.76	
	2		91.55	
	3		76.39	
	4		71.75	
2013 – 2014	10		97.56	
	11		108.63	
	12		106.04	
	1		91.80	
	2		76.67	
	3		72.09	
	4		81.56	
2014 – 2015	10		108.98	
	11		106.33	
	12		92.05	
	1		76.94	
	2		72.44	
	3		81.96	
	4		98.37	

Year	Month	Actual	Forecast	Residual
2015 – 2016	10		106.61	
	11		92.30	
	12		77.22	
	1		72.78	
	2		82.36	
	3		98.78	
	4		109.69	
2016 – 2017	10		92.55	
	11		77.50	
	12		73.13	
	1		82.77	
	2		99.19	
	3		110.04	
	4		107.18	
2017 – 2018	10		77.78	
	11		73.47	
	12		83.17	
	1		99.59	
	2		110.39	
	3		107.47	
	4		93.05	
2018 – 2019	10		73.82	
	11		83.57	
	12		100.00	
	1		110.75	
	2		107.75	
	3		93.31	
	4		78.34	
2019 – 2020	10		83.98	
	11		100.40	
	12		111.10	
	1		108.04	
	2		93.56	
	3		78.62	
	4		74.51	
2020 – 2021	10		100.81	
	11		111.45	
	12		108.32	
	1		93.81	
	2		78.90	
	3		74.86	
	4		84.78	

Table A.1.6: Predicted and actual monthly rainfall for Hebron station using nonlinear regression and their residual

Year	Month	Actual	Forecast	Residual
1975 – 1976	10	3	60.44	-57.44
	11	33	64.50	-31.50
	12	90	76.36	13.64
	1	51	87.38	-36.38
	2	144	89.52	54.48
	3	67	81.18	-14.18
	4	21	68.41	-47.41
1976 – 1977	10	17	63.07	-46.07
	11	33	74.32	-41.32
	12	37	86.01	-49.01
	1	245	89.60	155.40
	2	67	82.46	-15.46
	3	106	69.75	36.25
	4	155	60.68	94.32
1977 – 1978	10	38	72.29	-34.29
	11	36	84.48	-48.48
	12	197	89.48	107.52
	1	76	83.64	-7.64
	2	63	71.16	-8.16
	3	97	61.09	35.91
	4	7	60.73	-53.73
1978 – 1979	10	17	82.82	-65.82
	11	32	89.16	-57.16
	12	123	84.68	38.32
	1	154	72.61	81.39
	2	34	61.69	-27.69
	3	100	59.83	40.17
	4	14	68.36	-54.36
1979 – 1980	10	20	88.63	-68.63
	11	125	85.58	39.42
	12	286	74.09	211.91
	1	167	62.47	104.53
	2	166	59.14	106.86
	3	79	66.49	12.51
	4	19	79.16	-60.16
1980 – 1981	10	9	86.32	-77.32
	11	5	75.56	-70.56
	12	208	63.40	144.60
	1	102	58.65	43.35
	2	92	64.73	27.27
	3	106	77.20	28.80
	4	27	86.96	-59.96
1981 – 1982	10	4	77.01	-73.01
	11	49	64.47	-15.47
	12	8	58.36	-50.36

Year	Month	Actual	Forecast	Residual
	1	115	63.09	51.91
	2	207	75.20	131.80
	3	122	85.84	36.16
	4	7	87.27	-80.27
1982 – 1983	10	16	65.67	-49.67
	11	117	58.28	58.72
	12	52	61.60	-9.60
	1	285	73.16	211.84
	2	291	84.55	206.45
	3	115	87.45	27.55
	4	12	79.72	-67.72
1983 – 1984	10	4	58.41	-54.41
	11	32	60.26	-28.26
	12	13	71.13	-58.13
	1	136	83.09	52.91
	2	20	87.43	-67.43
	3	127	80.95	46.05
	4	35	68.34	-33.34
1984 – 1985	10	39	59.09	-20.09
	11	27	69.11	-42.11
	12	50	81.49	-31.49
	1	13	87.20	-74.20
	2	247	82.06	164.94
	3	49	69.77	-20.77
	4	60	59.25	0.75
1985 – 1986	10	12	67.14	-55.14
	11	32	79.76	-47.76
	12	76	86.77	-10.77
	1	87	83.03	3.97
	2	146	71.24	74.76
	3	7	59.94	-52.94
	4	54	57.31	-3.31
1986 – 1987	10	29	77.93	-48.93
	11	219	86.13	132.87
	12	79	83.85	-4.85
	1	140	72.72	67.28
	2	70	60.80	9.20
	3	100	56.72	43.28
	4	0	63.43	-63.43
1987 – 1988	10	58	85.29	-27.29
	11	21	84.50	-63.50
	12	163	74.18	88.82
	1	162	61.80	100.20
	2	234	56.34	177.66
	3	101	61.73	39.27
	4	14	74.03	-60.03
1988 – 1989	10	10	84.97	-74.97

Year	Month	Actual	Forecast	Residual
	11	39	75.60	-36.60
	12	140	62.94	77.06
	1	110	56.16	53.84
	2	103	60.16	42.84
	3	78	72.00	6.00
	4	0	83.05	-83.05
1989 – 1990	10	7	76.96	-69.96
	11	72	64.19	7.81
	12	33	56.19	-23.19
	1	152	58.74	93.26
	2	95	69.96	25.04
	3	57	81.67	-24.67
	4	88	85.33	2.67
1990 – 1991	10	2	65.53	-63.53
	11	16	56.42	-40.42
	12	4	57.49	-53.49
	1	157	67.94	89.06
	2	92	80.14	11.86
	3	193	85.20	107.80
	4	7	79.40	-72.40
1991 – 1992	10	10	56.84	-46.84
	11	64	56.41	7.59
	12	334	65.94	268.06
	1	197	78.47	118.53
	2	335	84.86	250.14
	3	63	80.44	-17.44
	4	1	68.40	-67.40
1992 – 1993	10	0	55.53	-55.53
	11	132	64.00	68.00
	12	158	76.68	81.32
	1	183	84.32	98.68
	2	163	81.34	81.66
	3	46	69.87	-23.87
	4	0	58.23	-58.23
1993 – 1994	10	0	62.14	-62.14
	11	130	74.80	55.20
	12	45	83.58	-38.58
	1	179	82.07	96.93
	2	117	71.34	45.66
	3	72	59.16	12.84
	4	17	54.36	-37.36
1994 – 1995	10	0	72.85	-72.85
	11	130	82.64	47.36
	12	45	82.63	-37.63
	1	179	72.79	106.21
	2	117	60.24	56.76
	3	72	54.08	17.92

Year	Month	Actual	Forecast	Residual
	4	17	58.76	-41.76
1995 – 1996	10	0	81.52	-81.52
	11	43	83.00	-40.00
	12	78	74.18	3.82
	1	122	61.44	60.56
	2	38	54.01	-16.01
	3	191	57.26	133.74
	4	17	68.81	-51.81
1996 – 1997	10	30	83.18	-53.18
	11	19	75.50	-56.50
	12	49	62.74	-13.74
	1	132	54.14	77.86
	2	200	55.93	144.07
	3	89	66.77	22.23
	4	11	78.76	-67.76
1997 – 1998	10	7	76.72	-69.72
	11	4	64.12	-60.12
	12	145	54.47	90.53
	1	114	54.77	59.23
	2	56	64.75	-8.75
	3	116	77.15	38.85
	4	0	82.91	-82.91
1998 – 1999	10	8	65.56	-57.56
	11	16	54.99	-38.99
	12	17	53.79	-36.79
	1	81	62.79	18.21
	2	69	75.42	-6.42
	3	19	82.47	-63.47
	4	44	78.79	-34.79
1999 – 2000	10	4	55.69	-51.69
	11	5	53.01	-48.01
	12	21	60.89	-39.89
	1	297	73.58	223.42
	2	65	81.82	-16.82
	3	75	79.60	-4.60
	4	0	68.50	-68.50
2000 – 2001	10	23	52.43	-29.43
	11	10	59.08	-49.08
	12	212	71.65	140.35
	1	146	80.98	65.02
	2	92	80.25	11.75
	3	25	69.96	-44.96
	4	5	57.57	-52.57
2001 – 2002	10	9	57.38	-48.38
	11	54	69.67	-15.67
	12	137	79.94	57.06
	1	330	80.71	249.29

Year	Month	Actual	Forecast	Residual
	2	61	71.38	-10.38
	3	0	58.71	-58.71
	4	0	51.88	-51.88
2002 – 2003	10	8	67.64	-59.64
	11	28	78.72	-50.72
	12	272	80.98	191.02
	1	76	72.74	3.26
	2	185	59.97	125.03
	3	116	51.92	64.08
	4	3	54.41	-51.41
2003 – 2004	10	13	77.34	-64.34
	11	3	81.05	-78.05
	12	145	74.01	70.99
	1	183	61.31	121.69
	2	98	52.15	45.85
	3	24	53.16	-29.16
	4	2	63.58	-61.58
2004 – 2005	10	4	80.91	-76.91
	11	211	75.17	135.83
	12	50	62.72	-12.72
	1	153	52.58	100.42
	2	118	52.10	65.90
	3	49	61.59	-12.59
	4	13	74.12	-61.12
2005 – 2006	10	10.4	76.21	-65.81
	11	48.3	64.18	-15.88
	12	84.2	53.20	31
	1	84.8	51.22	33.58
	2	85	59.65	25.35
	3	17.4	72.33	-54.93
	4	83.9	80.02	3.88
2006 – 2007	10	15.6	65.66	-50.06
	11	24.6	53.99	-29.93
	12	117.1	50.54	66.56
	1	153.1	57.80	95.3
	2	109	70.45	38.55
	3	110	79.27	30.73
	4	2.2	77.82	-75.62
2007 – 2008	10	0	49.80	-49.8
	11	23.6	54.42	-30.82
	12	43.9	66.48	-22.94
	1	151.1	77.19	73.91
	2	109.5	78.74	30.76
	3	0	69.96	-69.96
	4	0	57.21	-57.21
2008 – 2009	10		52.93	
	11		64.45	

Year	Month	Actual	Forecast	Residual
	12		75.89	
	1		78.90	
	2		71.27	
	3		58.52	
	4		49.88	
2009 – 2010	10		62.41	
	11		74.42	
	12		78.87	
	1		72.49	
	2		59.90	
	3		50.22	
	4		50.45	
2010 – 2011	10		72.81	
	11		78.62	
	12		73.59	
	1		61.34	
	2		50.74	
	3		49.48	
	4		58.43	
2011 – 2012	10		78.17	
	11		74.55	
	12		62.81	
	1		51.45	
	2		48.70	
	3		56.54	
	4		69.23	
2012 – 2013	10		75.36	
	11		64.28	
	12		52.32	
	1		48.13	
	2		54.73	
	3		67.30	
	4		76.67	
2013 – 2014	10		65.74	
	11		53.34	
	12		47.76	
	1		53.04	
	2		65.31	
	3		75.62	
	4		76.45	
2014 – 2015	10		54.49	
	11		47.60	
	12		51.49	
	1		63.29	
	2		74.40	
	3		76.71	
	4		68.52	

Year	Month	Actual	Forecast	Residual
2015 – 2016	10		47.65	
	11		50.08	
	12		61.25	
	1		73.00	
	2		76.77	
	3		69.78	
	4		57.09	
2016 – 2017	10		48.84	
	11		59.22	
	12		71.46	
	1		76.63	
	2		70.94	
	3		58.51	
	4		48.33	
2017 – 2018	10		57.23	
	11		69.78	
	12		76.28	
	1		71.97	
	2		59.96	
	3		48.95	
	4		46.91	
2018 – 2019	10		67.98	
	11		75.72	
	12		72.85	
	1		61.44	
	2		49.74	
	3		46.24	
	4		53.45	
2019 – 2020	10		74.96	
	11		73.57	
	12		62.91	
	1		50.69	
	2		45.77	
	3		51.70	
	4		64.13	
2020 – 2021	10		74.12	
	11		64.35	
	12		51.78	
	1		45.52	
	2		50.08	
	3		62.12	
	4		72.87	

Appendix A.2: Sum of Forecast and Actual Annual Rainfall Implementing Nonlinear Model

Table A.2.1: Sum of predicted and actual values for annual rainfall series in Tulkarem station

Year	Sum of Actual	Sum of Forecast	Residual
1975 –1976	488	553	-65
1976 – 1977*	802	554	248
1977 – 1978	635	552	83
1978 – 1979*	339	550	-211
1979 – 1980*	842	547	295
1980 – 1981	643	547	96
1981 – 1982	484	548	-64
1982 – 1983*	797	549	248
1983 – 1984*	381	548	-167
1984 – 1985	454	545	-91
1985 – 1986	561	542	19
1986 – 1987*	775	542	233
1987 – 1988	655	543	112
1988 – 1989	477	544	-67
1989 – 1990	679	543	136
1990 – 1991	558	540	18
1991 – 1992*	1371	538	833
1992 – 1993	624	537	87
1993 – 1994	481	538	-57
1994 – 1995*	859	539	320
1995 – 1996*	341	538	-197
1996 – 1997*	755	536	219
1997 – 1998*	756	533	223
1998 – 1999*	291	532	-241
1999 – 2000	599	533	66
2000 – 2001	455	534	-79
2001 – 2002	622	534	88
2002 – 2003*	799	531	268
2003 – 2004	495	528	-33
2004 – 2005	574	527	47
2005 – 2006	547	530	17
2006 – 2007	585	530	55

Year	Sum of Actual	Sum of Forecast	Residual
2007 – 2008	437.3	527	-89.7
2008 – 2009		524	
2009 – 2010		523	
2010 – 2011		524	
2011 – 2012		525	
2012 – 2013		525	
2013 – 2014		523	
2014 – 2015		520	
2015 – 2016		518	
2016 – 2017		519	
2017 – 2018		520	
2018 – 2019		520	
2019 – 2020		518	
2020 – 2021		515	

* Drought years
* Wet years

Table A.2.2: Sum of predicted and actual values for annual rainfall series in Jenin station

Year	Sum of Actual	Sum of Forecast	Residual
1975 –1976	431	371	60
1976 – 1977	414	369	45
1977 – 1978	304	374	-70
1978 – 1979*	267	372	-105
1979 – 1980*	586	376	210
1980 – 1981	467	376	91
1981 – 1982	299	377	-78
1982 – 1983*	646	380	266
1983 – 1984	374	378	-4
1984 – 1985*	285	383	-98
1985 – 1986	331	381	-50
1986 – 1987	434	385	49
1987 – 1988*	724	385	339
1988 – 1989	418	386	32
1989 – 1990	432	389	43
1990 – 1991	352	388	-36
1991 – 1992*	1012	393	619
1992 – 1993	455	390	65
1993 – 1994	314	394	-80
1994 – 1995*	503	394	109
1995 – 1996*	297	396	-99
1996 – 1997	451	398	53
1997 – 1998*	590	397	193
1998 – 1999*	223	402	-179
1999 – 2000	412	399	13
2000 – 2001*	255	404	-149
2001 – 2002	375	403	-28
2002 – 2003*	870	405	465
2003 – 2004	439	407	32
2004 – 2005	411	406	5
2005 – 2006	389	411	-22
2006 – 2007	479	409	70
2007 – 2008	315	413	-98
2008 – 2009		412	
2009 – 2010		414	

Year	Sum of Actual	Sum of Forecast	Residual
2010 – 2011		416	
2011 – 2012		416	
2012 – 2013		420	
2013 – 2014		418	
2014 – 2015		423	
2015 – 2016		421	
2016 – 2017		424	
2017 – 2018		425	
2018 – 2019		425	
2019 – 2020		429	
2020 – 2021		427	

* Drought years
* Wet years

Table A.2.3: Sum of predicted and actual values for annual rainfall series in Jericho station

Year	Sum of Actual	Sum of Forecast	Residual
1975 –1976	130	129	1
1976 – 1977	112	129	-17
1977 – 1978	106	130	-24
1978 – 1979	96	130	-34
1979 – 1980*	226	131	95
1980 – 1981	199	131	68
1981 – 1982	130	131	-1
1982 – 1983*	205	131	74
1983 – 1984	86	131	-45
1984 – 1985	140	131	9
1985 – 1986	86	131	-45
1986 – 1987	167	130	37
1987 – 1988	180	130	50
1988 – 1989	183	129	54
1989 – 1990	176	129	47
1990 – 1991	109	129	-20
1991 – 1992*	344	129	215
1992 – 1993	116	129	-13
1993 – 1994	93	129	-36
1994 – 199	153	129	24
1995 – 1996	142	130	12
1996 – 1997	160	130	30
1997 – 1998	176	131	45
1998 – 1999*	41	132	-91
1999 – 2000	109	132	-23
2000 – 2001	127	133	-6
2001 – 2002	201	133	68
2002 – 2003*	239	133	106
2003 – 2004	110	133	-23
2004 – 2005	140	133	7
2005 – 2006	162	133	29
2006 – 2007	138	132	6
2007 – 2008	122	132	-10
2008 – 2009		131	
2009 – 2010		131	

Year	Sum of Actual	Sum of Forecast	Residual
2010 – 2011		131	
2011 – 2012		130	
2012 – 2013		130	
2013 – 2014		130	
2014 – 2015		131	
2015 – 2016		131	
2016 – 2017		131	
2017 – 2018		132	
2018 – 2019		133	
2019 – 2020		133	
2020 – 2021		134	

* Drought years
* Wet years

Table A.2.4: Sum of predicted and actual values for annual rainfall series in Rammallah station

Year	Sum of Actual	Sum of Forecast	Residual
1975 –1976	479	520	-41
1976 – 1977	557	545	12
1977 – 1978	573	509	64
1978 – 1979	525	532	-7
1979 – 1980*	890	533	357
1980 – 1981*	709	507	202
1981 – 1982	613	540	73
1982 – 1983*	987	516	471
1983 – 1984*	323	514	-191
1984 – 1985*	317	538	-221
1985 – 1986	408	503	-95
1986 – 1987*	746	526	220
1987 – 1988*	783	526	257
1988 – 1989	405	500	-95
1989 – 1990	403	534	-131
1990 – 1991	511	509	2
1991 – 1992*	1576	509	1067
1992 – 1993*	810	532	278
1993 – 1994	582	496	86
1994 – 1995*	724	521	203
1995 – 1996	640	518	122
1996 – 1997	640	494	146
1997 – 1998	484	528	-44
1998 – 1999	476	502	-26
1999 – 2000	491	503	-12
2000 – 2001	453	525	-72
2001 – 2002	486	488	-2
2002 – 2003*	732	515	217
2003 – 2004	510	511	-1
2004 – 2005*	779	488	291
2005 – 2006	634	509	125
2006 – 2007	663	495	168
2007 – 2008	527	483	44
2008 – 2009		509	
2009 – 2010		504	

Year	Sum of Actual	Sum of Forecast	Residual
2010 – 2011		482	
2011 – 2012		516	
2012 – 2013		488	
2013 – 2014		491	
2014 – 2015		511	
2015 – 2016		476	
2016 – 2017		504	
2017 – 2018		497	
2018 – 2019		476	
2019 – 2020		510	
2020 – 2021		481	

* Drought years
* Wet years

Table A.2.5: Sum of predicted and actual values for annual rainfall series in Nablus station

Year	Sum of Actual	Sum of Forecast	Residual
1975 –1976	591	533	57
1976 – 1977	615	536	79
1977 – 1978	508	539	-30
1978 – 1979*	349	541	-193
1979 – 1980*	882	544	337
1980 – 1981	666	547	119
1981 – 1982	555	549	6
1982 – 1983*	1051	552	499
1983 – 1984*	335	555	-220
1984 – 1985*	464	557	-94
1985 – 1986	452	560	-108
1986 – 1987*	767	563	204
1987 – 1988*	829	565	263
1988 – 1989	566	568	-2
1989 – 1990	587	571	16
1990 – 1991	497	573	-76
1991 – 1992*	1359	576	783
1992 – 1993*	780	579	202
1993 – 1994	510	581	-72
1994 – 1995	702	584	118
1995 – 1996	708	587	121
1996 – 1997	749	589	160
1997 – 1998	733	592	141
1998 – 1999*	339	594	-255
1999 – 2000	697	597	100
2000 – 2001	412	600	-188
2001 – 2002	658	603	55
2002 – 2003*	943	605	337
2003 – 2004	567	608	-41
2004 – 2005*	790	610	180
2005 – 2006	693	613	80
2006 – 2007	655	616	39
2007 – 2008	432	619	-189
2008 – 2009		621	
2009 – 2010		624	

Year	Sum of Actual	Sum of Forecast	Residual
2010 – 2011		626	
2011 – 2012		629	
2012 – 2013		632	
2013 – 2014		634	
2014 – 2015		637	
2015 – 2016		640	
2016 – 2017		642	
2017 – 2018		645	
2018 – 2019		648	
2019 – 2020		650	
2020 – 2021		653	

* Drought years
* Wet years

Table A.2.6: Sum of predicted and actual values for annual rainfall series in Hebron station

Year	Sum of Actual	Forecast	Residual
1975 –1976	409	528	-119
1976 – 1977	660	526	134
1977 – 1978	514	523	-9
1978 – 1979	474	519	-45
1979 – 1980*	862	516	346
1980 – 1981	549	513	36
1981 – 1982	512	511	1
1982 – 1983*	888	510	378
1983 – 1984*	367	510	-143
1984 – 1985	485	508	-23
1985 – 1986	414	505	-91
1986 – 1987	637	502	135
1987 – 1988*	753	498	255
1988 – 1989	480	495	-15
1989 – 1990	504	493	11
1990 – 1991	471	492	-21
1991 – 1992*	1004	491	513
1992 – 1993	682	490	192
1993 – 1994	560	487	73
1994 – 1995	560	484	76
1995 – 1996	489	480	9
1996 – 1997	530	477	53
1997 – 1998	442	475	-33
1998 – 1999*	254	474	-220
1999 – 2000	467	473	-6
2000 – 2001	513	472	41
2001 – 2002	591	470	121
2002 – 2003*	688	466	222
2003 – 2004	468	463	5
2004 – 2005	598	459	139
2005 – 2006	414	457	-43
2006 – 2007	532	456	76
2007 – 2008	328	454	-126
2008 – 2009		452	
2009 – 2010		449	

Year	Sum of Actual	Forecast	Residual
2010 – 2011		445	
2011 – 2012		441	
2012 – 2013		439	
2013 – 2014		437	
2014 – 2015		437	
2015 – 2016		436	
2016 – 2017		434	
2017 – 2018		431	
2018 – 2019		427	
2019 – 2020		424	
2020 – 2021		421	

* Drought years
* Wet years

Appendix B.1: Forecast and Actual Monthly Rainfall Implementing ARIMA Model

Table B.1.1: Predicted and actual monthly rainfall for Tulkarem station using ARIMA model and their residual

Year	Month	Actual	Forecast	Residual
1981 – 1982	10	1	19.97008	-18.97
	11	148	36.85947	111.14
	12	38	141.1157	-103.12
	1	94	112.6645	-18.66
	2	125	143.4138	-18.41
	3	75	58.05585	16.94
	4	3	6.785854	-3.79
1982 – 1983	10	0	20.57842	-20.58
	11	138	37.19035	100.81
	12	137	138.2769	-1.28
	1	183	113.0745	69.93
	2	200	140.671	59.33
	3	120	58.50099	61.50
	4	19	7.193559	11.81
1983 – 1984	10	3	21.17655	-18.18
	11	71	37.5358	33.46
	12	25	135.5949	-110.59
	1	122	113.427	8.57
	2	40	138.0599	-98.06
	3	93	58.88629	34.11
	4	27	7.600027	19.40
1984 – 1985	10	23	21.75304	1.25
	11	25	37.87728	-12.88
	12	78	132.9998	-55.00
	1	123	113.73	9.27
	2	172	135.5735	36.43
	3	6	59.21507	-53.22
	4	27	8.004266	19.00
1985 – 1986	10	50	22.31773	27.68
	11	76	38.23138	37.77
	12	107	130.5474	-23.55
	1	175	113.9811	61.02
	2	108	133.2051	-25.21
	3	22	59.49029	-37.49
	4	23	8.405206	14.59
1986 – 1987	10	71	15.36128	55.64
	11	260	22.86194	237.14
	12	177	38.58097	138.42
	1	109	128.1746	-19.17
	2	37	114.1886	-77.19
	3	119	130.9486	-11.95
	4	2	59.71509	-57.72

Year	Month	Actual	Forecast	Residual
1987 – 1988	10	44	23.393	20.61
	11	13	38.94144	-25.94
	12	235	125.9318	109.07
	1	102	114.3491	-12.35
	2	167	128.7979	38.20
	3	87	59.89233	27.11
	4	7	9.193647	-2.19
1988 – 1989	10	27	23.90372	3.10
	11	59	39.29686	19.70
	12	151	123.7618	27.24
	1	100	114.4715	-14.47
	2	57	126.7476	-69.75
	3	83	60.02501	22.97
	4	0	9.579467	-9.58
1989 – 1990	10	32	24.4002	7.60
	11	95	39.66156	55.34
	12	189	121.7104	67.29
	1	150	114.5519	35.45
	2	155	124.7924	30.21
	3	27	60.11584	-33.12
	4	31	9.958632	21.04
1990 – 1991	10	7	24.87786	-17.88
	11	10	40.02071	-30.02
	12	20	119.7255	-99.73
	1	251	114.5993	136.40
	2	88	122.9276	-34.93
	3	144	60.16759	83.83
	4	38	10.33053	27.67
1991 – 1992	10	8	25.34038	-17.34
	11	221	40.38772	180.61
	12	436	117.8489	318.15
	1	278	114.6091	163.39
	2	390	121.1483	268.85
	3	30	60.18282	-30.18
	4	8	10.69447	-2.69
1992 – 1993	10	0	25.78457	-25.78
	11	51	40.74868	10.25
	12	310	116.0331	193.97
	1	122	114.5903	7.41
	2	78	119.4504	-41.45
	3	61	60.16409	0.84
	4	2	11.04997	-9.05
1993 – 1994	10	19	26.21294	-7.21
	11	18	41.11621	-23.12
	12	22	114.3161	-92.32
	1	229	114.5385	114.46
	2	93	117.8296	-24.83

Year	Month	Actual	Forecast	Residual
	3	92	60.11381	31.89
	4	8	11.39647	-3.40
1994 – 1995	10	34	26.62469	7.38
	11	309	41.4772	267.52
	12	259	112.6549	146.35
	1	73	114.4622	-41.46
	2	123	116.2821	6.72
	3	40	60.03428	-20.03
	4	21	11.73359	9.27
1995 – 1996	10	2	27.02007	-25.02
	11	95	41.84362	53.16
	12	63	111.0839	-48.08
	1	24	114.3567	-90.36
	2	145	114.8042	30.20
	3	12	59.92773	-47.93
	4	0	12.06088	-12.06
1996 – 1997	10	48	27.39886	20.60
	11	7	42.20307	-35.20
	12	99	109.564	-10.56
	1	138	114.2305	23.77
	2	257	113.3924	143.61
	3	195	59.79628	135.20
	4	11	12.37807	-1.38
1997 – 1998	10	39	27.76094	11.24
	11	81	42.56687	38.43
	12	183	108.1264	74.87
	1	199	114.079	84.92
	2	58	112.0436	-54.04
	3	190	59.64199	130.36
	4	6	12.68483	-6.68
1998 – 1999	10	4	28.1062	-24.11
	11	3	42.92327	-39.92
	12	60	106.7357	-46.74
	1	127	113.9101	13.09
	2	37	110.7545	-73.75
	3	34	59.4668	-25.47
	4	26	12.98099	13.02
1999 – 2000	10	4	28.43462	-24.43
	11	18	43.28302	-25.28
	12	43	105.4204	-62.42
	1	390	113.7192	276.28
	2	88	109.5223	-21.52
	3	56	59.27257	-3.27
	4	0	13.26629	-13.27
2000 – 2001	10	107	28.74618	78.25
	11	17	43.63496	-26.63
	12	124	104.1479	19.85

Year	Month	Actual	Forecast	Residual
	1	89	113.5138	-24.51
	2	116	108.3442	7.66
	3	0	59.06108	-59.06
	4	2	13.54067	-11.54
	10	6	29.04096	-23.04
	11	124	43.98932	80.01
	12	205	102.9443	102.06
2001 – 2002	1	232	113.2898	118.71
	2	55	107.2175	-52.22
	3	0	58.834	-58.83
	4	0	13.80397	-13.80
	10	12	29.31903	-17.32
	11	33	44.3355	-11.34
	12	124	101.7801	22.22
2002 – 2003	1	100	113.0539	-13.05
	2	337	106.1399	230.86
	3	161	58.59295	102.41
	4	32	14.05617	17.94
	10	6	29.58054	-23.58
	11	43	44.6832	-1.68
	12	92	100.6789	-8.68
2003 – 2004	1	241	112.8021	128.20
	2	89	105.1089	-16.11
	3	18	58.33943	-40.34
	4	6	14.29723	-8.30
	10	3	29.82564	-26.83
	11	127	45.02241	81.98
	12	63	99.61374	-36.61
2004 – 2005	1	219	112.5409	106.46
	2	140	104.1223	35.88
	3	17	58.07489	-41.07
	4	5	14.52718	-9.53
	10		30.05455	
	11		45.36232	
	12		98.60624	
2005 – 2006	1		112.2665	
	2		103.1779	
	3		57.80066	
	4		14.74604	
	10		30.26749	
	11		45.69344	
	12		97.63187	
2006 – 2007	1		111.9847	
	2		102.2739	
	3		57.51804	
	4		14.95393	
2007 – 2008	10		30.46473	

Year	Month	Actual	Forecast	Residual
	11		46.02451	
	12		96.71022	
	1		111.692	
	2		101.4083	
	3		57.22822	
	4		15.15091	
2008 – 2009	10		30.64656	
	11		46.34655	
	12		95.81897	
	1		111.3937	
	2		100.5792	
	3		56.93232	
	4		15.33715	
2009 – 2010	10		30.81329	
	11		46.66784	
	12		94.97599	
	1		111.0868	
	2		99.78501	
	3		56.63142	
	4		15.51276	
2010 – 2011	10		30.96524	
	11		46.97991	
	12		94.16088	
	1			
	2			
	3			
	4			

Table B.1.2: Predicted and actual monthly rainfall for Jenin station using ARIMA model and their residual

Year	Month	Actual	Forecast	Residual
1981 – 1982	10	0	9.356642	-9.35664
	11	64	39.4754	24.5246
	12	28	94.38412	-66.3841
	1	31	73.69952	-42.6995
	2	121	119.6336	1.36643
	3	55	53.48817	1.511826
	4	0	5.475516	-5.47552
1982 – 1983	10	0	9.641936	-9.64194
	11	80	40.35369	39.64631
	12	96	93.33889	2.661105
	1	162	76.38237	85.61763
	2	183	117.4896	65.51036
	3	125	52.90302	72.09698
	4	0	5.65923	-5.65923
1983 – 1984	10	0	9.940468	-9.94047
	11	68	41.19092	26.80908
	12	32	92.47627	-60.4763
	1	109	78.90596	30.09404
	2	47	115.5103	-68.5103
	3	78	52.33522	25.66478
	4	40	5.836258	34.16374
1984 – 1985	10	0	10.25122	-10.2512
	11	23	41.99226	-18.9923
	12	49	91.77651	-42.7765
	1	63	81.2778	-18.2778
	2	120	113.6802	6.319799
	3	8	51.78509	-43.7851
	4	22	6.006586	15.99341
1985 – 1986	10	0	10.57328	-10.5733
	11	56	42.76244	13.23756
	12	42	91.22223	-49.2222
	1	95	83.50564	11.49436
	2	103	111.9857	-8.98571
	3	14	51.25277	-37.2528
	4	21	6.170461	14.82954
1986 – 1987	10	0	10.90584	-10.9058
	11	157	43.50577	113.4942
	12	105	90.79805	14.20195
	1	72	85.59732	-13.5973
	2	19	110.4146	-91.4146
	3	81	50.7383	30.2617
	4	0	6.327917	-6.32792
1987 – 1988	10	0	11.24818	-11.2482
	11	15	44.22616	-29.2262
	12	211	90.4904	120.5096

Year	Month	Actual	Forecast	Residual
	1	181	87.56063	93.43937
	2	225	108.9559	116.0441
	3	92	50.24159	41.75841
	4	0	6.479236	-6.62448
1988 – 1989	10	0	11.59968	-11.5997
	11	60	44.92716	15.07284
	12	164	90.28718	73.71282
	1	86	89.40322	-3.40322
	2	31	107.5998	-76.5998
	3	77	49.76248	27.23752
	4	0	6.624482	-6.62448
1989 – 1990	10	0	11.95977	-11.9598
	11	58	45.61196	12.38804
	12	98	90.1777	7.822304
	1	118	91.13254	26.86746
	2	91	106.3375	-15.3375
	3	47	49.30073	-2.30073
	4	20	6.763956	13.23604
1990 – 1991	10	0	12.32797	-12.328
	11	11	46.28344	-35.2834
	12	10	90.15238	-80.1524
	1	156	92.75578	63.24422
	2	60	105.1611	-45.1611
	3	115	48.85606	66.14394
	4	0	6.897742	-6.89774
1991 – 1992	10	0	12.70385	-12.7038
	11	137	46.94417	90.05583
	12	254	90.20272	163.7973
	1	216	94.27986	121.7201
	2	367	104.0634	262.9366
	3	38	48.42812	-10.4281
	4	0	7.026145	-7.02615
1992 – 1993	10	0	13.08704	-13.087
	11	49	47.59644	1.403561
	12	239	90.32111	148.6789
	1	68	95.71139	-27.7114
	2	68	103.038	-35.038
	3	27	48.01653	-21.0165
	4	4	7.14926	-3.14926
1993 – 1994	10	0	13.47723	-13.4772
	11	40	48.24231	-8.24231
	12	6	90.50074	-84.5007
	1	152	97.05663	54.94337
	2	54	102.079	-48.079
	3	55	47.6209	7.379105
	4	7	7.267392	-0.26739
1994 – 1995	10	0	13.87416	-13.8742

Year	Month	Actual	Forecast	Residual
	11	192	48.8836	143.1164
	12	162	90.7355	71.2645
	1	33	98.32154	-65.3215
	2	88	101.1812	-13.1812
	3	28	47.24078	-19.2408
	4	0	7.380636	-7.38064
1995 – 1996	10	0	14.2776	-14.2776
	11	91	49.52194	41.47806
	12	33	91.01994	-58.0199
	1	130	99.51173	30.48827
	2	28	100.3399	-72.3399
	3	15	46.87575	-31.8758
	4	0	7.48929	-7.48929
1996 – 1997	10	0	14.68737	-14.6874
	11	3	50.15875	-47.1587
	12	43	91.34915	-48.3491
	1	154	100.6325	53.36749
	2	156	99.55082	56.44918
	3	85	46.52536	38.47464
	4	10	7.59345	2.40655
1997 – 1998	10	42	15.10332	26.89668
	11	49	50.7953	-1.7953
	12	150	91.71871	58.28129
	1	115	101.6889	13.31114
	2	73	98.80993	-25.8099
	3	144	46.18913	97.81087
	4	17	7.6934	9.3066
1998 – 1999	10	0	15.52532	-15.5253
	11	0	51.43272	-51.4327
	12	35	92.12467	-57.1247
	1	78	102.6854	-24.6854
	2	35	98.11376	-63.1138
	3	54	45.86663	8.133373
	4	21	7.789232	13.21077
1999 – 2000	10	0	15.9533	-15.9533
	11	4	52.07197	-48.072
	12	46	92.56346	-46.5635
	1	254	103.6266	150.3734
	2	52	97.45907	-45.4591
	3	53	45.55738	7.442618
	4	3	7.881215	-4.88122
2000 – 2001	10	55	16.38717	38.61283
	11	0	52.71392	-52.7139
	12	61	93.03188	-32.0319
	1	65	104.5165	-39.5165
	2	67	96.84293	-29.8429
	3	6	45.26095	-39.2609

Year	Month	Actual	Forecast	Residual
	4	1	7.969436	-6.96944
2001 – 2002	10	9	16.8269	-7.8269
	11	33	53.35931	-20.3593
	12	121	93.52703	27.47297
	1	164	105.3589	58.64106
	2	48	96.26267	-48.2627
	3	0	44.97687	-44.9769
	4	0	8.054148	-8.05415
2002 – 2003	10	0	17.27246	-17.2725
	11	41	54.00881	-13.0088
	12	192	94.04632	97.95368
	1	67	106.1575	-39.1575
	2	357	95.71587	261.2841
	3	174	44.70472	129.2953
	4	39	8.13543	30.86457
2003 – 2004	10	3	17.72384	-14.7238
	11	42	54.66298	-12.663
	12	100	94.5874	5.4126
	1	176	106.9154	69.08458
	2	95	95.20029	-0.20029
	3	8	44.44405	-36.4441
	4	15	8.213519	6.786481
2004 – 2005	10	0	18.18104	-18.181
	11	86	55.3223	30.6777
	12	44	95.14817	-51.1482
	1	116	107.6359	8.364076
	2	142	94.71391	47.28609
	3	20	44.19446	-24.1945
	4	3	8.288488	-5.28849
2005 – 2006	10	21.7	18.64409	3.055913
	11	44.4	55.98721	-11.5872
	12	75.1	95.72674	-20.6267
	1	87.6	108.3219	-20.7219
	2	73.8	94.25487	-20.4549
	3	10.2	43.95554	-33.7555
	4	76.2	8.360554	67.83945
2006 – 2007	10	25.9	19.11301	6.786991
	11	50.3	56.65805	-6.35805
	12	100.4	96.32139	4.078613
	1	109.1	108.9759	0.124097
	2	125.8	93.82148	31.97852
	3	57.5	43.72688	13.77312
	4	10.3	8.429785	1.870215
2007 – 2008	10		19.58785	
	11		57.33515	
	12		96.93059	
	1		109.6006	

Year	Month	Actual	Forecast	Residual
	2		93.41216	
	3		43.50809	
	4		8.496381	
2008 – 2009	10		20.06865	
	11		58.01876	
	12		97.55295	
	1		110.1982	
	2		93.02551	
	3		43.29882	
	4		8.560402	
2009 – 2010	10		20.55547	
	11		58.7091	
	12		98.18725	
	1		110.771	
	2		92.6602	
	3		43.0987	
	4		8.622034	
2010 – 2011	10		21.04836	
	11		59.40636	
	12		98.83236	
	1			
	2			
	3			

Table B.1.3: Predicted and actual monthly rainfall for Jericho station using ARIMA model and their residual

Year	Month	Actual	Forecast	Residual
1981 – 1982	10	0	0.302971	-0.30297
	11	10	35.67298	-25.673
	12	2	24.92566	-22.9257
	1	30	16.62156	13.37844
	2	37	49.72482	-12.7248
	3	36	20.07801	15.92199
	4	15	0.004371	14.99563
1982 – 1983	10	0	0.404327	-0.40433
	11	29	35.05129	-6.05129
	12	20	25.05156	-5.05156
	1	62	16.83912	45.16088
	2	54	48.55356	5.446436
	3	39	20.27796	18.72204
	4	1	0.006296	0.993704
1983 – 1984	10	0	0.517881	-0.51788
	11	12	34.45509	-22.4551
	12	6	25.17767	-19.1777
	1	32	17.05335	14.94665
	2	4	47.41732	-43.4173
	3	28	20.45524	7.544759
	4	4	0.008707	3.991293
1984 – 1985	10	0	0.642723	-0.64272
	11	9	33.88339	-24.8834
	12	8	25.29095	-17.291
	1	21	17.26422	3.735783
	2	66	46.31503	19.68497
	3	26	20.61047	5.389531
	4	10	0.01165	9.98835
1985 – 1986	10	0	0.778196	-0.7782
	11	17	33.33524	-16.3352
	12	23	25.40441	-2.40441
	1	9	17.47183	-8.47183
	2	27	45.24569	-18.2457
	3	3	20.74428	-17.7443
	4	7	0.015168	6.984832
1986 – 1987	10	0	0.923443	-0.92344
	11	83	32.80972	50.19028
	12	17	25.50617	-8.50617
	1	27	17.67616	9.323844
	2	20	44.20831	-24.2083
	3	20	20.85733	-0.85733
	4	0	0.019299	-0.0193
1987 – 1988	10	0	1.077895	-1.07789
	11	1	32.30596	-31.306
	12	49	25.60807	23.39193

Year	Month	Actual	Forecast	Residual
	1	42	17.87729	24.12271
	2	69	43.20193	25.79807
	3	19	20.9503	-1.9503
	4	0	0.024077	-0.02408
1988 – 1989	10	0	1.240741	-1.24074
	11	10	31.82311	-21.8231
	12	86	25.69902	60.30098
	1	31	18.07518	12.92482
	2	25	42.22564	-17.2256
	3	31	21.02388	9.976118
	4	0	0.02953	-0.02953
1989 – 1990	10	0	1.411493	-1.41149
	11	15	31.36037	-16.3604
	12	20	25.79008	-5.79008
	1	56	18.26992	37.73008
	2	26	41.27854	-15.2785
	3	39	21.07876	17.92124
	4	20	0.035681	19.96432
1990 – 1991	10	0	1.589387	-1.58939
	11	4	30.91697	-26.917
	12	1	25.87123	-24.8712
	1	54	18.46147	35.53853
	2	22	40.35976	-18.3598
	3	27	21.11564	5.88436
	4	1	0.042549	0.957451
1991 – 1992	10	0	1.774003	-1.774
	11	58	30.49218	27.50782
	12	104	25.95245	78.04755
	1	57	18.64991	38.35009
	2	112	39.46847	72.53153
	3	12	21.13523	-9.13523
	4	1	0.050146	0.949854
1992 – 1993	10	0	1.964623	-1.96462
	11	25	30.08528	-5.08528
	12	35	26.02444	8.975556
	1	17	18.83518	-1.83518
	2	27	38.60384	-11.6038
	3	12	21.13823	-9.13823
	4	0	0.058482	-0.05848
1993 – 1994	10	0	2.160893	-2.16089
	11	18	29.69559	-11.6956
	12	4	26.09646	-22.0965
	1	34	19.01736	14.98264
	2	20	37.76509	-17.7651
	3	14	21.12534	-7.12534
	4	3	0.06756	2.93244
1994 – 1995	10	0	2.362132	-2.36213

Year	Month	Actual	Forecast	Residual
	11	66	29.32247	36.67753
	12	52	26.16021	25.83979
	1	2	19.1964	-17.1964
	2	28	36.95144	-8.95144
	3	4	21.09727	-17.0973
	4	1	0.077378	0.922622
1995 – 1996	10	0	2.568048	-2.56805
	11	6	28.96528	-22.9653
	12	21	26.22393	-5.22393
	1	46	19.37236	26.62764
	2	13	36.16215	-23.1622
	3	48	21.0547	26.9453
	4	8	0.087932	7.912068
1996 – 1997	10	0	2.777998	-2.778
	11	6	28.62344	-22.6234
	12	21	26.28001	-5.28001
	1	53	19.54519	33.45481
	2	43	35.3965	7.603498
	3	35	20.99832	14.00168
	4	2	0.099211	1.900789
1997 – 1998	10	31	2.991742	28.00826
	11	11	28.29636	-17.2964
	12	45	26.336	18.664
	1	34	19.71495	14.28505
	2	17	34.65379	-17.6538
	3	38	20.92881	17.07119
	4	0	0.111202	-0.1112
1998 – 1999	10	0	3.208676	-3.20868
	11	0	27.9835	-27.9835
	12	1	26.38524	-25.3852
	1	12	19.88158	-7.88158
	2	14	33.93332	-19.9333
	3	11	20.84683	-9.84683
	4	3	0.123887	2.876113
1999 – 2000	10	0	3.428606	-3.42861
	11	2	27.68432	-25.6843
	12	8	26.4343	-18.4343
	1	55	20.04513	34.95487
	2	17	33.23444	-16.2344
	3	27	20.75302	6.246977
	4	0	0.137245	-0.13724
2000 – 2001	10	18	3.650964	14.34904
	11	1	27.39832	-26.3983
	12	36	26.47719	9.522811
	1	31	20.20557	10.79443
	2	32	32.5565	-0.5565
	3	2	20.64804	-18.648

Year	Month	Actual	Forecast	Residual
	4	7	0.151253	6.848747
2001 – 2002	10	0	3.875598	-3.8756
	11	15	27.12501	-12.125
	12	49	26.51984	22.48016
	1	78	20.36291	57.63709
	2	25	31.89888	-6.89888
	3	20	20.53251	-0.53251
	4	14	0.165882	13.83412
2002 – 2003	10	20	4.101975	15.89803
	11	21	26.86393	-5.86393
	12	50	26.5571	23.4429
	1	35	20.51713	14.48287
	2	70	31.26096	38.73904
	3	40	20.40704	19.59296
	4	3	0.181105	2.818895
2003 – 2004	10	1	4.329981	-3.32998
	11	1	26.61462	-25.6146
	12	44	26.59404	17.40596
	1	30	20.66825	9.331747
	2	23	30.64216	-7.64216
	3	9	20.27223	-11.2722
	4	2	0.196889	1.803111
2004 – 2005	10	8	4.559113	3.440887
	11	26	26.37665	-0.37665
	12	30	26.62611	3.373888
	1	43	20.81624	22.18376
	2	18	30.04191	-12.0419
	3	13	20.12865	-7.12865
	4	2	0.2132	1.7868
2005 – 2006	10	0.5	4.789294	-4.28929
	11	12.9	26.14961	-13.2496
	12	28.8	26.65779	2.142209
	1	31.4	20.96112	10.43888
	2	16.9	29.45963	-12.5596
	3	0.7	19.97687	-19.2769
	4	70.3	0.230002	70.07
2006 – 2007	10	9.5	5.02005	4.47995
	11	5.8	25.9331	-20.1331
	12	36.8	26.6853	10.1147
	1	23.5	21.10285	2.397146
	2	22.5	28.8948	-6.3948
	3	31.4	19.81744	11.58256
	4	8.2	0.247258	7.952742
2007 – 2008	10	0.2	5.251337	-5.05
	11	19.9	25.72674	-5.82
	12	14.5	26.71234	-47.03
	1	53.3	21.24146	32.06

Year	Month	Actual	Forecast	Residual
	2	34.3	28.34689	5.96
	3	0	19.6509	-19.6509
	4	0	0.26493	-0.26493
2008 – 2009	10		5.482707	
	11		25.53016	
	12		26.73566	
	1		21.37692	
	2		27.81537	
	3		19.47775	
	4		0.282978	
2009 – 2010	10		5.714144	
	11		25.343	
	12		26.75843	
	1		21.50923	
	2		27.29976	
	3		19.2985	
	4		0.301361	
2010 – 2011	10		5.94523	
	11		25.16493	
	12		26.77813	
	1			
	2			
	3			

Table B.1.4: Predicted and actual monthly rainfall for Rammallah station using ARIMA model and their residual

Year	Month	Actual	Forecast	Residual
1981 – 1982	10	0	47.40242	-47.4024
	11	119	80.07541	38.92459
	12	28	100.7824	-72.7824
	1	147	96.99256	50.00744
	2	168	68.63394	99.36606
	3	147	33.59575	113.4043
	4	4	9.424322	-5.42432
1982 – 1983	10	22	40.17542	-18.1754
	11	102	67.24375	34.75625
	12	106	83.24469	22.75531
	1	253	76.91323	176.0868
	2	310	52.10283	257.8972
	3	176	23.68599	152.314
	4	18	7.045212	10.95479
1983 – 1984	10	0	35.08713	-35.0871
	11	36	59.02529	-23.0253
	12	15	72.18276	-57.1828
	1	110	66.07701	43.92299
	2	40	44.38725	-4.38725
	3	100	21.72409	78.27591
	4	22	6.176705	15.82329
1984 – 1985	10	33	35.60017	-2.60017
	11	21	57.97637	-36.9764
	12	26	69.81645	-43.8164
	1	37	63.75351	-26.7535
	2	153	44.84235	108.1577
	3	25	22.71541	2.284587
	4	22	8.008504	13.9915
1985 – 1986	10	28	38.31023	-10.3102
	11	5	59.28348	-54.2835
	12	54	69.5993	-15.5993
	1	86	63.92618	22.07382
	2	158	45.18918	112.8108
	3	28	24.3601	3.639901
	4	49	9.37882	39.62118
1986 – 1987	10	45	38.37707	6.622927
	11	278	57.18154	220.8185
	12	105	66.19343	38.80657
	1	146	60.03761	85.96239
	2	51	42.80759	8.192415
	3	115	23.20612	91.79388
	4	6	9.36098	-3.36098
1987 – 1988	10	39	36.02037	2.979627
	11	15	52.84825	-37.8482

Year	Month	Actual	Forecast	Residual
	12	238	60.42589	177.5741
	1	140	54.76124	85.23876
	2	205	38.94315	166.0568
	3	107	21.38472	85.61528
	4	39	36.02037	2.979627
1988 – 1989	10	8	34.3907	-26.3907
	11	32	49.62954	-17.62954
	12	115	56.48089	58.51911
	1	100	51.11574	48.88426
	2	90	36.75281	53.24719
	3	60	20.66227	39.33773
	4	0	9.094118	-9.09412
1989 – 1990	10	5	34.29152	-29.29152
	11	54	48.44554	5.55446
	12	22	54.54211	-32.54211
	1	130	49.42897	80.57103
	2	80	35.96122	44.03878
	3	50	20.90819	29.09181
	4	62	9.873862	52.126138
1990 – 1991	10	0	34.46693	-34.4669
	11	49	47.44958	1.55042
	12	9	52.79861	-43.7986
	1	208	47.72454	160.2755
	2	96	35.05006	60.94994
	3	134	20.90305	113.0969
	4	15	10.42984	4.570163
1991 – 1992	10	29	33.82271	-4.82271
	11	143	45.6071	97.3929
	12	498	50.18731	447.8127
	1	219	45.24998	173.75
	2	611	33.43014	577.5699
	3	63	20.32717	42.67283
	4	13	10.56091	2.439094
1992 – 1993	10	120	32.77972	87.22028
	11	310	43.46177	266.5382
	12	187	47.44003	139.56
	1	129	42.7257	86.2743
	2	50	31.80675	18.19325
	3	0	19.73503	-19.735
	4	14	10.6799	3.3201
1993 – 1994	10	39	32.06627	6.933727
	11	33	41.83984	-8.83984
	12	203	45.33014	157.6699
	1	142	40.84927	101.1507
	2	142	30.71323	111.2868
	3	23	19.51719	3.482815
	4	0	11.04301	-11.043

Year	Month	Actual	Forecast	Residual
1994 – 1995	10	267	31.73296	235.267
	11	256	40.69373	215.3063
	12	40	43.73974	-3.73974
	1	113	39.43164	73.56836
	2	48	29.95065	18.04935
	3	0	19.48933	-19.4893
	4	0	11.50286	-11.5029
1995 – 1996	10	92	31.36831	60.63169
	11	45	39.54917	5.450827
	12	200	42.16423	157.8358
	1	59	38.00621	20.99379
	2	218	29.12622	188.8738
	3	26	19.3552	6.6448
	4	0	11.84746	-11.8475
1996 – 1997	10	18	30.79759	-12.7976
	11	88	38.24191	49.75809
	12	167	40.47457	126.5254
	1	188	36.48549	151.5145
	2	146	28.19823	117.8018
	3	21	19.10648	1.893518
	4	12	12.08489	-0.08489
1997 – 1998	10	50	30.19086	19.80914
	11	165	36.97778	128.0222
	12	127	38.89085	88.10915
	1	77	35.08708	41.91292
	2	47	27.36401	19.63599
	3	18	18.90863	-0.90863
	4	0	12.3462	-12.3462
1998 – 1999	10	18	29.7123	-11.7123
	11	23	35.91549	-12.9155
	12	164	37.55318	126.4468
	1	87	33.92433	53.07567
	2	177	26.70976	150.2902
	3	3	18.82405	-15.824
	4	4	12.6737	-8.6737
1999 – 2000	10	19	29.32336	-10.3234
	11	21	34.9908	-13.9908
	12	283	36.37662	246.6234
	1	82	32.90408	49.09592
	2	85	26.14726	58.85274
	3	1	18.77699	-17.777
	4	0	13.00474	-13.0047
2000 – 2001	10	12	28.91561	-16.9156
	11	153	34.0837	118.9163
	12	100	35.24026	64.75974
	1	148	31.91689	116.0831
	2	9	25.58732	-16.5873

Year	Month	Actual	Forecast	Residual
	3	11	18.70057	-7.70057
	4	20	13.28975	6.710254
2001 – 2002	10	6	28.47078	-22.4708
	11	95	33.18117	61.81883
	12	41	34.13796	6.862044
	1	248	30.96519	217.0348
	2	67	25.04102	41.95898
	3	29	18.61162	10.38838
	4	0	13.54753	-13.5475
2002 – 2003	10	5	28.04433	-23.0433
	11	25	32.34152	-7.34152
	12	250	33.12684	216.87316
	1	107	30.1028	76.8972
	2	137	24.55744	112.4426
	3	175	18.55325	156.4467
	4	33	13.81434	19.18566
2003 – 2004	10	2	27.66665	-25.6666
	11	42	31.58859	10.41141
	12	159	32.22308	126.7769
	1	183	29.33969	153.6603
	2	98	24.14292	73.85708
	3	24	18.5296	5.470396
	4	2	14.09214	-12.0921
2004 – 2005	10	4	27.31643	-23.3164
	11	211	30.89342	180.1066
	12	50	31.39266	18.60734
	1	222	28.64148	193.3585
	2	235	23.76681	211.2332
	3	42	18.51536	23.48464
	4	15	14.35981	0.640193
2005 – 2006	10	19.5	26.96779	-7.46779
	11	57.7	30.22757	27.47243
	12	118.2	30.6071	87.5929
	1	137	27.98307	109.0169
	2	111.1	23.40982	87.69018
	3	11.1	18.49711	-7.39711
	4	179.1	14.60813	164.4919
2006 – 2007	10	47.8	26.62293	21.17707
	11	24	29.59327	-5.59327
	12	144	29.86907	114.1309
	1	167.3	27.3687	139.9313
	2	130.4	23.07848	107.3215
	3	144.6	18.48325	126.1168
	4	5	14.84612	-9.84612
2007 – 2008	10	1	26.29701	-25.29701
	11	106.5	29.00402	-77.31
	12	57.5	29.19005	28.31

Year	Month	Actual	Forecast	Residual
	1	216.7	26.80867	189.9
	2	144.4	22.78273	121.62
	3	1.5	18.48341	-16.98
	4	.7	15.08255	-14.38
2008 – 2009	10		25.99375	
	11		28.46011	
	12		28.56751	
	1		26.29926	
	2		22.51922	
	3		18.49507	
	4		15.31523	
2009 – 2010	10		25.70516	
	11		27.95083	
	12		27.98919	
	1		25.8286	
	2		22.27802	
	3		18.51059	
	4		15.53817	
2010 – 2011	10		25.42555	
	11		27.46917	
	12		27.44764	
	1			
	2			
	3			

Table B.1.5: Predicted and actual monthly rainfall for Nablus station using ARIMA model and their residual

Year	Month	Actual	Forecast	Residual
1981 – 1982	10	0.	7.0025	-7.00
	11	135.1	36.2257	98.87
	12	19.9	97.36339	-77.46
	1	92.6	78.76315	13.84
	2	171.2	113.0075	58.19
	3	129.6	48.93169	80.67
	4	7.0	6.388578	0.61
1982 – 1983	10	10.3	6.978461	3.32
	11	0.	36.64617	-36.65
	12	215.8	96.542	119.26
	1	267.0	81.97625	185.02
	2	322.9	110.3451	212.55
	3	219.9	47.88362	172.02
	4	14.8	6.542987	8.26
1983 – 1984	10	0.	6.980818	-6.98
	11	70.4	37.04628	33.35
	12	24.2	95.85475	-71.65
	1	155.2	84.97469	70.23
	2	85.2	107.9285	-22.73
	3	0.	46.88189	-46.88
	4	0.	6.658425	-6.66
1984 – 1985	10	21.5	7.005712	14.49
	11	29.6	37.42981	-7.83
	12	58.5	95.28944	-36.79
	1	65.5	87.76662	-22.27
	2	245.3	105.7069	139.59
	3	20.1	45.92193	-25.82
	4	23.2	6.738367	16.46
1985 – 1986	10	19.9	7.05041	12.85
	11	47.1	37.80021	9.30
	12	42.9	94.83446	-51.93
	1	93.0	90.35991	2.64
	2	163.2	103.6818	59.52
	3	48.7	45.00058	3.70
	4	36.8	6.78652	30.01
1986 – 1987	10	52.4	7.11206	45.29
	11	249.6	38.16052	211.44
	12	141.4	94.47978	46.92
	1	130.0	92.76432	37.24
	2	62.3	101.8111	-39.51
	3	129.0	44.11412	84.89
	4	1.9	6.806228	-4.91
1987 – 1988	10	52.9	7.188705	45.71
	11	23.2	38.51349	-15.31
	12	224.0	94.2158	129.78

Year	Month	Actual	Forecast	Residual
	1	126.9	94.98881	31.91
	2	306.9	100.0977	206.80
	3	94.9	43.26003	51.64
	4	0.	6.800904	-6.80
1988 – 1989	10	16.0	7.278203	8.72
	11	55.8	38.86151	16.94
	12	236.7	94.03427	142.67
	1	96.3	97.04369	-0.74
	2	46.6	98.50649	-51.91
	3	114.2	42.43527	71.76
	4	0.	6.773533	-6.77
1989 – 1990	10	9.9	7.379141	2.52
	11	94.9	39.20672	55.69
	12	125.3	93.92725	31.37
	1	131.6	98.93821	32.66
	2	98.9	97.04118	1.86
	3	72.9	41.63783	31.26
	4	53.0	6.727084	46.27
1990 – 1991	10	3.5	7.489889	-3.99
	11	24.3	39.55097	-15.25
	12	9.5	93.88792	-84.39
	1	251.4	100.6825	150.72
	2	74.3	95.67247	-21.37
	3	103.8	40.86526	62.93
	4	30.1	6.664097	23.44
1991 – 1992	10	12.7	7.609428	5.09
	11	153.5	39.8959	113.60
	12	472.2	93.9097	378.29
	1	261.1	102.2856	158.81
	2	384.7	94.40444	290.30
	3	69.7	40.11594	29.58
	4	4.7	6.587061	-1.89
1992 – 1993	10	0.	7.736514	-7.74
	11	84.9	40.24291	44.66
	12	360.9	93.98695	266.91
	1	142.3	103.757	38.54
	2	117.7	93.21262	24.49
	3	68.7	39.38787	29.31
	4	5.8	6.498064	-0.70
1993 – 1994	10	14.7	7.870415	6.83
	11	21.6	40.59324	-18.99
	12	28.7	94.11422	-65.41
	1	192.5	105.1052	87.39
	2	114.0	92.10116	21.90
	3	129.1	38.67979	90.42
	4	9.0	6.399129	2.60
1994 – 1995	10	20.6	8.010183	12.59

Year	Month	Actual	Forecast	Residual
	11	263.5	40.9479	222.55
	12	186.0	94.28684	91.71
	1	57.9	106.339	-48.44
	2	95.4	91.04964	4.35
	3	43.1	37.99005	5.11
	4	35.3	6.291929	29.01
1995 – 1996	10	1.8	8.155302	-6.36
	11	118.8	41.30781	77.49
	12	59.2	94.50027	-35.30
	1	229.8	107.466	122.33
	2	35.9	90.06203	-54.16
	3	228.7	37.31765	191.38
	4	33.4	6.178074	27.22
1996 – 1997	10	34.1	8.305056	25.79
	11	16.4	41.67369	-25.27
	12	85.4	94.75065	-9.35
	1	158.2	108.494	49.71
	2	199.0	89.12141	109.88
	3	233.1	36.66126	196.44
	4	22.7	6.058872	16.64
1997 – 1998	10	16.3	8.459094	7.84
	11	59.9	42.04618	17.85
	12	167.4	95.0342	72.37
	1	148.2	109.4301	38.77
	2	91.9	88.23137	3.67
	3	244.5	36.02007	208.48
	4	5.0	5.935576	-0.94
1998 – 1999	10	1.6	8.616883	-7.02
	11	1.7	42.42579	-40.73
	12	54.4	95.34772	-40.95
	1	154.2	110.281	43.92
	2	66.8	87.378	-20.58
	3	40.1	35.393	4.71
	4	20.6	5.80919	14.79
1999 – 2000	10	5.8	8.778196	-2.98
	11	16.3	42.81294	-26.51
	12	39.4	95.68807	-56.29
	1	471.0	111.0528	359.95
	2	84.7	86.56441	-1.86
	3	79.1	34.7794	44.32
	4	4.	5.680674	-5.28
2000 – 2001	10	63.7	8.942647	54.76
	11	3.5	43.20796	-39.71
	12	123.9	96.0526	27.85
	1	85.1	111.7517	-26.65
	2	122.5	85.77931	36.72
	3	9.3	34.17839	-24.88

Year	Month	Actual	Forecast	Residual
	4	3.6	5.55078	-1.95
2001 – 2002	10	20.8	9.110103	11.69
	11	75.1	43.61111	31.49
	12	161.6	96.43869	65.16
	1	157.8	112.3827	45.42
	2	56.6	85.02522	-28.43
	3	151.9	33.58944	118.31
	4	34.1	5.420228	28.68
2002 – 2003	10	2.6	9.280296	-6.68
	11	32.1	44.02257	-11.92
	12	130.4	96.84413	33.56
	1	73.7	112.9513	-39.25
	2	416.4	84.29313	332.11
	3	236.6	33.01185	203.59
	4	50.9	5.289574	45.61
2003 – 2004	10	2.6	9.453161	-6.85
	11	32.1	44.4425	-12.34
	12	130.4	97.26676	33.13
	1	230.0	113.4617	116.54
	2	136.2	83.58495	52.62
	3	24.2	32.44516	-8.25
	4	11.1	5.159347	5.94
2004 – 2005	10	4.	9.628526	-9.23
	11	152.8	44.87096	107.93
	12	82.6	97.70474	-15.10
	1	239.8	113.9186	125.88
	2	267.6	82.89367	184.71
	3	37.3	31.88883	5.41
	4	9.4	5.029945	4.37
2005 – 2006	10	10.5	9.806377	0.69
	11	55.9	45.308	10.59
	12	170.8	98.15626	72.64
	1	152.3	114.3258	37.97
	2	154.9	82.22056	72.68
	3	20.6	31.34246	-10.74
	4	128	4.901748	123.10
2006 – 2007	10	98.6	9.986617	88.61
	11	28.5	45.75363	-17.25
	12	123	98.61979	24.38
	1	105.6	114.6871	-9.09
	2	174.9	81.56036	93.34
	3	116.6	30.8056	85.79
	4	8.2	4.775036	3.42
2007 – 2008	10	0	10.16926	-10.17
	11	85.3	46.20783	39.09
	12	78.4	99.09384	-20.69
	1	157.7	115.0057	42.69

Year	Month	Actual	Forecast	Residual
	2	104.7	80.91368	23.79
	3	6	30.27793	-24.28
	4	.1	4.650071	-4.55
2008 – 2009	10		10.35429	
	11		46.67054	
	12		99.57711	
	1		115.2848	
	2		80.27684	
	3		29.75909	
	4		4.527044	
2009 – 2010	10		10.54173	
	11		47.1417	
	12		100.0684	
	1		115.5272	
	2		79.64976	
	3		29.24879	
	4		4.406126	
2010 – 2011	10		10.7316	
	11		47.6212	
	12		100.5666	
	1			
	2			
	3			

Table B.1.6: Predicted and actual monthly rainfall for Hebron station using ARIMA model and their residual

Year	Month	Actual	Forecast	Residual
1981 – 1982	10	4	7.805421	-3.80542
	11	49	34.70791	14.29209
	12	8	80.60917	-72.6092
	1	115	98.88121	16.11879
	2	207	167.1897	39.81034
	3	122	70.05897	51.94103
	4	7	13.5951	-6.5951
1982 – 1983	10	16	8.480847	7.519153
	11	117	35.03637	81.96363
	12	52	80.03385	-28.0338
	1	285	101.6337	183.3663
	2	291	160.9691	130.0309
	3	115	69.31771	45.68229
	4	12	13.30204	-1.30204
1983 – 1984	10	4	9.113634	-5.11363
	11	32	35.37739	-3.37739
	12	13	79.62384	-66.6238
	1	136	103.9867	32.01327
	2	20	155.345	-135.345
	3	127	68.45973	58.54027
	4	35	13.03196	21.96804
1984 – 1985	10	39	9.705054	29.29495
	11	27	35.73024	-8.73024
	12	50	79.35049	-29.3505
	1	13	105.9796	-92.9796
	2	247	150.2333	96.76668
	3	49	67.50875	-18.5088
	4	60	12.77913	47.22087
1985 – 1986	10	12	10.25713	1.742868
	11	32	36.09402	-4.09402
	12	76	79.1896	-3.1896
	1	87	107.6488	-20.6488
	2	146	145.5633	0.436669
	3	7	66.48478	-59.4848
	4	54	12.54051	41.45949
1986 – 1987	10	29	10.77228	18.22772
	11	219	36.46773	182.5323
	12	79	79.12072	-0.12072
	1	140	109.0282	30.97178
	2	70	141.2753	-71.2753
	3	100	65.40477	34.59523
	4	0	12.31212	-12.3121
1987 – 1988	10	58	11.25318	46.74682
	11	21	36.85026	-15.8503
	12	163	79.12648	83.87352

Year	Month	Actual	Forecast	Residual
	1	162	110.1486	51.85137
	2	234	137.3188	96.68115
	3	101	64.28287	36.71713
	4	14	12.09219	1.907809
1988 – 1989	10	10	11.70256	-1.70256
	11	39	37.24046	1.759545
	12	140	79.1921	60.8079
	1	110	111.038	-1.03802
	2	103	133.6509	-30.6509
	3	78	63.13095	14.86905
	4	0	11.87797	-11.878
1989 – 1990	10	7	12.12317	-5.12317
	11	72	37.63716	34.36284
	12	33	79.30503	-46.305
	1	152	111.7217	40.27835
	2	95	130.2351	-35.2351
	3	57	61.95884	-4.95884
	4	88	11.66849	76.33151
1990 – 1991	10	2	12.51762	-10.5176
	11	16	38.03919	-22.0392
	12	4	79.45457	-75.4546
	1	157	112.2222	44.77778
	2	92	127.0402	-35.0402
	3	193	60.7747	132.2253
	4	7	11.46187	-4.46187
1991 – 1992	10	10	12.88845	-2.88845
	11	64	38.4454	25.5546
	12	334	79.63158	254.3684
	1	197	112.56	84.43997
	2	335	124.0394	210.9606
	3	63	59.58518	3.414819
	4	1	11.25767	-10.2577
1992 – 1993	10	0	13.23799	-13.238
	11	132	38.85464	93.14536
	12	158	79.82829	78.17171
	1	183	112.7532	70.24677
	2	163	121.2101	41.78991
	3	46	58.39578	-12.3958
	4	0	11.0546	-11.0546
1993 – 1994	10	0	13.56842	-13.5684
	11	130	39.26582	90.73418
	12	45	80.03808	-35.0381
	1	179	112.818	66.18203
	2	117	118.5324	-1.53241
	3	72	57.2109	14.7891
	4	17	10.85257	6.147426
1994 – 1995	10	0	13.56842	-13.5684

Year	Month	Actual	Forecast	Residual
	11	130	39.26582	90.73418
	12	45	80.03808	-35.0381
	1	179	112.818	66.18203
	2	117	118.5324	-1.53241
	3	72	57.2109	14.7891
	4	17	10.85257	6.147426
1995 – 1996	10	0	14.17977	-14.1798
	11	43	40.08976	2.910236
	12	78	80.47516	-2.47516
	1	122	112.618	9.382032
	2	38	113.5666	-75.5666
	3	191	54.86826	136.1317
	4	17	10.44912	6.550885
1996 – 1997	10	30	14.46413	15.53587
	11	19	40.50055	-21.5006
	12	49	80.6936	-31.6936
	1	132	112.3773	19.6227
	2	200	111.2511	88.74891
	3	89	53.71556	35.28444
	4	11	10.24722	0.752781
1997 – 1998	10	7	14.73631	-7.73631
	11	4	40.90931	-36.9093
	12	145	80.90719	64.09281
	1	114	112.0567	1.943325
	2	56	109.032	-53.032
	3	116	52.57772	63.42228
	4	0	10.04526	-10.0453
1998 – 1999	10	8	14.99762	-6.99762
	11	16	41.31518	-25.3152
	12	17	81.11303	-64.113
	1	81	111.665	-30.665
	2	69	106.8997	-37.8997
	3	19	51.45605	-32.4561
	4	44	9.842861	34.15714
1999 – 2000	10	4	15.24923	-11.2492
	11	5	41.71733	-36.7173
	12	21	81.30869	-60.3087
	1	297	111.2101	185.7899
	2	65	104.8459	-39.8459
	3	75	50.35151	24.64849
	4	0	9.640323	-9.64032
2000 – 2001	10	23	15.49218	7.507818
	11	10	42.11502	-32.115
	12	212	81.49214	130.5079
	1	146	110.6989	35.30105
	2	92	102.8632	-10.8632
	3	25	49.26478	-24.2648

Year	Month	Actual	Forecast	Residual
	4	5	9.437408	-4.43741
2001 – 2002	10	9	15.72739	-6.72739
	11	54	42.50752	11.49248
	12	137	81.66171	55.33829
	1	330	110.1378	219.8622
	2	61	100.9454	-39.9454
	3	0	48.19627	-48.1963
	4	0	9.234448	-9.23445
2002 – 2003	10	8	15.95566	-7.95566
	11	28	42.89417	-14.8942
	12	272	81.81601	190.184
	1	76	109.532	-33.532
	2	185	99.08674	85.91326
	3	116	47.14626	68.85374
	4	3	9.031306	-6.03131
2003 – 2004	10	13	16.17768	-3.17768
	11	3	43.27436	-40.2744
	12	145	81.95392	63.04608
	1	183	108.8866	74.11343
	2	98	97.28235	0.717652
	3	24	46.11482	-22.1148
	4	2	8.828309	-6.82831
2004 – 2005	10	4	16.39408	-12.3941
	11	211	43.64751	167.3525
	12	50	82.07455	-32.0745
	1	153	108.2057	44.79432
	2	118	95.52786	22.47214
	3	49	45.10195	3.898053
	4	13	8.625392	4.374608
2005 – 2006	10	10.4	16.60537	-6.20537
	11	48.3	44.01311	4.286892
	12	84.2	82.17717	2.022831
	1	84.8	107.4932	-22.6932
	2	85	93.81943	-8.81943
	3	17.4	44.1075	-26.7075
	4	83.9	8.422866	75.47713
2006 – 2007	10	15.6	16.81201	-1.21201
	11	24.6	44.37066	-19.7707
	12	117.1	82.26125	34.83875
	1	153.1	106.7524	46.34757
	2	109	92.15366	16.84634
	3	110	43.13129	66.86871
	4	2.2	8.220713	-6.02071
2007 – 2008	10	0	17.01439	-17.01439
	11	23.6	44.71973	-21.11
	12	43.9	82.32638	-38.42
	1	151.1	105.9865	45.12

Year	Month	Actual	Forecast	Residual
	2	109.5	90.52751	18.98
	3	0	42.17304	-42.1730
	4	0	8.019219	-8.019219
2008 – 2009	10		17.21283	
	11		45.0599	
	12		82.37229	
	1		105.1979	
	2		88.93828	
	3		41.23247	
	4		7.818399	
2009 – 2010	10		17.40761	
	11		45.39081	
	12		82.39879	
	1		104.3892	
	2		87.38357	
	3		40.30923	
	4		7.61851	
2010 – 2011	10		17.59897	
	11		45.71212	
	12		82.40579	
	1			
	2			
	3			

Appendix B.2: Sum of Forecast and Actual Annual Rainfall Implementing ARIMA Model

Table B.2.1: Actual and forecasted, and residual value for the rainfall data for the period 1980/81 to 2009/2010 in Tulkarem station

Year	Sum of Actual	Sum of Forecast	Residual
1981 – 1982	484	519	-35
1982 – 1983∗	797	515	282
1983 – 1984*	381	512	-131
1984 – 1985	454	509	-55
1985 – 1986	561	506	55
1986 – 1987∗	775	510	265
1987 – 1988	655	500	155
1988 – 1989	477	498	-21
1989 – 1990	679	495	184
1990 – 1991	558	493	65
1991 – 1992∗	1371	490	881
1992 – 1993	624	488	136
1993 – 1994	481	486	-5
1994 – 1995∗	859	483	376
1995 – 1996*	341	481	-140
1996 – 1997	755	479	276
1997 – 1998∗	756	477	279
1998 - 1999*	291	475	-184
1999 – 2000	599	473	126
2000 – 2001	455	471	-16
2001 – 2002	622	469	153
2002 – 2003∗	799	467	332
2003 – 2004	495	465	30
2004 – 2005	574	464	110
2005 – 2006	547	462	-95
2006 – 2007	585	460	125
2007 – 2008	437.8	459	-21.9
2008 – 2009		457	
2009 – 2010		455	

* Drought years
∗ Wet years

Table B.2.2: Actual, forecasted, and residual value for the rainfall data for the period 1980/81 to 2009/2010 in Jenin station

Year	Sum of Actual	Sum of Forecast	Residual
1981 – 1982	299	396	-97
1982 – 1983*	646	396	250
1983 – 1984	374	396	-22
1984 – 1985*	285	397	-112
1985 – 1986	331	397	-66
1986 – 1987	434	398	36
1987 – 1988*	724	399	325
1988 – 1989	418	400	18
1989 – 1990	432	401	31
1990 – 1991	352	402	-50
1991 – 1992*	1012	404	608
1992 – 1993	455	405	50
1993 – 1994	314	406	-92
1994 – 1995	503	408	95
1995 – 1996*	297	409	-112
1996 – 1997	451	410	41
1997 – 1998*	590	412	178
1998 - 1999*	223	414	-191
1999 – 2000	412	415	-3
2000 – 2001*	255	417	-161
2001 – 2002	375	418	-43
2002 – 2003*	870	420	450
2003 – 2004	439	422	17
2004 – 2005	411	423	-12
2005 – 2006	389	425	-36
2006 – 2007	479	427	52
2007 – 2008	315	429	-114
2008 – 2009		431	
2009 – 2010		433	

* Drought years
* Wet years

Table B.2.3: Actual, forecasted, and residual value for the rainfall data for the period 1980/81 to 2009/2010 in Jericho station

Year	Sum of Actual	Sum of Forecast	Residual
1981 – 1982	130	147	-17
1982 – 1983*	205	146	59
1983 – 1984	86	145	-59
1984 – 1985	140	144	-4
1985 – 1986	86	143	-57
1986 – 1987	167	142	25
1987 – 1988	180	141	39
1988 – 1989	183	140	43
1989 – 1990	176	139	28
1990 – 1991	109	138	-29
1991 – 1992*	344	138	206
1992 – 1993	116	137	-21
1993 – 1994	93	136	-43
1994 – 1995	153	135	18
1995 – 1996	142	134	8
1996 – 1997	160	134	26
1997 – 1998	176	133	43
1998 - 1999*	41	132	-91
1999 – 2000	109	132	-23
2000 – 2001	127	131	-4
2001 – 2002	201	130	71
2002 – 2003*	239	130	109
2003 – 2004	110	129	-19
2004 – 2005	140	129	11
2005 – 2006	162	128	34
2006 – 2007	138	128	10
2007 – 2008	122	127	-5
2008 – 2009		127	
2009 – 2010		126	

* Drought years
* Wet years

Table B.2.4: Actual, forecasted, and residual value for the rainfall data for the period 1980/81 to 2009/2010 in Rammallah station

Year	Sum of Actual	Sum of Forecast	Residual
1981 – 1982	613	437	176
1982 – 1983⁎	987	350	637
1983 – 1984	323	305	17
1984 – 1985	317	303	14
1985 – 1986	408	310	98
1986 – 1987⁎	746	297	449
1987 – 1988⁎	783	300	483
1988 – 1989	405	258	147
1989 – 1990	403	253	150
1990 – 1991	511	249	263
1991 – 1992⁎	1576	239	1337
1992 – 1993⁎	810	229	581
1993 – 1994	582	221	361
1994 – 1995⁎	724	217	507
1995 – 1996	640	211	429
1996 – 1997	640	205	435
1997 – 1998	484	200	284
1998 - 1999	476	195	281
1999 – 2000	491	192	299
2000 – 2001	453	188	265
2001 – 2002	486	184	302
2002 – 2003⁎	732	181	551
2003 – 2004	510	178	332
2004 – 2005⁎	779	175	604
2005 – 2006	634	172	462
2006 – 2007	663	170	493
2007 – 2008	527	168	359
2008 – 2009		166	
2009 – 2010		164	

* Drought years
⁎ Wet years

Table B.2.5: Actual, forecasted, and residual value for the rainfall data for the period 1980/81 to 2009/2010 in Nablus station

Year	Sum of Actual	Forecast	Residual
1981 – 1982	555	388	168
1982 – 1983*	1051	387	664
1983 – 1984	335	386	-51
1984 – 1985	464	386	78
1985 – 1986	452	386	66
1986 – 1987*	767	385	381
1987 – 1988*	829	385	444
1988 – 1989	566	385	181
1989 – 1990	587	385	202
1990 – 1991	497	385	112
1991 – 1992*	1359	385	974
1992 – 1993	780	385	395
1993 – 1994	510	385	125
1994 – 1995	702	385	317
1995 – 1996	708	385	323
1996 – 1997	749	385	364
1997 – 1998	733	385	348
1998 - 1999	339	385	-46
1999 – 2000	697	385	311
2000 – 2001	412	385	26
2001 – 2002	658	386	272
2002 – 2003*	943	386	557
2003 – 2004	567	386	181
2004 – 2005	790	386	404
2005 – 2006	693	386	307
2006 – 2007	655	386	269
2007 – 2008	432	386	46
2008 – 2009		386	
2009 – 2010		387	

* Drought years
* Wet years

Table B.2.6: Actual, forecasted, and residual value for the rainfall data for the period 1980/81 to 2009/2010 in Hebron station

Year	Sum of Actual	Forecast	Residual
1981 – 1982	512	473	39
1982 – 1983*	888	469	419
1983 – 1984*	367	465	-89
1984 – 1985	485	461	24
1985 – 1986	414	458	-44
1986 – 1987	637	454	183
1987 – 1988*	753	451	302
1988 – 1989	480	448	32
1989 – 1990	504	445	59
1990 – 1991	471	442	29
1991 – 1992*	1004	438	566
1992 – 1993	682	435	247
1993 – 1994	560	432	128
1994 – 1995	560	432	128
1995 – 1996	489	426	63
1996 – 1997	530	423	107
1997 – 1998	442	420	22
1998 - 1999*	254	417	-163
1999 – 2000	467	414	53
2000 – 2001	513	411	102
2001 – 2002	591	408	183
2002 – 2003	688	405	283
2003 – 2004	468	403	65
2004 – 2005	598	400	198
2005 – 2006	414	397	17
2006 – 2007	532	394	138
2007 – 2008	328	391	-63
2008 – 2009		388	
2009 – 2010		385	

* Drought years
* Wet ye

تنبؤ كميات الأمطار في الضفة الغربية

إعداد
أحمد عوض

إشراف
الدكتور عامر مرعي

الملخص

تعانى فلسطين من نقص المياه نظرا لعدة أسباب، أولاً لفلسطين مناخ البحر الأبيض المتوسط الذي يتسم بأنه طويل، حار وجاف في الصيف، بارد وقصير في الشتاء وفترة سقوط الأمطار قصيرة تقتصر على أشهر معدودة. ثانياً سبب سياسي أدى إلى صراع بين الإسرائيليون والفلسطينيون حيث يلقي كل منهما اللوم على الآخر وينظر إلى نفسه كضحية.

سلطة المياه الفلسطينية في الضفة الغربية تقول انه في أشهر الصيف شركة المياه الإسرائيلية ماكروت تقلل من إمدادات المياه إلى المناطق الفلسطينية ، على سبيل المثال ، فإن 300000 من السكان الذين يعيشون في الخليل بحاجة إلى 25000 متر مكعب من المياه يوميا ، غير أن شركة ماكروت تزودهم ب 5500 متر مكعب فقط.

وبالإضافة إلى ندرة المياه فان فلسطين تعاني من مشاكل أخرى كثيرة منها:
سوء توزيع في المياه وسوء في إدارة المياه أدى مشاكل بيئية ومشاكل نوعية. هذه المشاكل قد عززت الخبراء لدراسة هذه المشاكل بالتفاصيل.
إن سقوط الأمطار هو عامل رئيس لتخطيط وإدارة مشاريع الري والإنتاج الزراعي حيث أن غالبية السكان في فلسطين تعتمد إلى حد كبير على القطاع الزراعي، لذلك هطول الأمطار قد أثر بشكل مباشر على كسب رزقهم.

وفي ضوء ذلك تم تحليل وصياغة نماذج إحصائية لسجلات الأمطار في الضفة الغربية بهدف التنبؤ بكميات الأمطار المستقبلية وتأثير ذلك على البيئة.

للقيام بذلك في هذا البحث، تم جمع البيانات المطرية من ست محطات في الضفة الغربية. طول كل سجل يختلف من محطة إلى أخرى، حيث تم تحليل وصياغة نماذج لكل محطة باستخدام تحليل السلاسل الزمنية لتقدير كميات الأمطار في المستقبل. لهذا استخدمت طريقتان أساسيتان وهما:

أولاً: المتوسطات المتحركة ذاتية الانحدار.

ثانياً: نموذج لاخطي يعتمد على اقتران الجيب تمام.

تبين من خلال الدراسة أنة يتوقع تناقص في كميات الأمطار في جميع مناطق الضفة الغربية ،وان هذا التناقص سوف يكون خطي كما تبين النموذج اللاخطي أفضل في توقع كميات الأمطار خصوصا في المناطق الجبلية التي يكون تقلبات كبيرة في كميات سقوط الأمطار.

خلصت الدراسة أن تناقص كميات الأمطار سوف يؤثر سلباً على البيئة وعلى الغطاء النباتي مما يتطلب زيادة الوعي لمشاكل ندرة المياه والبحث عن طرق لاستغلال مياه الأمطار وان يبين المفاوض الفلسطيني مخاطر سيطرة الاحتلال الإسرائيلي على موارد المياه في فلسطين وخزانات المياه الجوفية في الضفة الغربية.