

## CHAPTER 4

### AGRO-CLIMATOLOGY OF KERALA

#### 4.1. CLIMATE.

Kerala experiences a wide variety of climate from perhumid to moist sub-humid type, because of the wide variations in relief from the coast to the Sahyadris. Such a climatic spectrum is capable of supporting enormous varieties of crops in the region. The important features of agroclimatology of the State are now briefly described.

##### **4.1.1. TEMPERATURE.**

Coastal regions experience more or less uniform day time temperature throughout the year, except during June, July, and August, when the temperature drops because of the overcast skies of the monsoon season.

Due to the influence of the South- West monsoon the maximum temperature is recorded in the pre-monsoon months. At the coastal stations the maximum temperature is often around 33<sup>0</sup>C during April while the minimum temperature is around 22<sup>0</sup>C during January. The interior stations have a higher maximum temperature (about 37<sup>0</sup>C), and minimum temperature is usually less than that at the coastal stations.

The lowest mean monthly temperature at all stations in the State occur in July or August and the highest during the pre-monsoon months. "The zone with highest maximum temperature for the whole year (<27.5<sup>0</sup>C) falls in the midland region; along the coast, temperature is moderate, whereas in the east it is low." (CESS, 1984).

#### 4.1.2. RAINFALL.

The State receives abundant rainfall mainly from the South-West monsoon. The mean annual rainfall of the State is about 300cm. Based on the rainfall pattern there four seasons may be delineated :

1. Winter - January - February
2. Pre-monsoon - March - May
3. Monsoon - June - September
4. Post-monsoon - October - December

The annual rainfall of the State varies from less than 100cm in Chinnar to more than 400cm in Neriamangalam. The rainfall increases from South to North and from the coast to the Sahyadris. Most of the State has two peaks of rainfall, one during the South-West monsoon period and the other during the North-East monsoon period.

The South- West monsoon contributes about 66% of the total annual rainfall of the State. It is basically caused by the orographic lifting of moisture laden wind from the Arabian Sea. Normally the South-West monsoon sets over Kerala by the end of May or early June. It is locally known as *Kalavarsham*. Since the onset period is by the middle of Malayalam month 'Edavam', it is also known as *Edavappathy*. The South-West monsoon also shows the same pattern as the annual rainfall ; it increases from south to north. "The monsoon rainfall is more than 80% of the annual rainfall in the extreme northern part of the State and gradually decreases to about 45% in the extreme south. The general pattern is disturbed over the low rainfall region around Chinnar and heavy rainfall pocket around Neriamangalam."(James,1991).

During the North-East monsoon season, which lasts from October to November, the State receives about 18% of the annual rainfall. This rainfall is locally known as *Thulavarsham*. The southern districts receive more rainfall during this season than the northern districts. About 30% of the annual rainfall of the southern districts is received during this period, while it contributes only 9% of the annual rainfall of the northern districts. This rainfall is usually associated with cyclonic activities and thunder storms.

Rainfall during the winter (December-February) season is meagre and contributes only 1% of the annual rainfall of the State. The southern districts have about 3% of the annual rainfall during this period.

The pre-monsoon season, which lasts from March to May, contributes about 15% of the annual rainfall of the State. The rainfall during this season is mainly from the convective processes associated with thunder showers.

#### **4.1.3. RAINFALL VARIABILITY.**

The rainfall variability for the State as a whole is low ; it ranges from 15% in the northern districts to 30% in the southern districts. During the monsoon season, the variability is generally higher; during the month of June and July, variability is 30-40%, in August it is 40-60% and in September, 50 to 60%. The variability during the pre-monsoon and post monsoon periods are relatively higher and range from over 80% in the northern districts to 50-80% in the southern districts.

#### **4.1.4. RELATIVE HUMIDITY.**

Being located on the coast, the relative humidity of the State is usually high. "The monsoon currents bring lot of moisture from the Arabian Sea and it is found that the precipitable water vapour over Kerala increase from 3 to 3.5 gms. in winter months to about 5 gms. in the monsoon months.(Ananthakrishnan et.al.,1965). The relative humidity decreases from west to east. During the winter months the relative humidity decreases with altitude. The average relative humidity in the coastal region is about 77%. A maximum of around 88% occurs during monsoon months, while the minimum is about 66%, experienced during January.

#### **4.1.5.WINDS.**

The winds blown over most parts of the State is thermally driven. This thermo-dynamism is due to the differential heating and cooling of the land and water bodies.The resultant land and sea breezes have a westerly component during day time and easterly component during night and early morning throught out the year. These winds are usually strong during afternoons and weak during nights.

### **4.2. AGRO-CLIMATIC ZONES**

The climatic conditions and soil types of a region play a dominant role in determining the agricultural landuse pattern and crop yields. Understanding of these two elements is a pre-requisite for planning and maximising agricultural production for sustainable development

According to FAO, an agro-climatic zone is a land unit interim of major climate and growing period which is climatically suitable for a certain range of crops and cultivation.

Based on the mid term approvals of the VII<sup>th</sup> Five Year Plan (1985-1990) the Planning Commission divided India into 15 broad agro-climatic zones based on physiography and climate.

- Zone 1 - Western Himalayan Regions
- “ 2 - Eastern Himalayan Regions
- “ 3 - Lower Gangetic Plains
- “ 4 - Middle Gangetic Plains
- “ 5 - Upper Gangetic Plains
- “ 6 - Trans Gangetic Plains
- “ 7 - Eastern Plain & Hill Regions
- “ 8 - Central Plain & Hill Regions
- “ 9 - Western Plain & Hill Regions
- “ 10 - Southern Plain & Hill Regions
- “ 11 - East coast Plain & Hill Regions
- “ 12 - West coast Plain & Hill Regions
- “ 13 - Gujarath Plain & Hill Regions
- “ 14 - Western dry Regions
- “ 15 - The Island Regions

Subsequently under the National Agricultural Research Project (NARP), the State Agricultural Universities were asked to divide the States into major sub zones based on rainfall, existing cropping pattern and administration division .

Consequently Kerala State was divided into the following five agro-climatic zones.(Fig.4.2.1).

**1. Northern Zone:** Comprises of Kasargode, Kannur, Kozhicode and Malappuram districts .This zone has a 293 km of coastline.

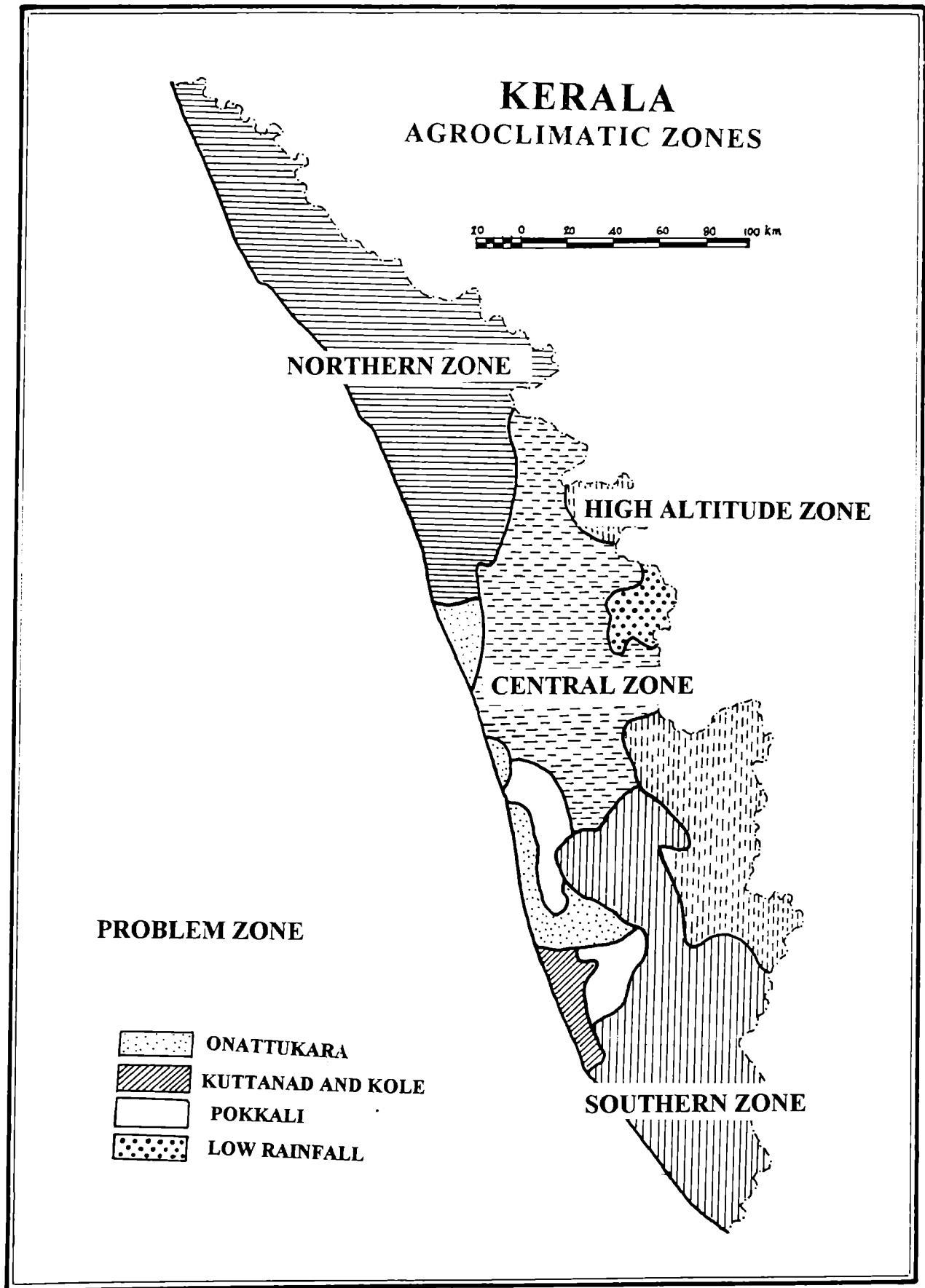


Fig. 4.21. KERALA ; AGRO - CLIMATIC ZONES

The highland comprises of about 300 sq.kms. and midland about 400 sq.kms.

**2. Central Zone:** This zone includes all the areas of the State excluding the high ranges, Coastal zone and Kole lands of Ernakulam, Thrissur and Palakkad districts.

**3.Southern Zone:** Consists of Kottayam, Alappuzha , Patthanamthitta, Kollam and Thiruvananthapuram districts.

**4. High Altitude Zone :** This encompasses the high ranges with an elevation above 750m of Wayanad, Palakkad, Idukki, Kollam and Thiruvananthapuram districts. It has a total geographical area of 11140 sq.km.

**5.Problem Area Zone :** This include the lowland areas, Onattukara, Kuttanad and Kole lands, Pokkali and low rainfall areas of Malappuram, Thrissur, Ernakulam, Kottayam and Alappuzha.

Earlier, understanding the need for a rational classification of agro-climatic zones, the Govt. of Kerala appointed a committee to delineate the State into various climatic zones. The committee in its report, (1974) divided the State in 13 agro-climatic zones.(Table.4.1). Here the development blocks were taken as the lowest units.

#### **4.3. AGRO-CLIMATOLOGY OF KERALA**

In order to have proper agricultural planning, it is essential to have a detailed understanding of the water need, water loss, water surplus and water deficiency of the particular region. These elements of water balance calculated using the Thornthwaite (1948) method, gives a vivid picture of the agro-climatic situation of the particular region.

In this Section a detailed analysis of annual rainfall, Potential Evapotranspiration (PE), Actual Evapotranspiration (AE), Water Surplus(WS), Water Deficiency (WD), the climatic shifts and incidence of droughts are given for the selected 19 stations (Fig.4.3) of Kerala.

Sl.No	ZONES	AREA (Sq.Km)
1	ONATUKARA	519
2	COASTAL SANDY	1564
3	SOUTHERN MIDLAND	3224
4	CENTRAL MIDLAND	2666
5	NORTHERN MIDLAND	3765
6	NORTHERN MIDLAND (MALAPPURAM)	4524
7	HIGHLAND	8861
8	PALAKKAD	1280
9	RED LOAM	317
10	CHITTOOR BLOCK	508
11	KUTTANAD	284
12	RIVER BANK ALLUVIUM	
13	HIGHRANGES	5140

(Source : Report of the committee on agro-climatic zones, 1974)

Table.4.1. AGRO-CLIMATIC ZONES OF KERALA

### A. NORTHERN ZONE

#### **4.3.1. KASARGOD**

Located at 12<sup>o</sup>31' N and 74<sup>o</sup> 55' E, Kasargod receives 3632 mm. annual rainfall. The rainfall pattern shows a slight declining trend.(Fig.4.3.1a).The highest rainfall recorded at Kasargod was 6134 mm. 1961.

A slight increasing trend in PE and decreasing trend in AE is evident from Fig.4.3.1b.



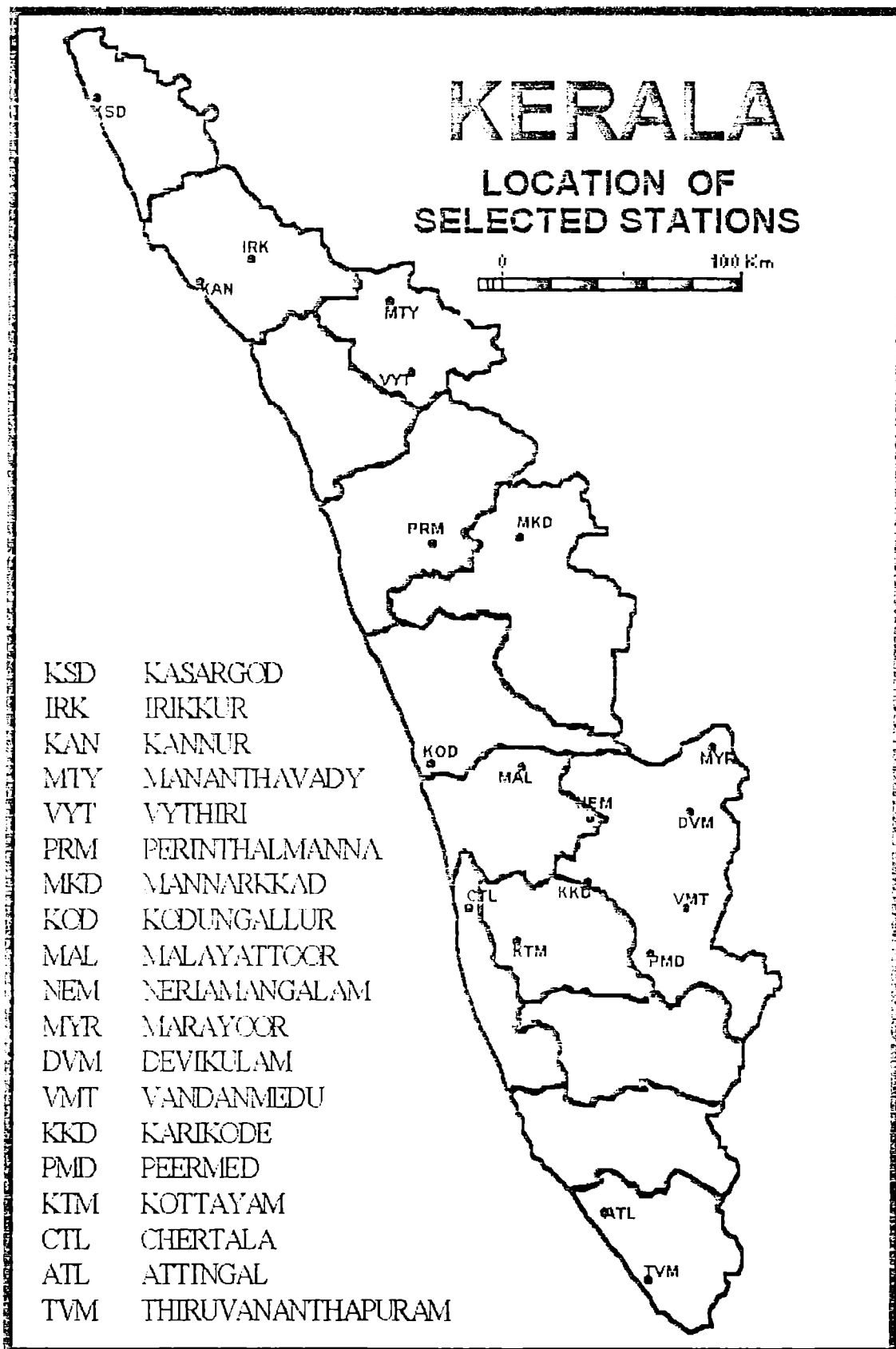


Fig. 4.3. KERALA - SELECTED STATIONS

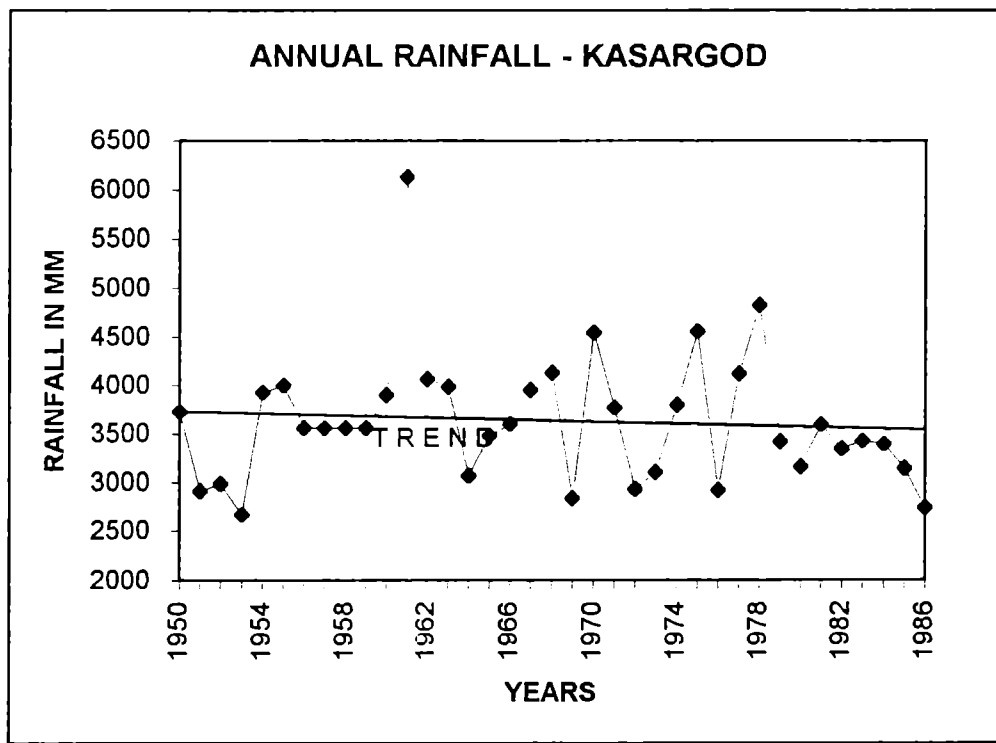


Fig. 4.3.1a. ANNUAL RAINFALL - KASARGOD

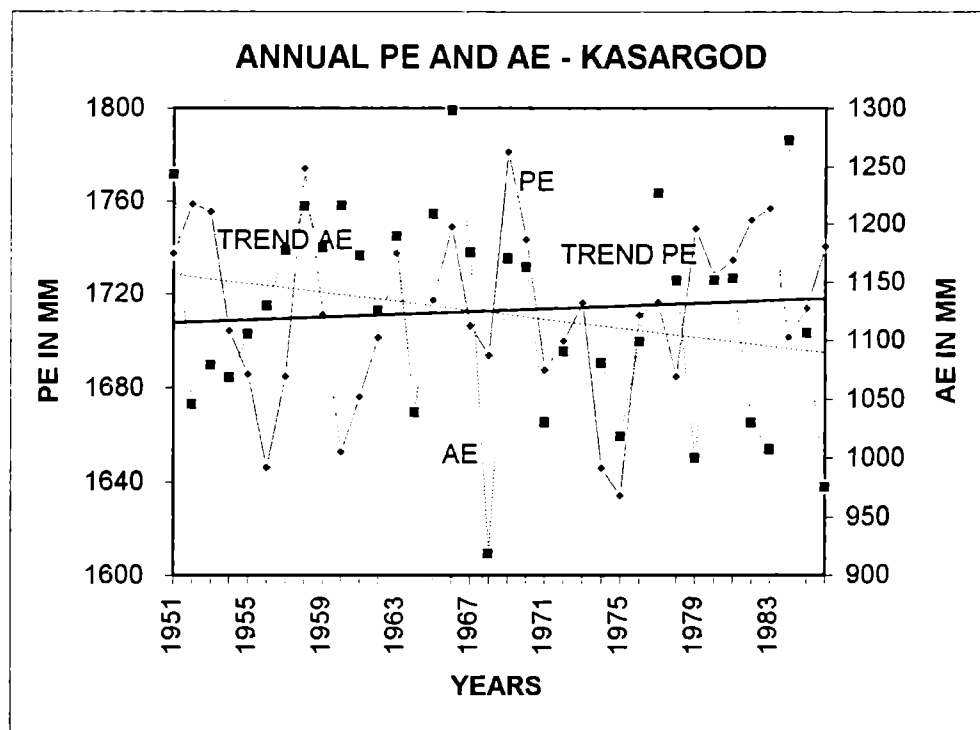


Fig. 4.3.1b. ANNUAL PE & AE - KASARGOD

A sharp increase in WD and decline in WS is the main feature of water balance of Kasargod. (Fig.4.3.1c).

Kasargod experiences a perhumid climate. There were no major shifts in climate. Most of the shifts were within the humid sub categories. (Fig.4.3.1d ).

The absence of any disastrous droughts is the conspicuous feature of Kasargod. (Fig.4.3.1e). Twelve years within the period 1950-1986 had droughts, of which one was of severe magnitude, three were large and the remaining were of moderate category.

#### 4.3.2. KANNUR

Kannur is located at  $11^{\circ}52'N$  and  $75^{\circ}22' E$ . With a mean annual rainfall of 3220 mm., Kannur shows no trend in the rainfall pattern (Fig.4.3.2a). The highest annual rainfall was recorded at Kannur was 5661.mm in the year 1961, and the lowest was 2024 mm.in 1964.

Contrary to many other stations, Kannur shows an increasing trend in both PE and AE. (Fig.4.3.2b).

Similar to the rainfall pattern ,WS shows a declining trend and WD displays an increasing trend. (Fig.4.3.2c).

Kannur also experienced many of the climatic shifts within the humid category. (Fig.4.3.2d). The year 1964 witnessed a shift to  $C_1$  type following the deficient rainfall that year. There were 15 drought years during the period 1950-1986, of which one was severe and one was disastrous. (Fig.4.3.2e).

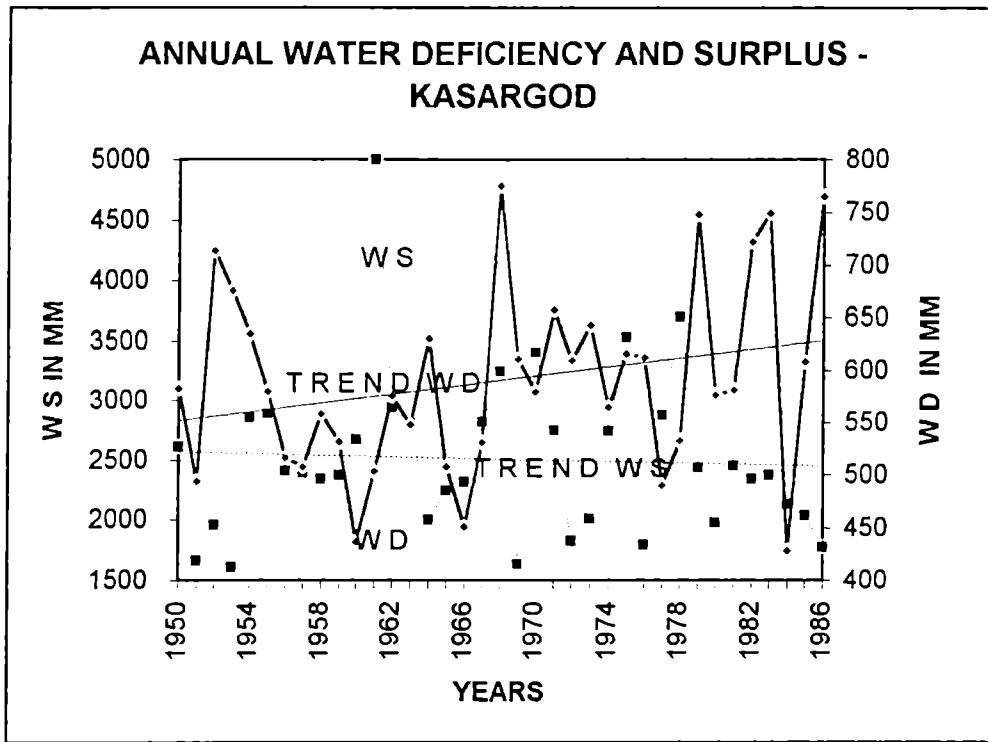


Fig. 4.3.1c. ANNUAL WD & WS - KASARGOD

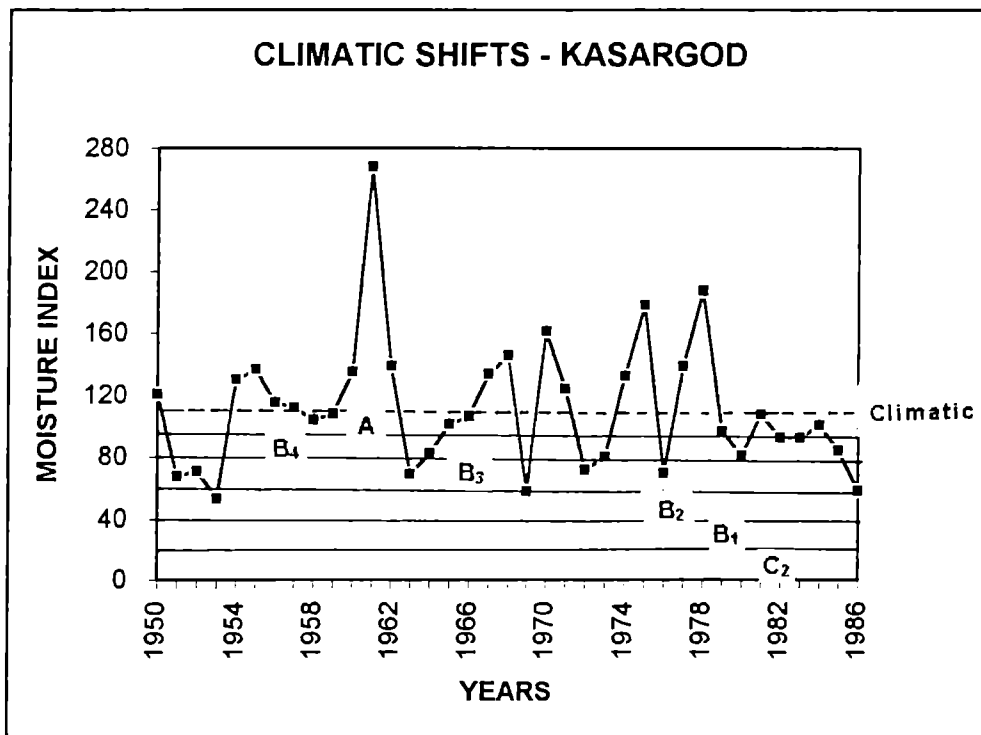


Fig. 4.3.1d. CLIMATIC SHIFTS - KASARGOD

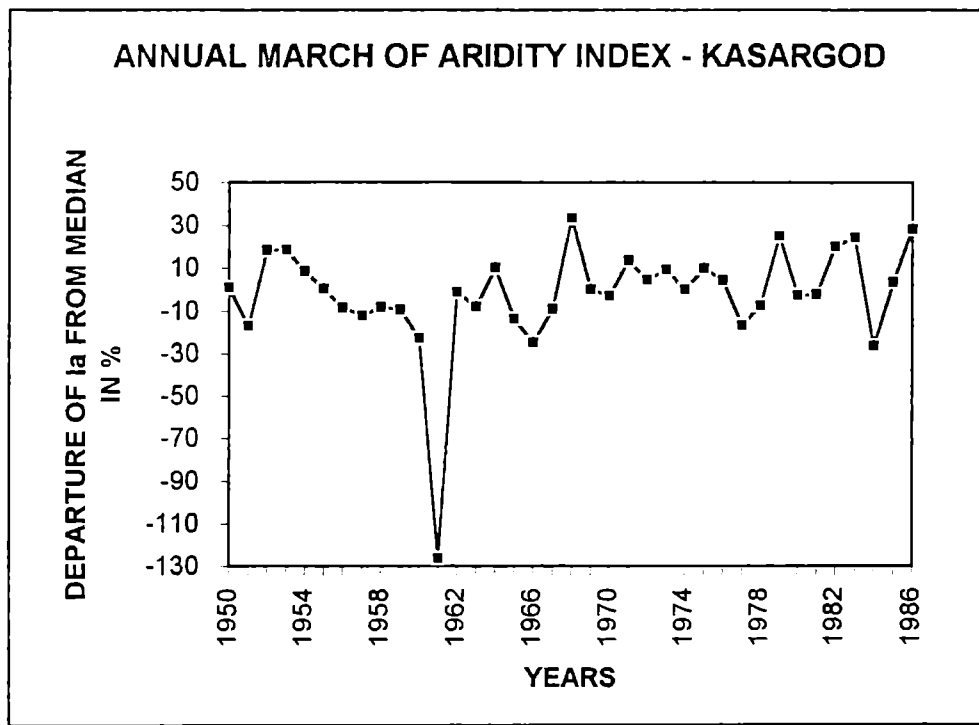


Fig. 4.3.1e. ANNUAL MARCH OF ARIDITY INDEX  
KASARGOD

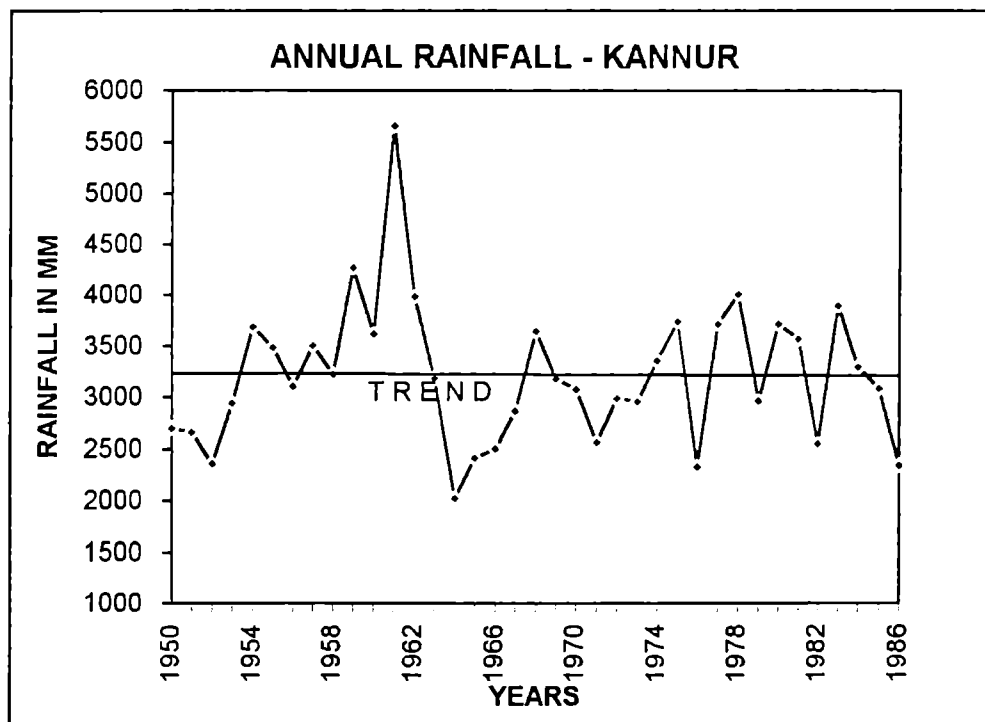


Fig. 4.3.2a. ANNUAL RAINFALL - KANNUR

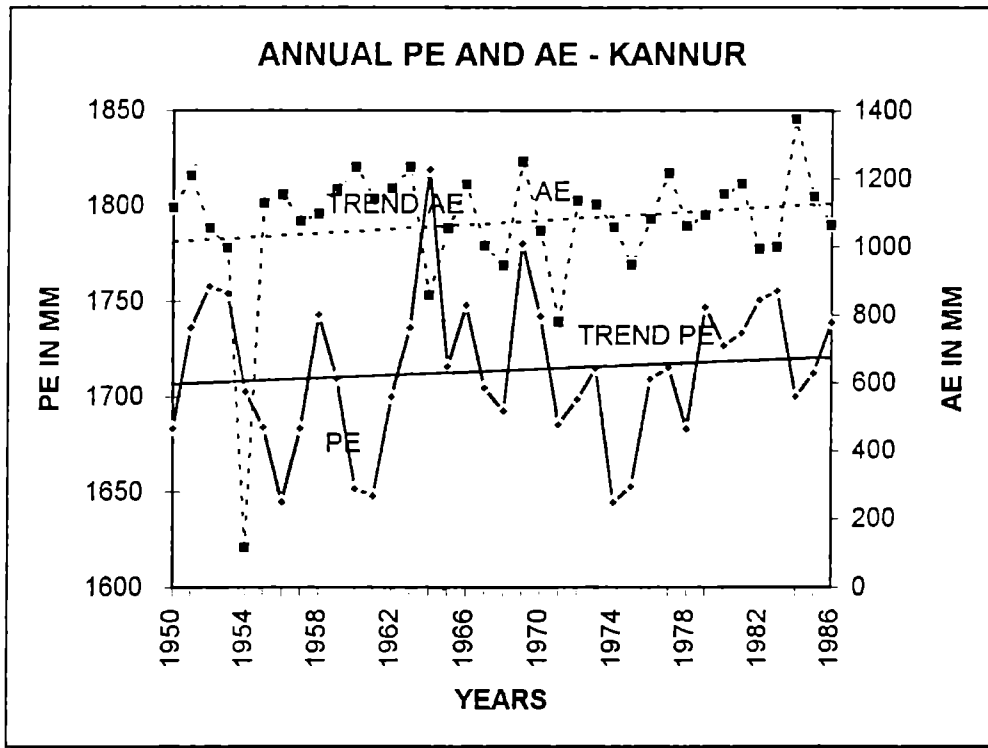


Fig. 4.3.2b. ANNUAL PE & AE - KANNUR

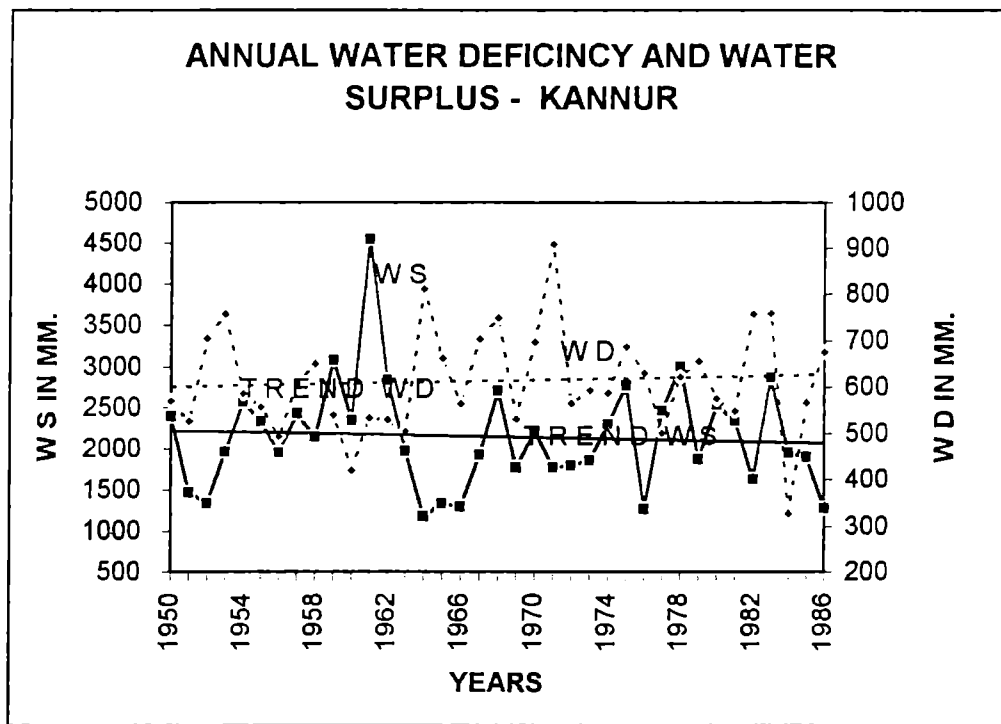


Fig. 4.3.2c. ANNUAL WD & WS - KANNUR

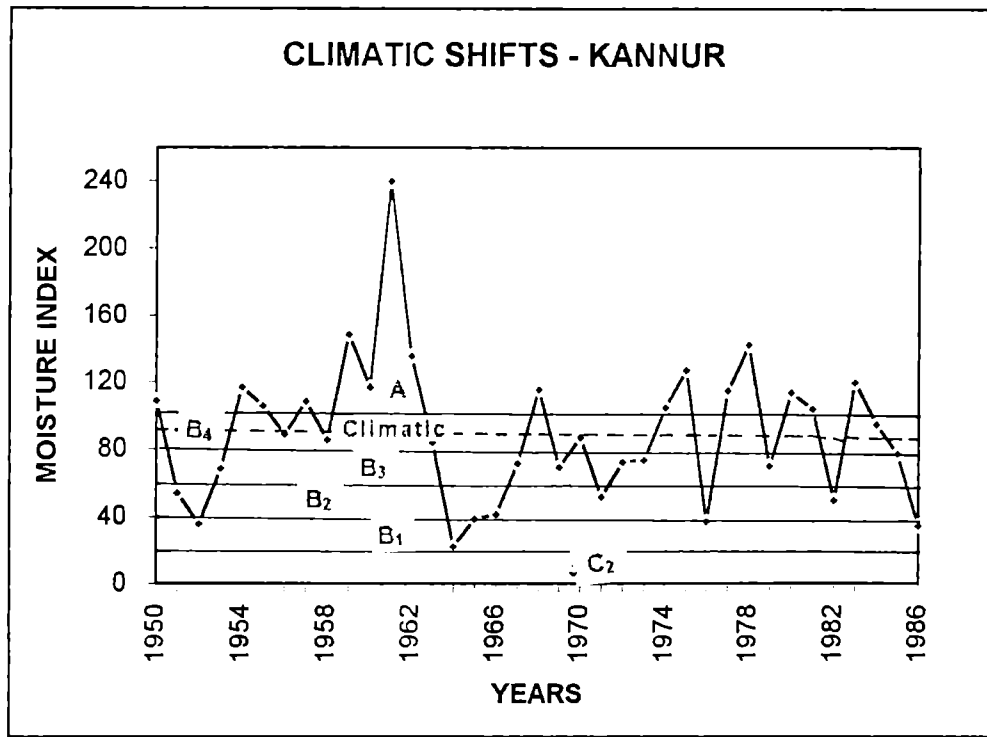


Fig. 4.3.2d. CLIMATIC SHIFTS - KANNUR

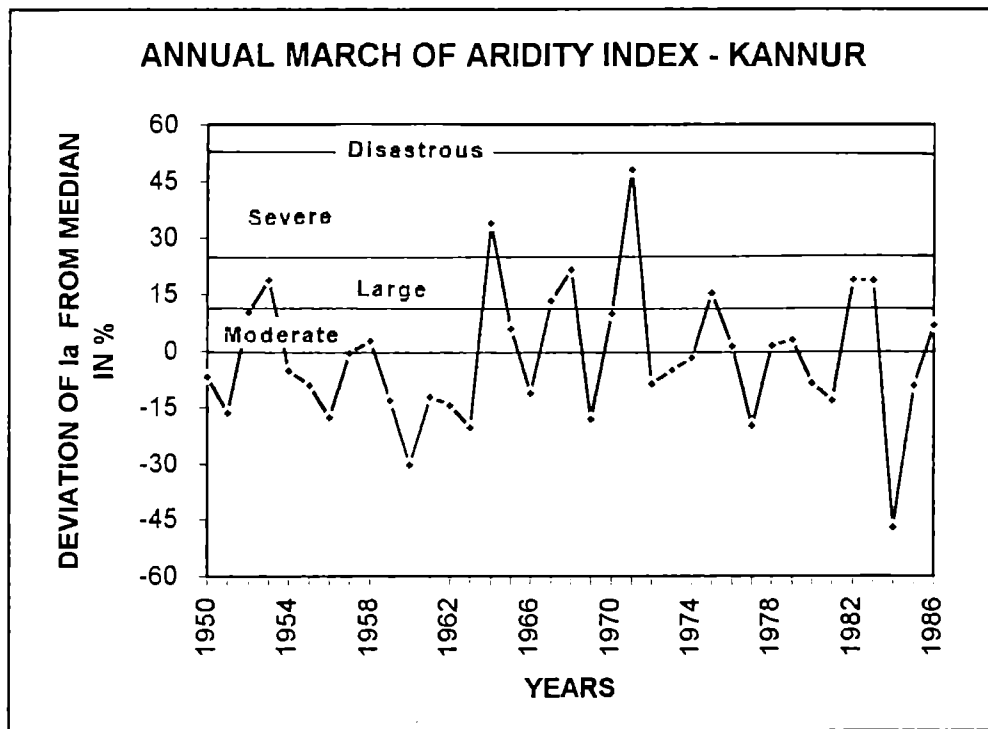


Fig. 4.3.2e. ANNUAL MARCH OF ARIDITY INDEX - KANNUR

### **4.3.3. IRIKKUR**

Irikkur is located at 11<sup>0</sup>58' N and 75<sup>0</sup>35' E. It experiences a perhumid type of climate and has a mean annual rainfall of 3418 mm.

The annual rainfall pattern indicates a declining trend (Fig.4.3.3a). The highest annual rainfall of the station was 6919 mm. recorded in 1968. The lowest was recorded in 1974 when the annual rainfall was only 1087 mm.

The gradual increasing trend of PE and corresponding decrease in AE is vivid from Fig.4.3.2.b.

Irikkur too displays a diminishing trend in WS and an upward trend in WD. (Fig.4.3.3c)

The majority of the climatic shifts were within the humid type. But in 1974, when the rainfall was lowest, the climate shifted to semi-arid (D) type. (Fig.4.3.3d).

Including the year 1974, there were five disastrous droughts in Irikkur. However the total number of droughts were comparatively less. (Fig.4.3.3e).

### **4.3.4. PERINTHALMANNA**

Perinthalmanna is located at 10<sup>0</sup>58' N and 76<sup>0</sup>14' E and receives a mean annual rainfall of 2787 mm. It shows a moderate increasing trend in rainfall.(Fig. 4.3.4a).

Like many other stations in the State, Perinthalmanna also shows an increasing trend in PE and a decreasing trend in AE. (Fig.4.3.4b). However, no trend was observed in the WS and WD (Fig.4.3.4c). The highest water surplus (3962 mm.) was



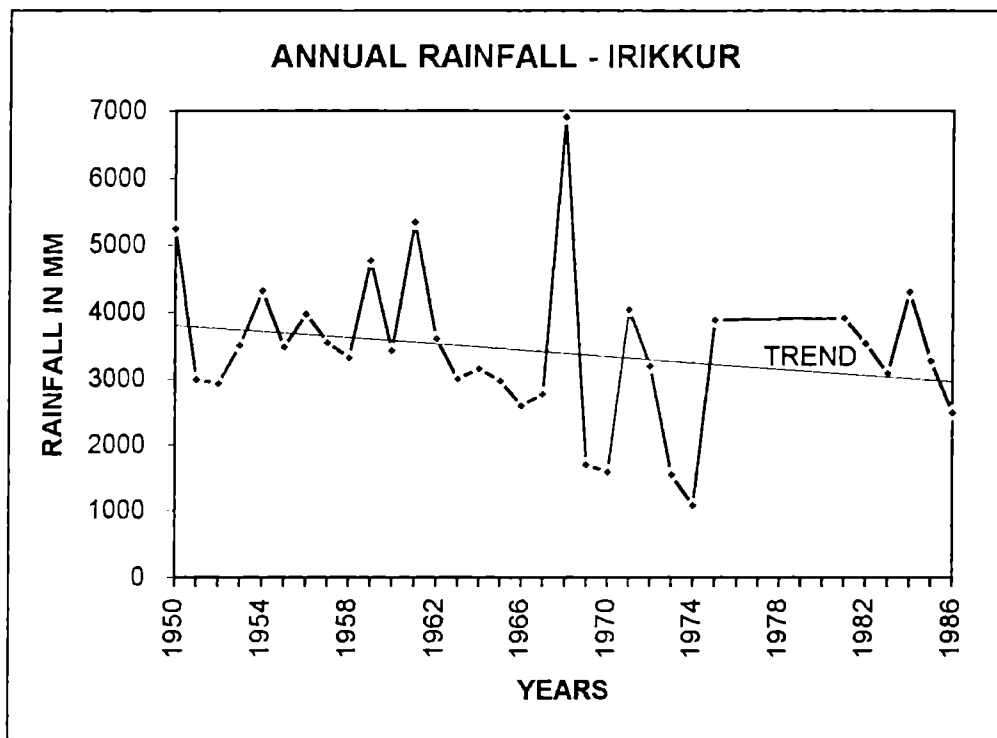


Fig. 4.3.3a. ANNUAL RAINFALL - IRIKKUR

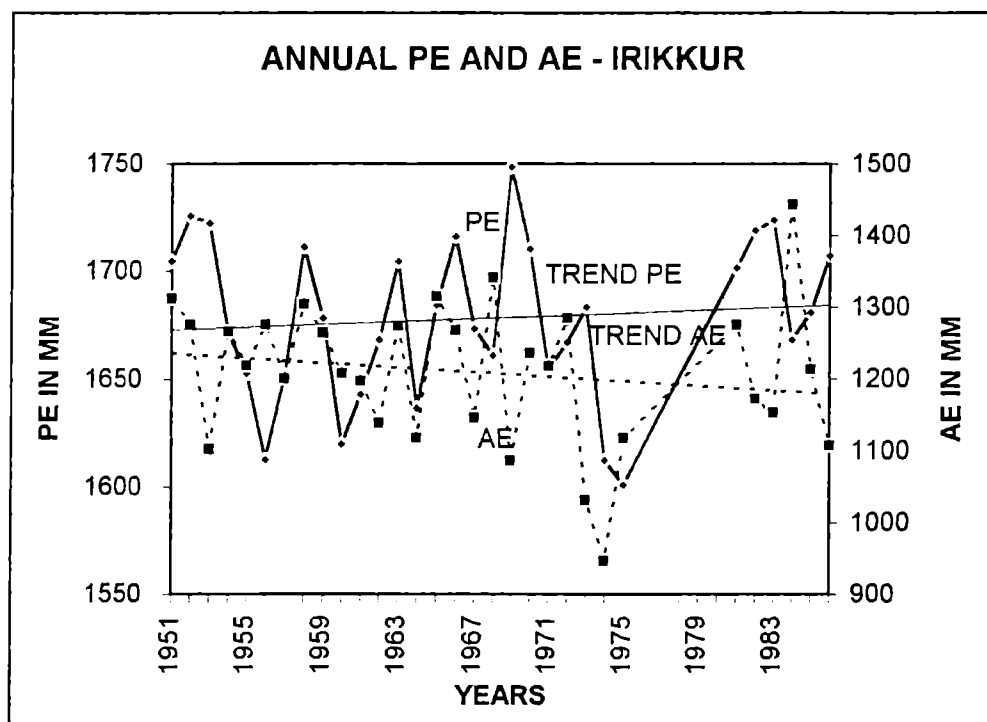


Fig. 4.3.3b. ANNUAL PE & AE - IRIKKUR

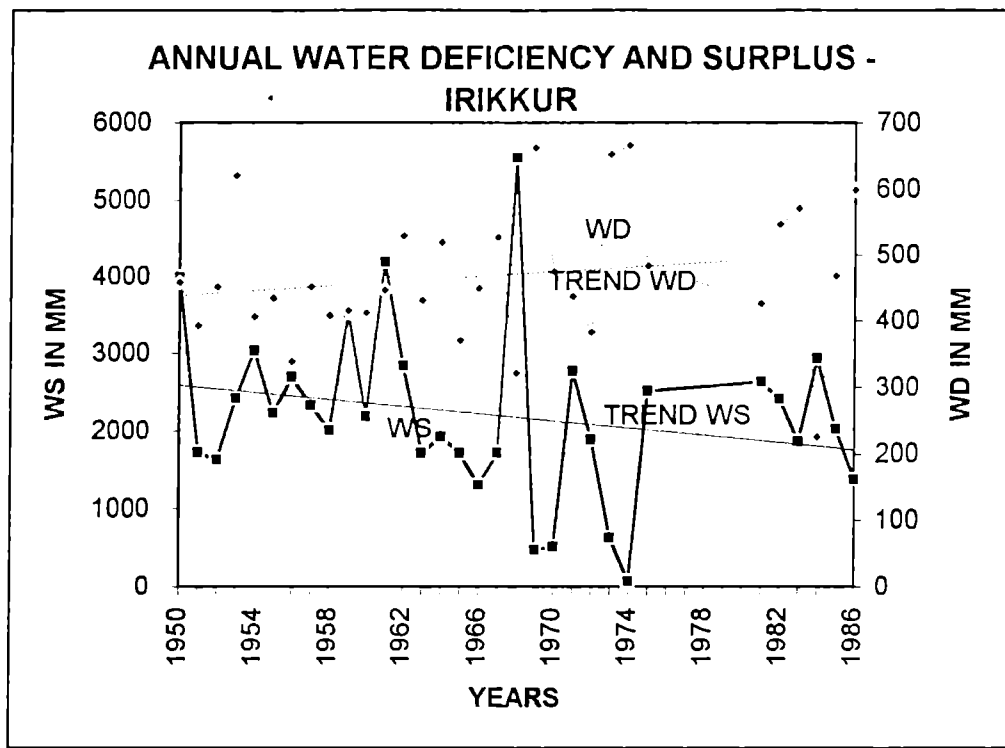


Fig. 4.3.3c. ANNUAL WD & WS - IRIKKUR

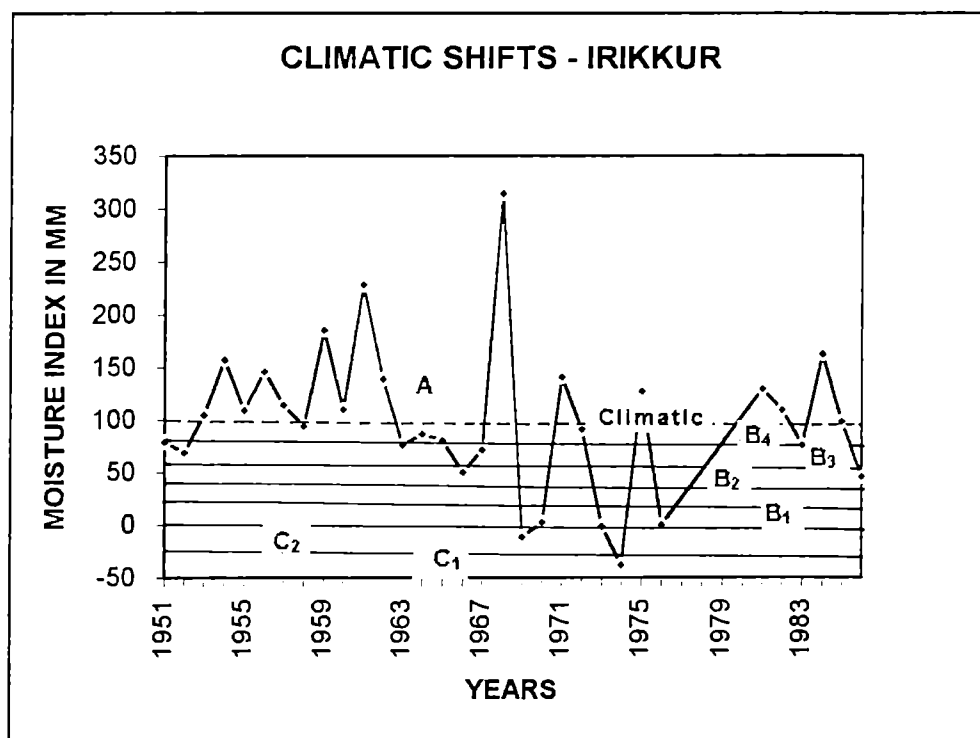


Fig. 4.3.3d. CLIMATIC SHIFTS - IRIKKUR

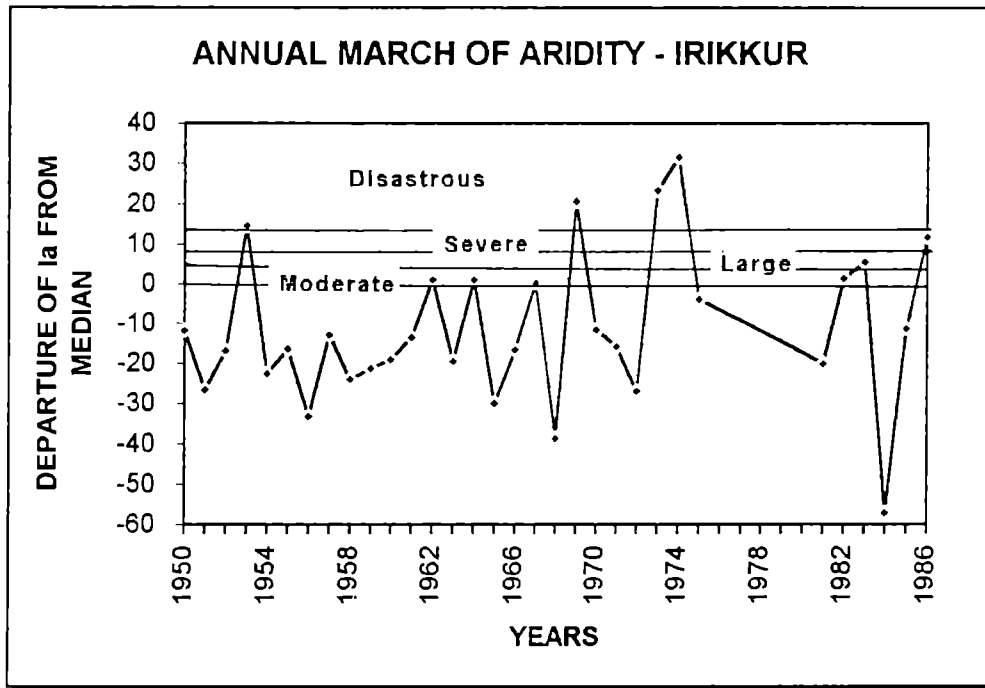


Fig. 4.3.3e. ANNUAL MARCH OF ARIDITY INDEX - IRIKKUR

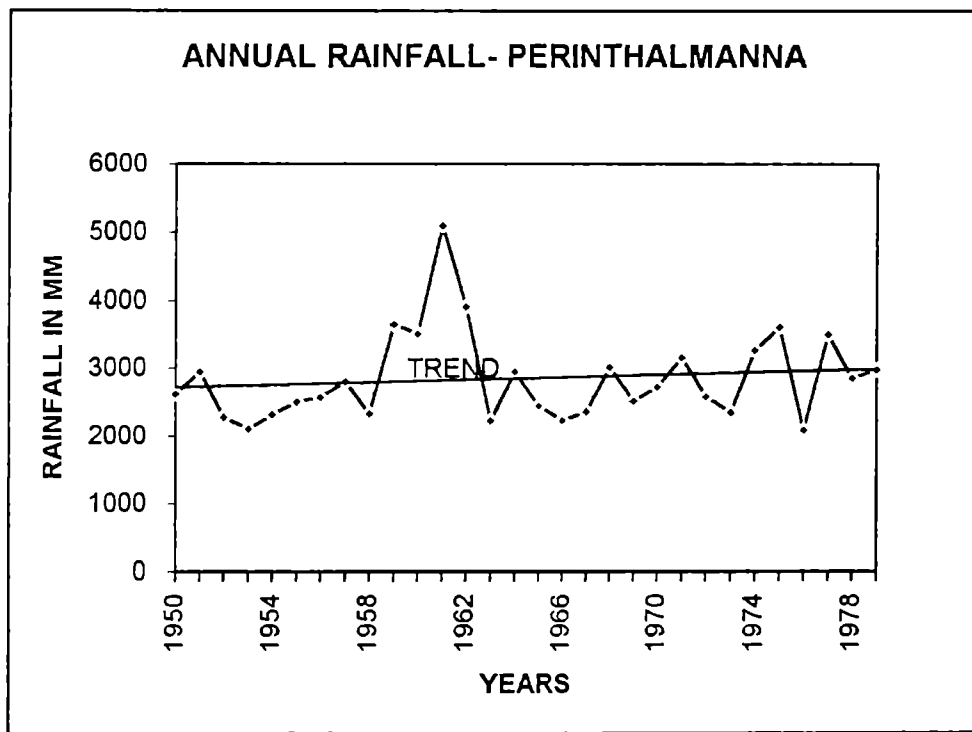


Fig. 4.3.4a. ANNUAL RAINFALL - PERINTHALMANNA

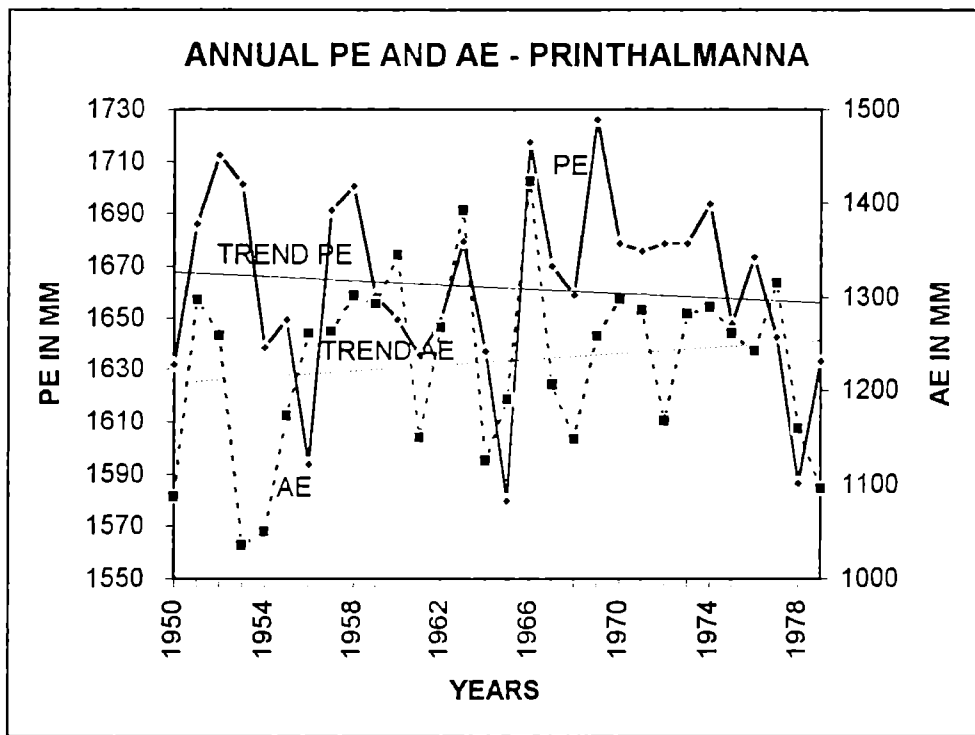


Fig. 4.3.4b. ANNUAL PE & AE - PERINTHALMANNA

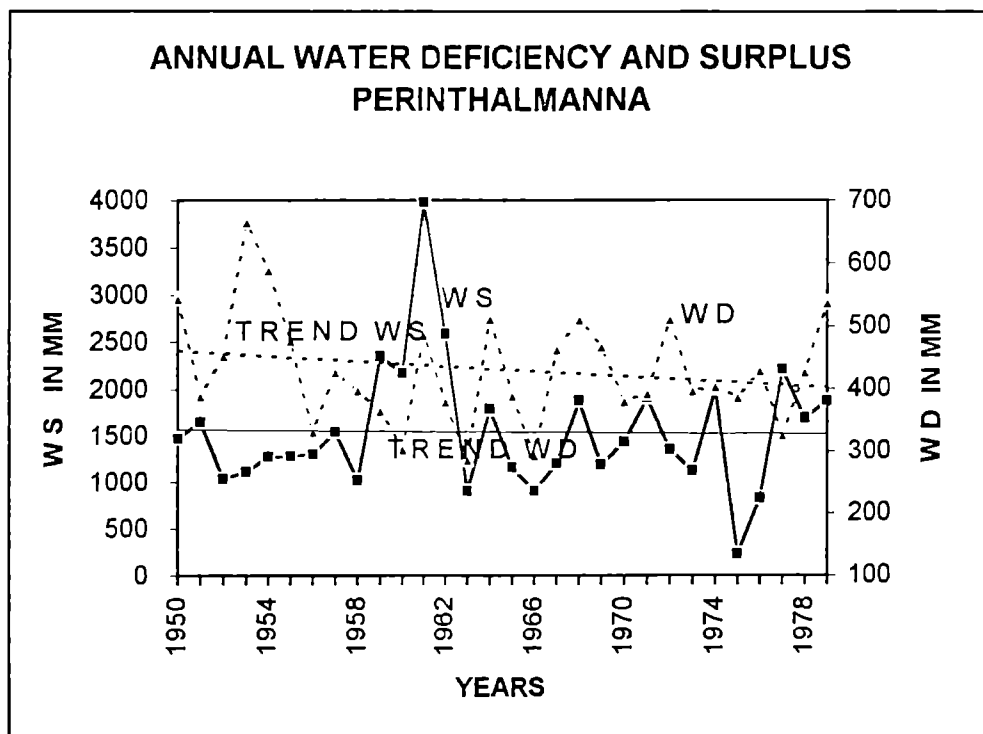


Fig. 4.3.4c. ANNUAL WD & WS - PERINTHALMANNA

recorded in the year 1961, and the highest water deficit (666 mm.) was experienced in the year 1953.

Perinthalmanna experiences humid B<sub>4</sub> climate. A majority of the climatic shifts were within the humid type. (Fig. 4.3.4d). Six years recorded shift towards moist sub-humid type.

This station had comparatively less number of droughts. (Fig. 4.3.4e). There were two consecutive years of disastrous droughts in 1953 and 1954. There were also four severe droughts during this period

## **B. CENTRAL ZONE**

### **4.3.5. MANNARAKKAD**

Located at 10<sup>0</sup>59' N and 76<sup>0</sup>28' E, Mannarakkad receives 2710 mm. annual rainfall. During the period 1950-1986, 18 years recorded below normal rainfall. (Fig. 4.3.5a). A marked declining trend in the annual rainfall can be noticed. The highest annual rainfall of 4416 mm. was recorded in 1961. The lowest was in the year 1983, when the annual rainfall was only 1520 mm.

The annual PE of Mannarakkad does not show any trend, while the AE shows a declining trend. (Fig. 4.3.5b).

Following the rainfall pattern, the WS and WD displays a decreasing and increasing trend respectively. (Fig. 4.3.5c).

The humid B<sub>2</sub> type of climate of Mannarakkad indicates varying shifts during the period 1950-1986. Seven years recorded shift towards C<sub>2</sub> type and five years towards perhumid type category. (Fig. 4.3.5d).

Two consecutive years of disastrous droughts occurred in 1983 and 1984. (Fig. 4.3.5e). Another notable aspect is that, it had six consecutive years of droughts of higher magnitudes from 1981 to 1986.

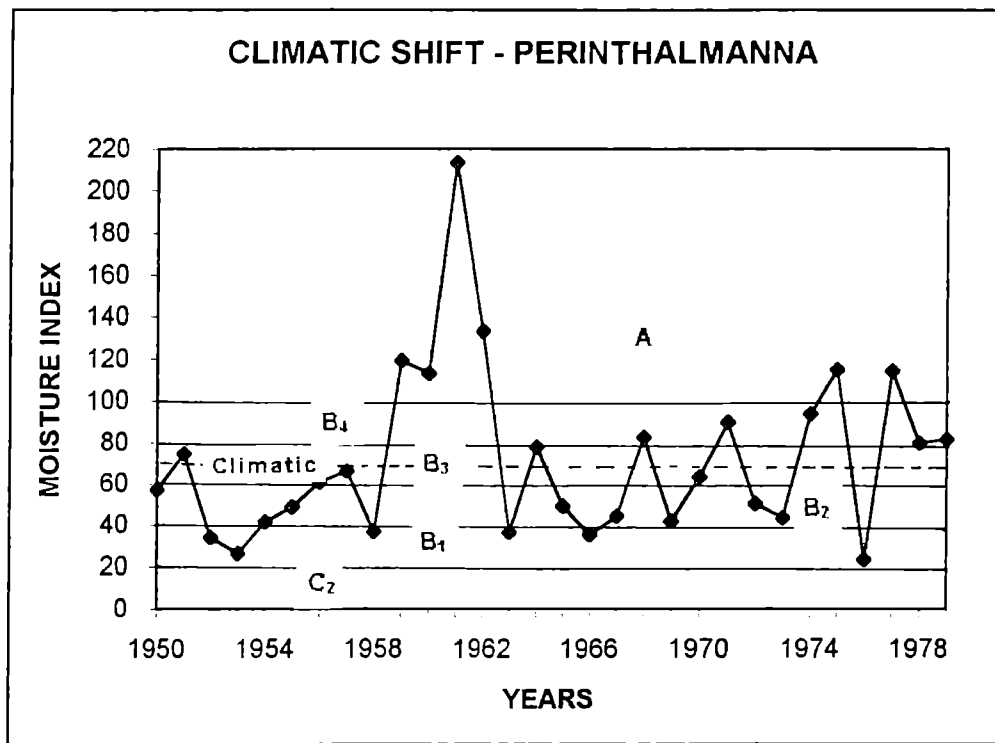


Fig. 4.3.4d. CLIMATIC SHIFTS - PERINTHALMANNA

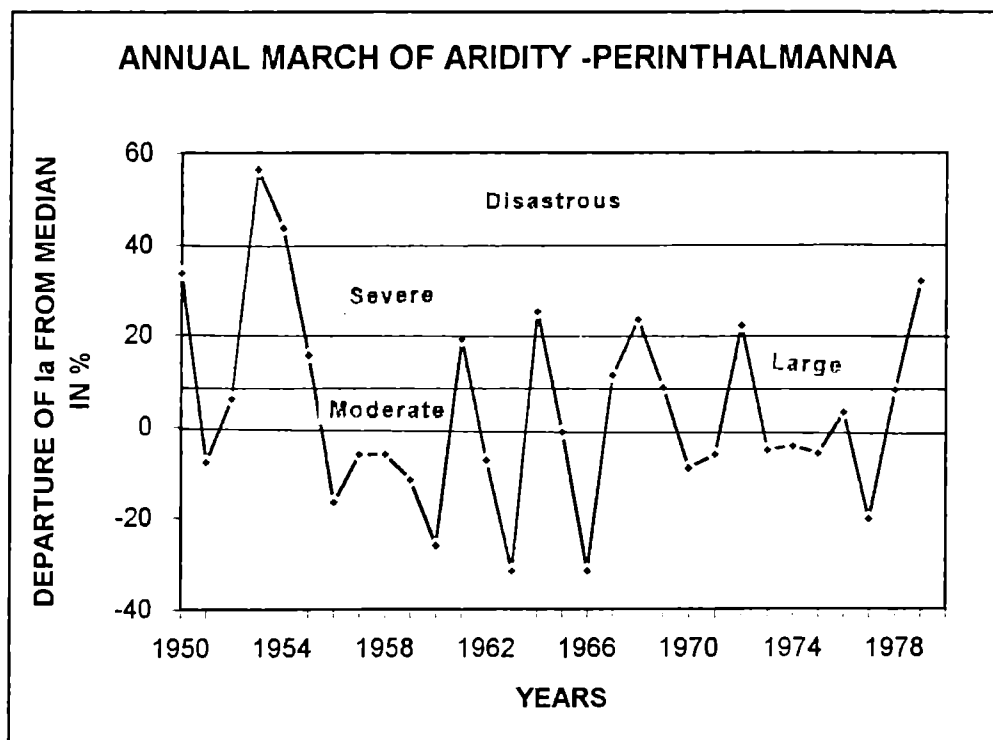


Fig. 4.3.4e. ANNUAL MARCH OF ARIDITY INDEX  
PERINTHALMANNA

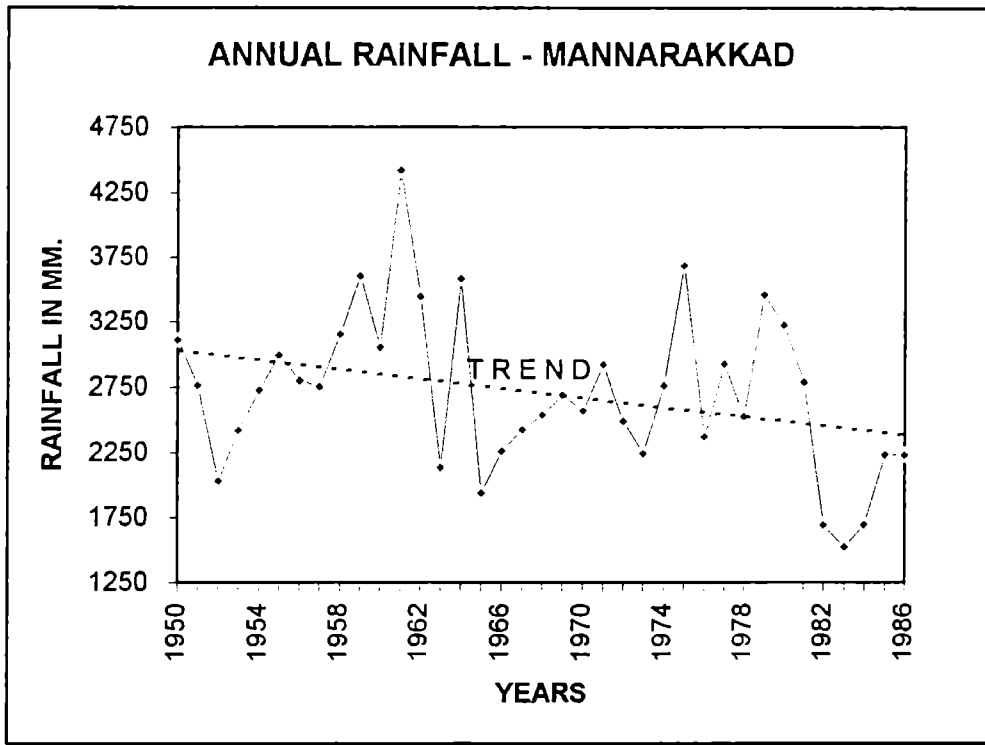


Fig. 4.3.5a. ANNUAL RAINFALL - MANNARAKKAD

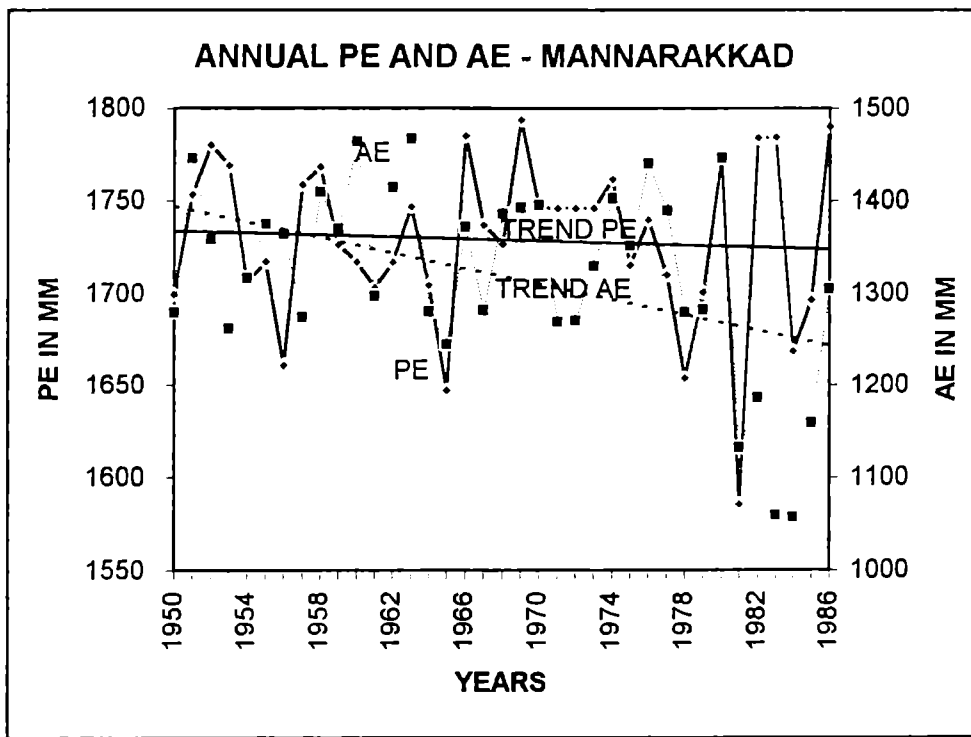


Fig. 4.3.5b. ANNUAL PE & AE - MANNARAKKAD

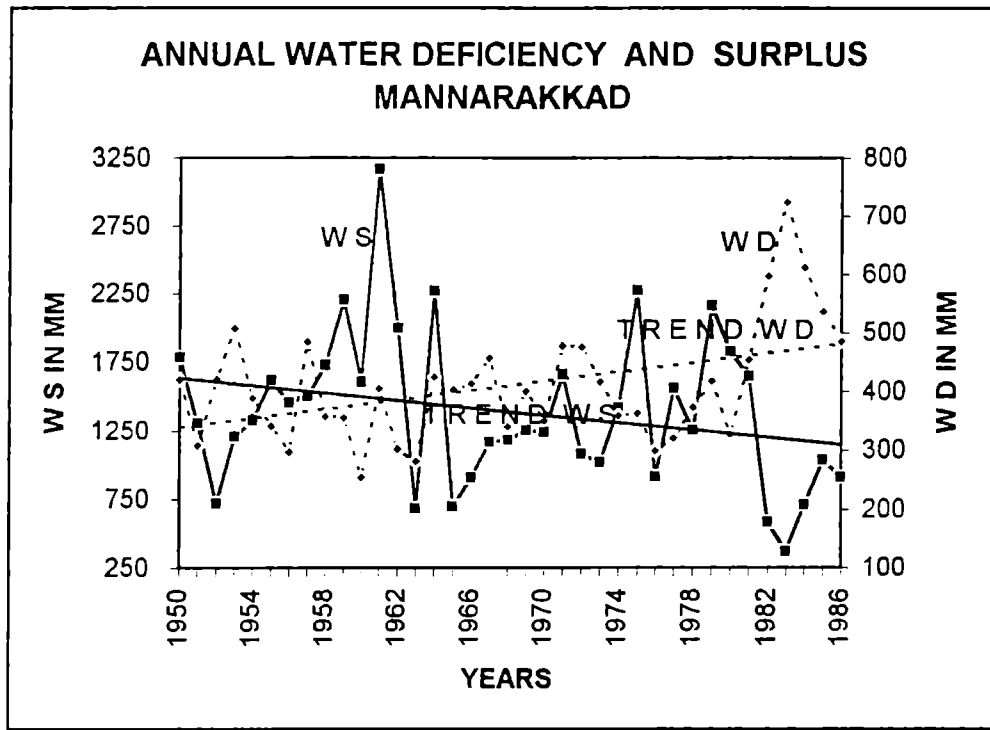


Fig. 4.3.5c. ANNUAL WD & WS - MANNARAKKAD

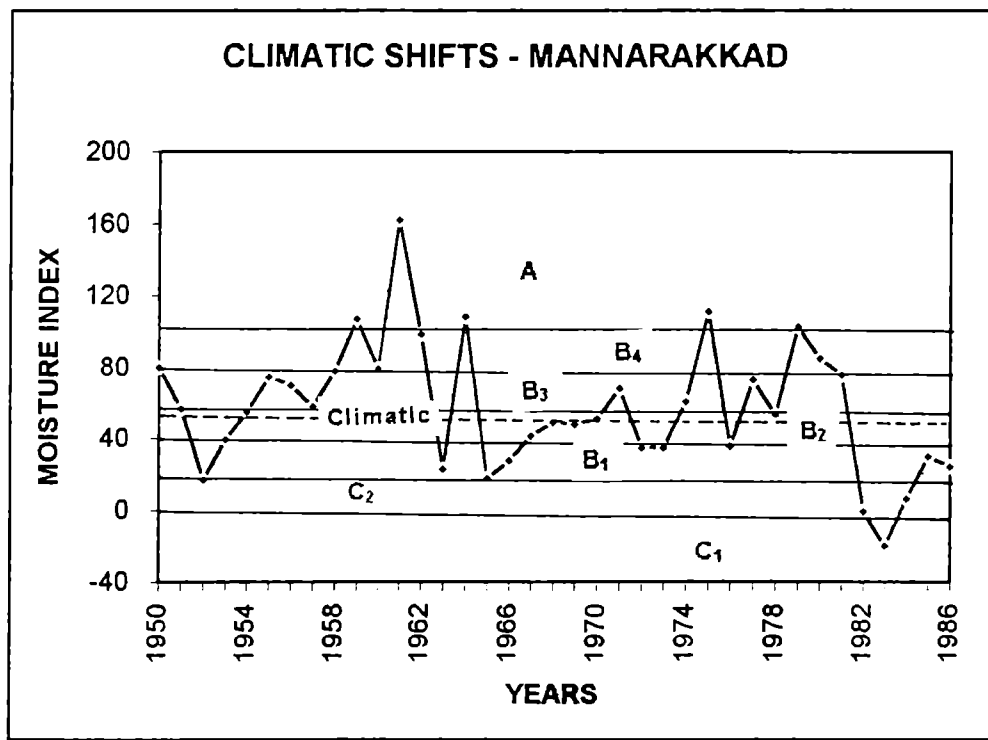


Fig. 4.3.5d. CLIMATIC SHIFTS - MANNARAKKAD



#### 4.3.6. KODUNGALLUR

Kodungallur is located at  $10^{\circ}13'$  N and  $76^{\circ}12'$  E. It gets 2904 mm. of annual rainfall. With wide fluctuations in annual rainfall, which varies from 1889 mm. to 4518 mm., it displays a slight decreasing trend. (Fig. 4.3.6a).

A distinct increasing trend in PE and a decreasing trend in AE is evident from Fig. 4.3.6b.

Following the pattern of rainfall, the WS shows a decreasing trend, while the WD is on the increase. (Fig. 4.3.6c).

Kodungallur has a  $B_3$  type of climate. Five years recorded shifts towards perhumid type. Most of the shifts were within the humid type. (Fig. 4.3.6d).

The annual march of aridity index shows (Fig. 4.3.6e) that there was only one disastrous drought in Kodungallur, in the year 1968. But 17 years experienced moderate droughts and there were large droughts in 1979, 1980 and 1983.

#### 4.3.7. MALAYATTOOR

Located at  $10^{\circ}12'$  N and  $76^{\circ}31'$  E, Malayattoor receives 3156 mm. of annual rainfall. Here again about 50% of the years under study recorded below normal rainfall. (Fig. 4.3.7a). The annual rainfall pattern indicates a decreasing trend. The lowest recorded rainfall in Malayattoor was 1916 mm. (1974), and the highest was 4085 mm. (1982).

The annual PE pattern shows no trend, while the AE shows a moderate declining trend. (Fig. 4.3.7b).

Like many other stations, marked decreasing trend in WS and increasing trend in WD is observed in Malayattoor also. (Fig. 4.3.7c).

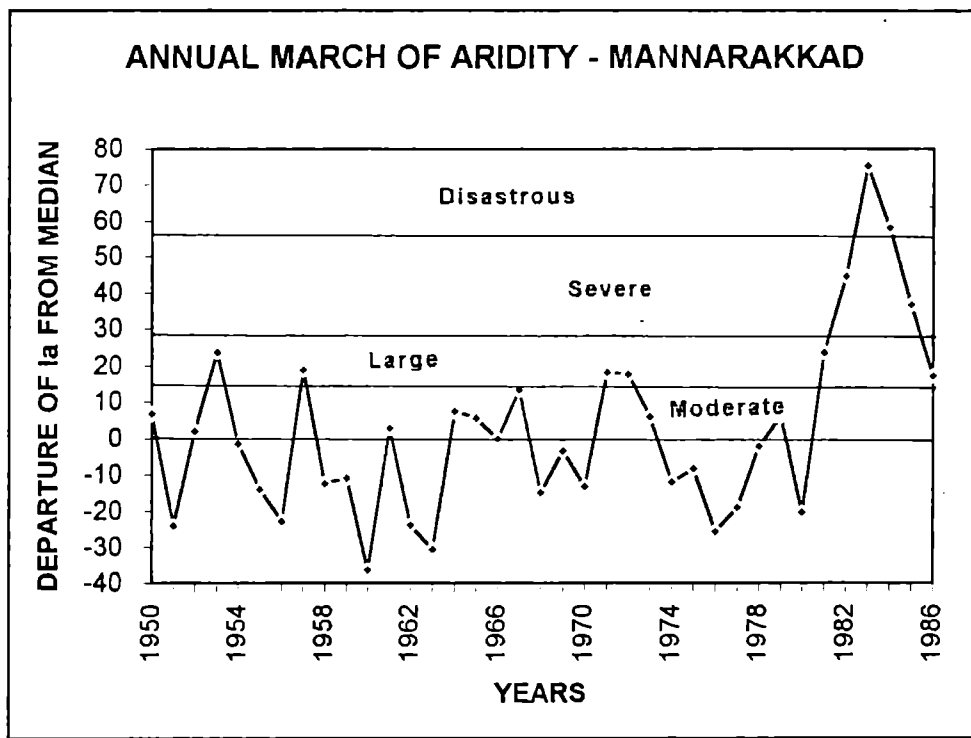


Fig. 4.3.5e. ANNUAL MARCH OF ARIDITY INDEX  
MANNARAKKAD

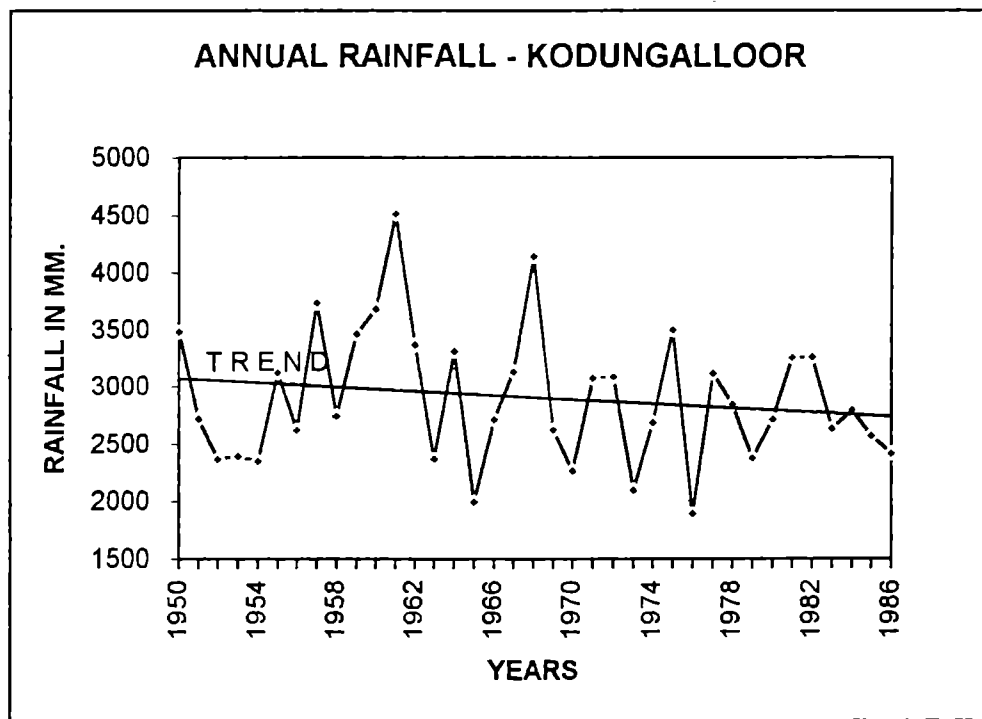


Fig. 4.3.6a. ANNUAL RAINFALL - KODUNGALLUR

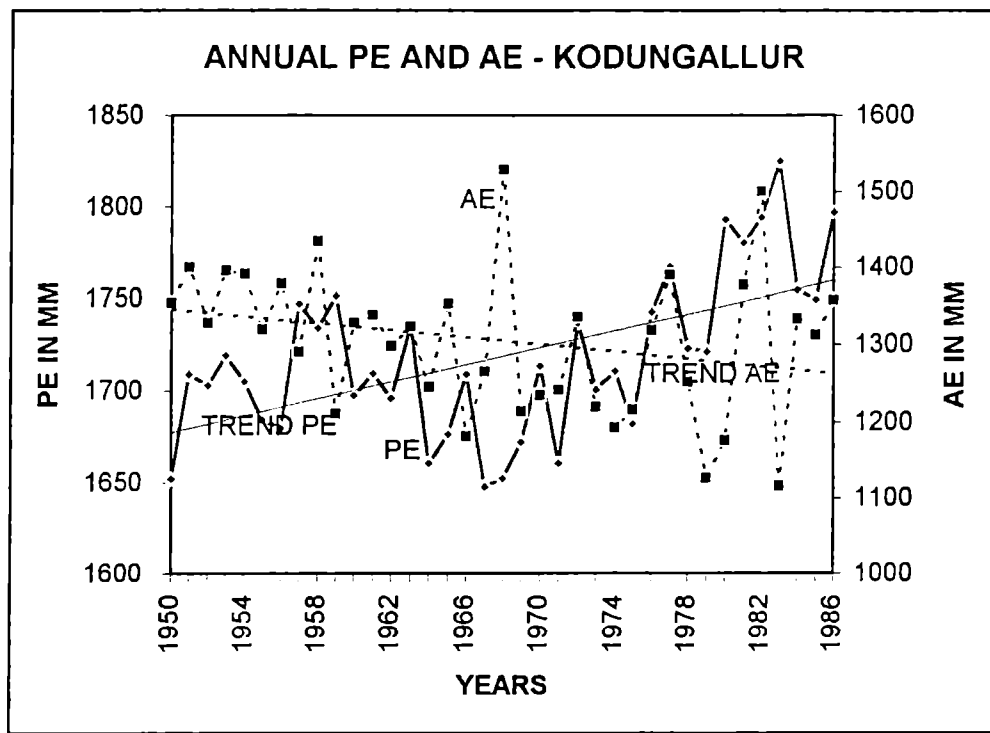


Fig. 4.3.6b. ANNUAL PE & AE - KODUNGALLUR

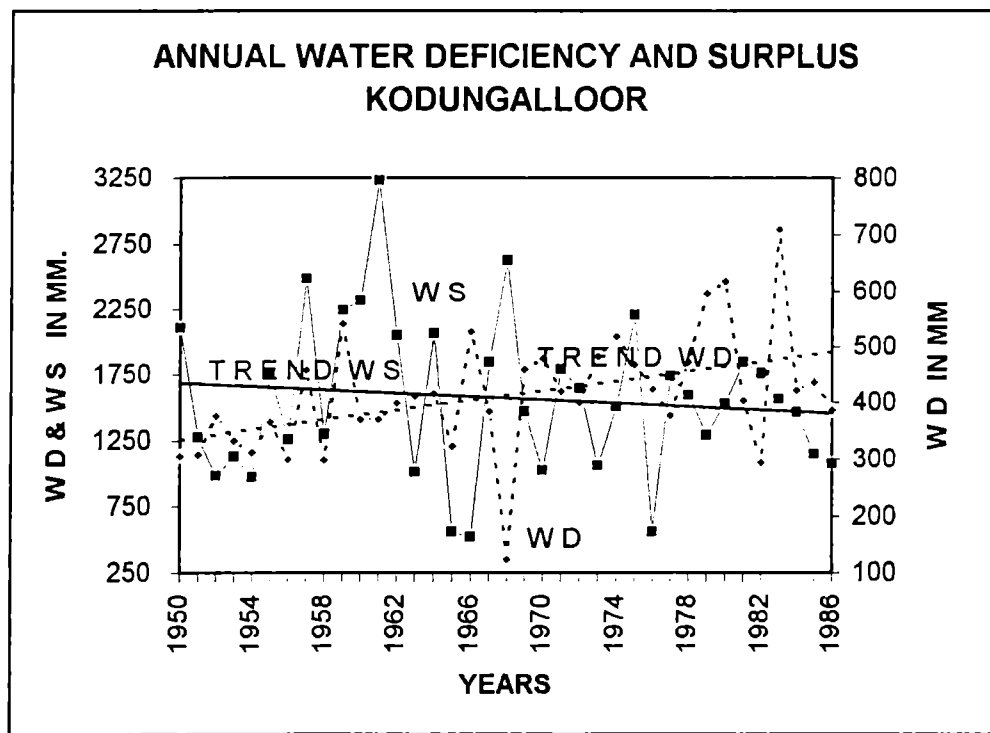


Fig. 4.3.6c. ANNUAL WD & WS - KODUNGALLUR

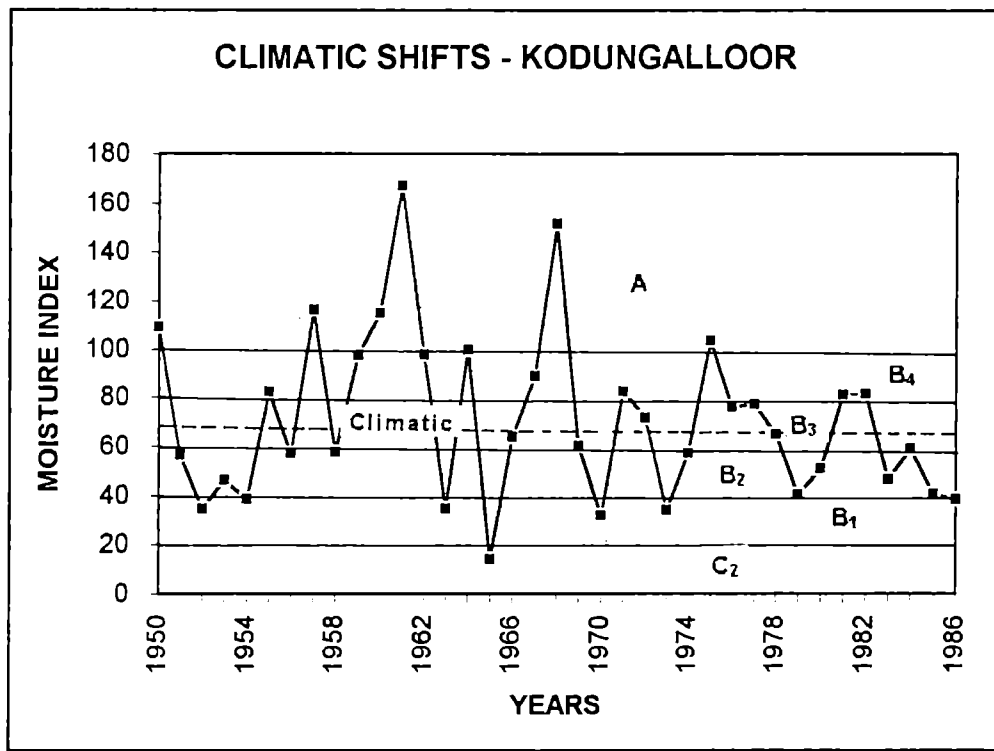


Fig. 4.3.6d. CLIMATIC SHIFTS - KODUNGALLUR

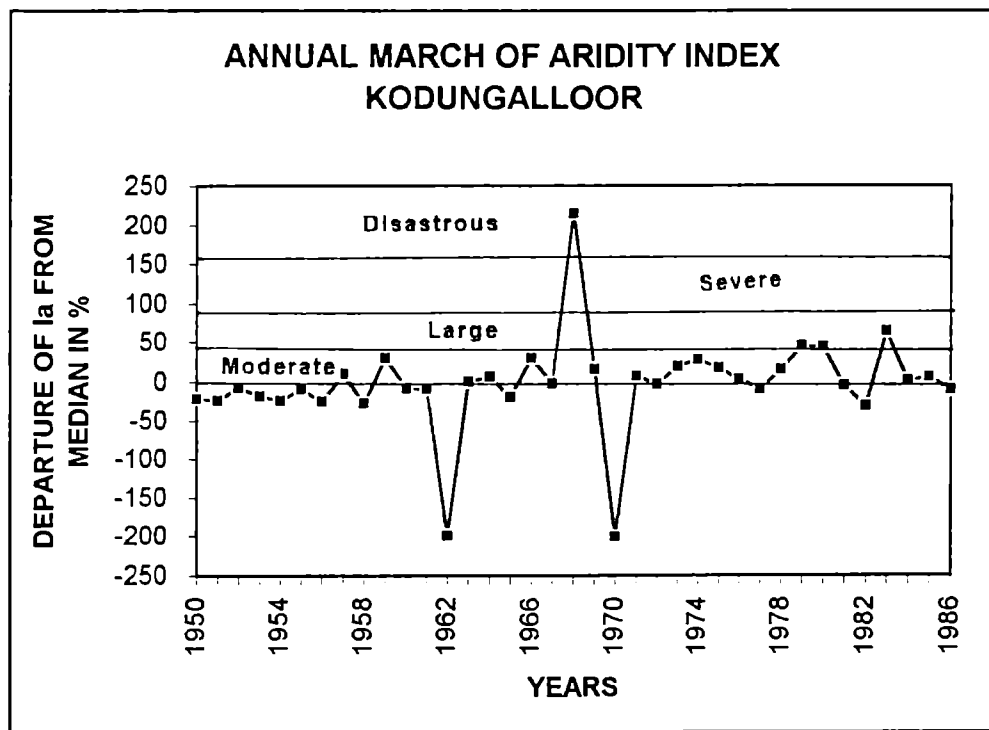


Fig. 4.3.6e. ANNUAL MARCH OF ARIDITY INDEX  
KODUNGALLUR

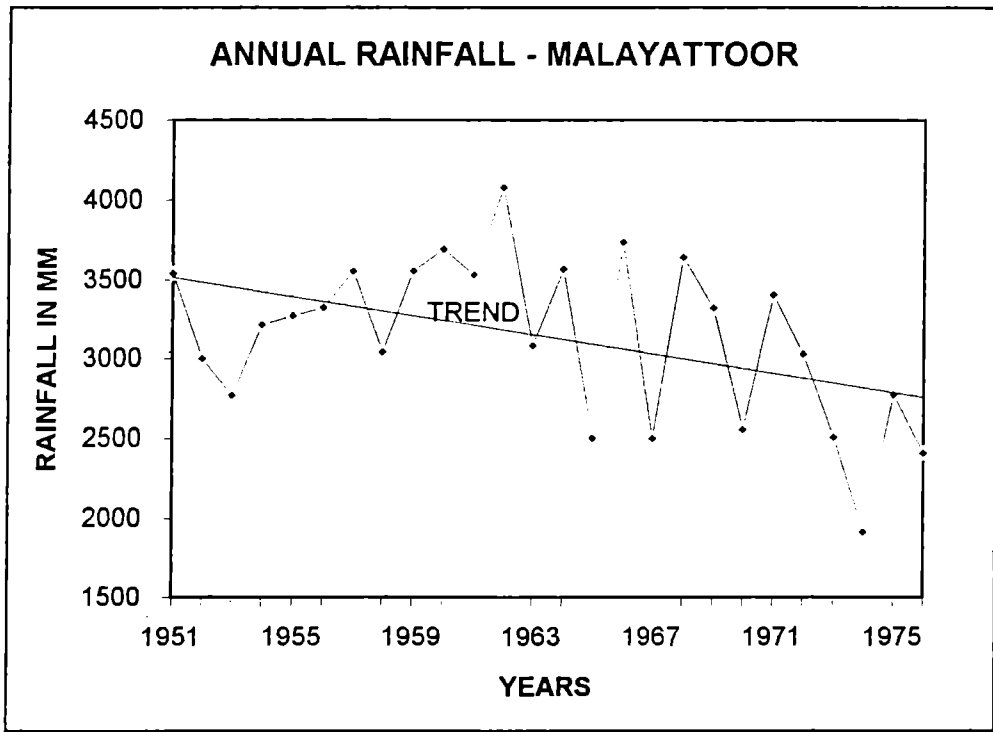


Fig. 4.3.7a. ANNUAL RAINFALL - MALAYATTOOR

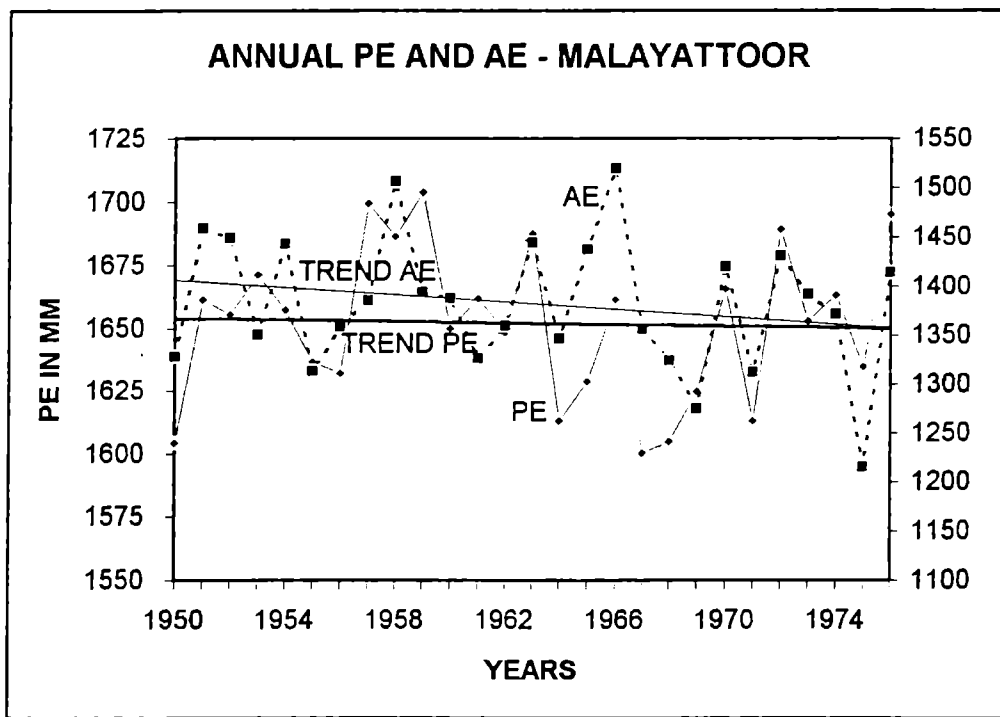


Fig. 4.3.7b. ANNUAL PE & AE - MALAYATTOOR

Malayattoor has a humid (B<sub>1</sub>) type of climate. The climatic shift of this station is mainly towards perhumid side. (Fig.4.3.7d). The only major shift towards drier side was in the year 1974, when the moisture index dropped down to 19.8, indicating a shift towards C<sub>2</sub> type.

There were no disastrous droughts in Malayattoor.(Fig.4.3.7e). Eight years had moderate droughts, six years had large droughts and two years severe droughts.

### C. SOUTHERN ZONE

#### **4.3.8. NERIAMANGALAM.**

Located at 10<sup>0</sup>03' N and 76<sup>0</sup>47' E Neriamangalam receives the highest annual rainfall in Kerala - 4637 mm. The highest annual rainfall received at Neriamangalam was 7787 mm.in 1950 and the lowest was 2359 mm.in 1961. Here too a declining trend can be seen in the rainfall pattern.(Fig.4.3.8a).

The annual PE and AE indicates a slight declining trend (Fig 4.3.8b).

Like many other stations, Neriamangalam also shows a decline in annual WS and increase in WD. (Fig.4.3.8c).

Consequent on receiving heavy rainfall, Neriamangalam experiences a perhumid type of climate. The only climatic shift recorded was in the year 1961, when the station experienced B<sub>3</sub> type climate. (Fig.4.3.8d).

Although Neriamangalam records highest rainfall, the wide annual fluctuations caused droughts of various magnitude. There were six moderate, five large, three severe and one disastrous droughts. (Fig.4.3.8e).

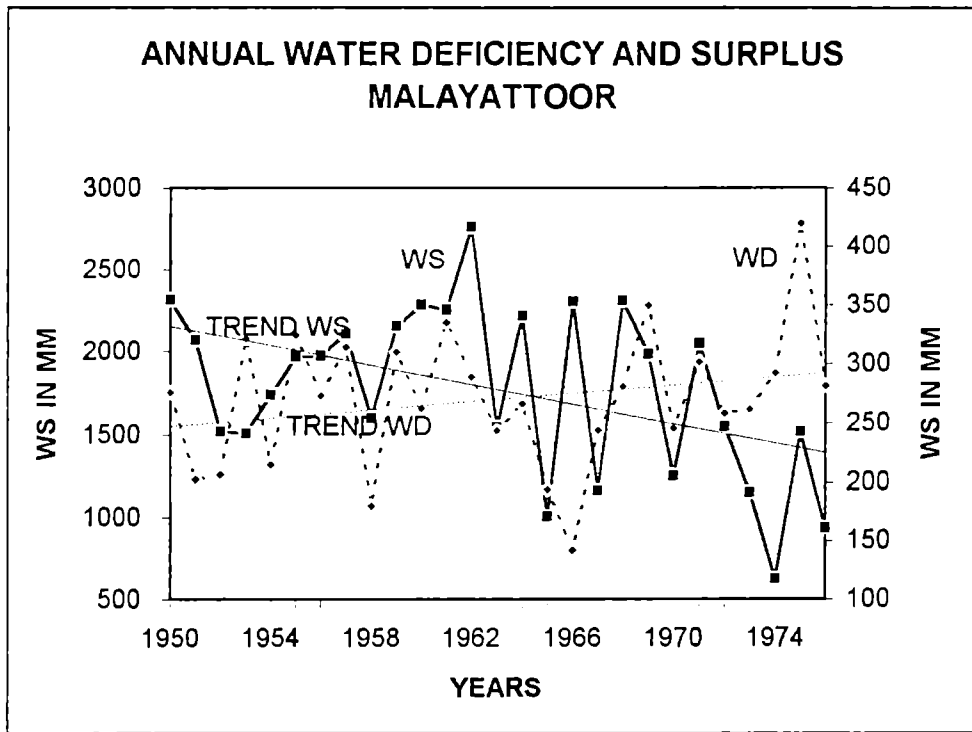


Fig. 4.3.7c. ANNUAL WD & WS - MALAYATTOOR

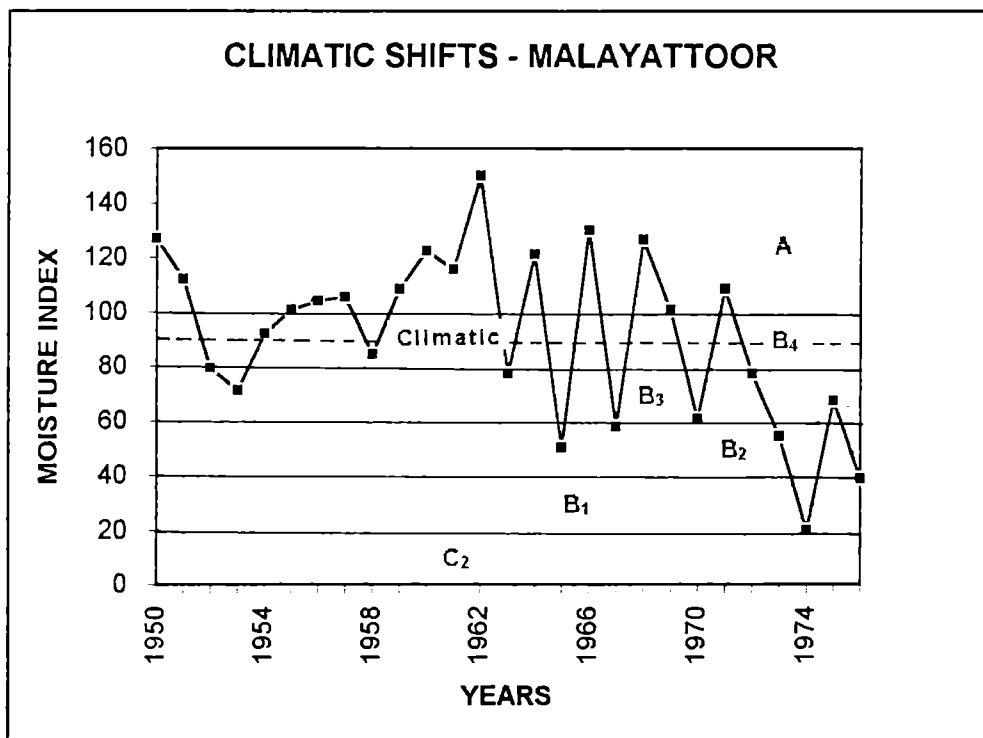


Fig. 4.3.7d. CLIMATIC SHIFTS - MALAYATTOOR

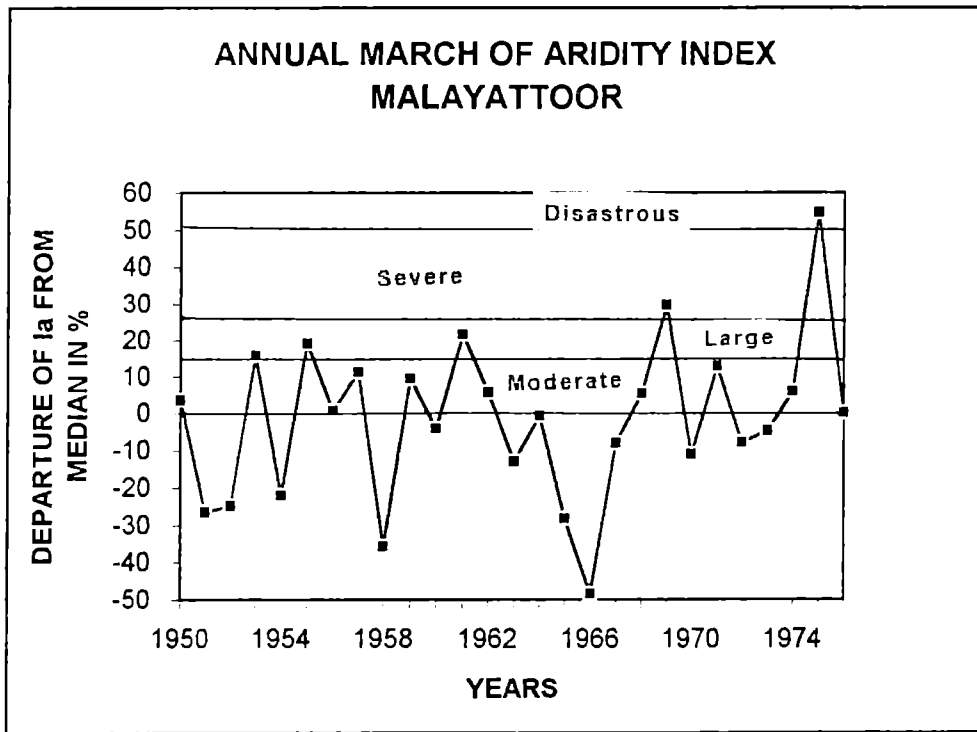


Fig. 4.3.7e. ANNUAL MARCH OF ARIDITY INDEX  
MALAYATTOOR

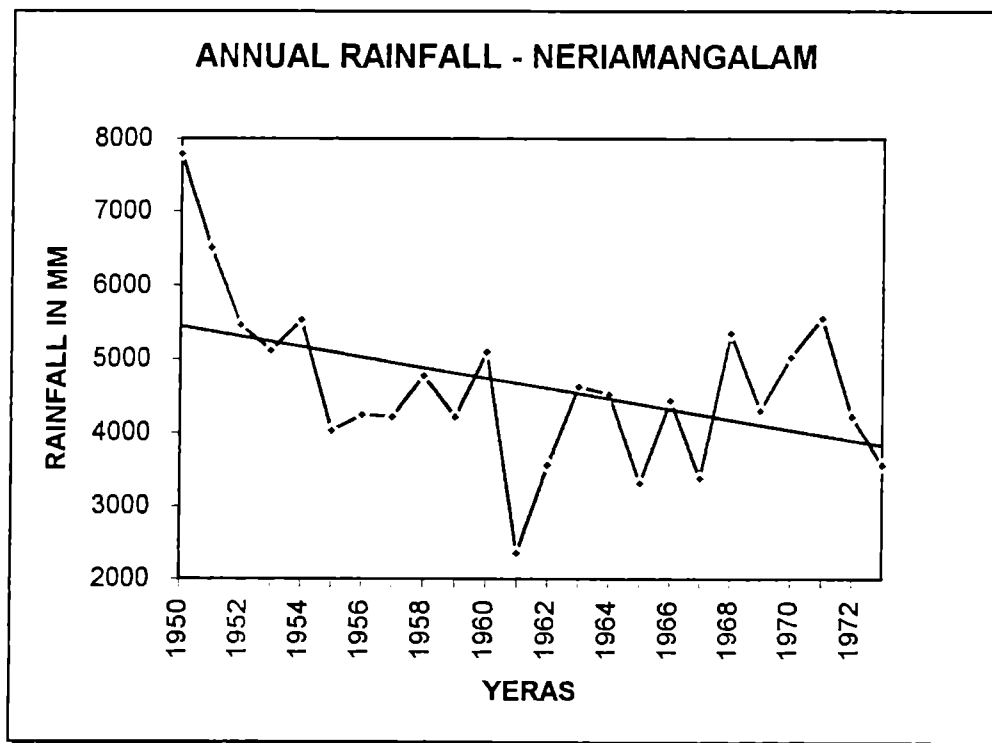


Fig. 4.3.8a. ANNUAL RAINFALL - NERIAMANGALAM



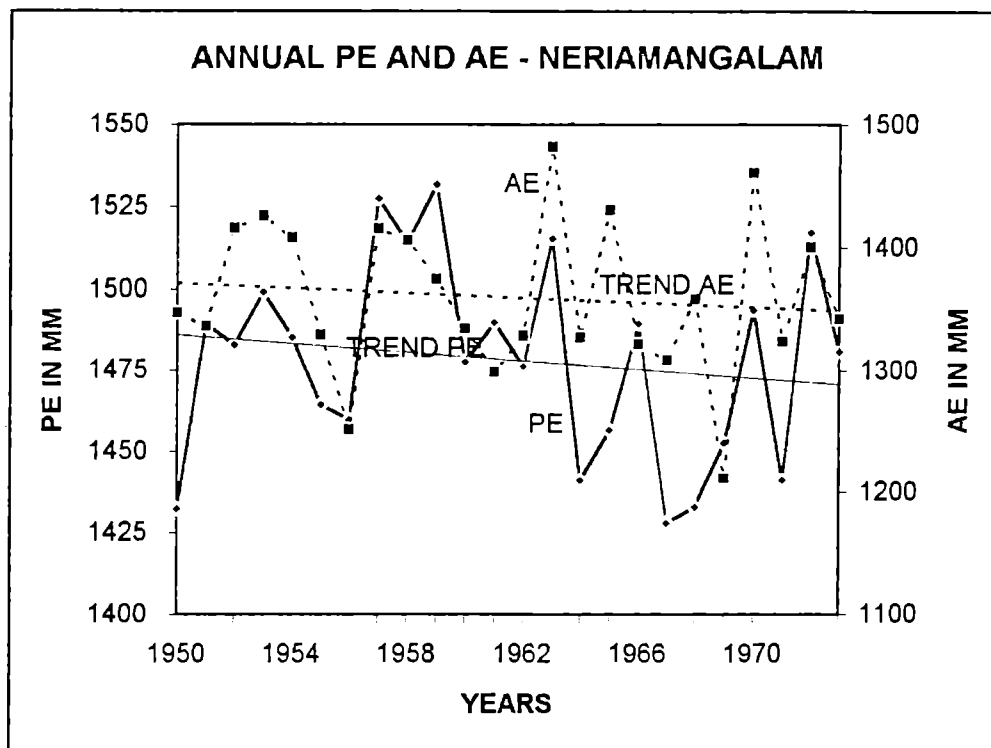


Fig. 4.3.8b. ANNUAL PE & AE - NERIAMANGALAM

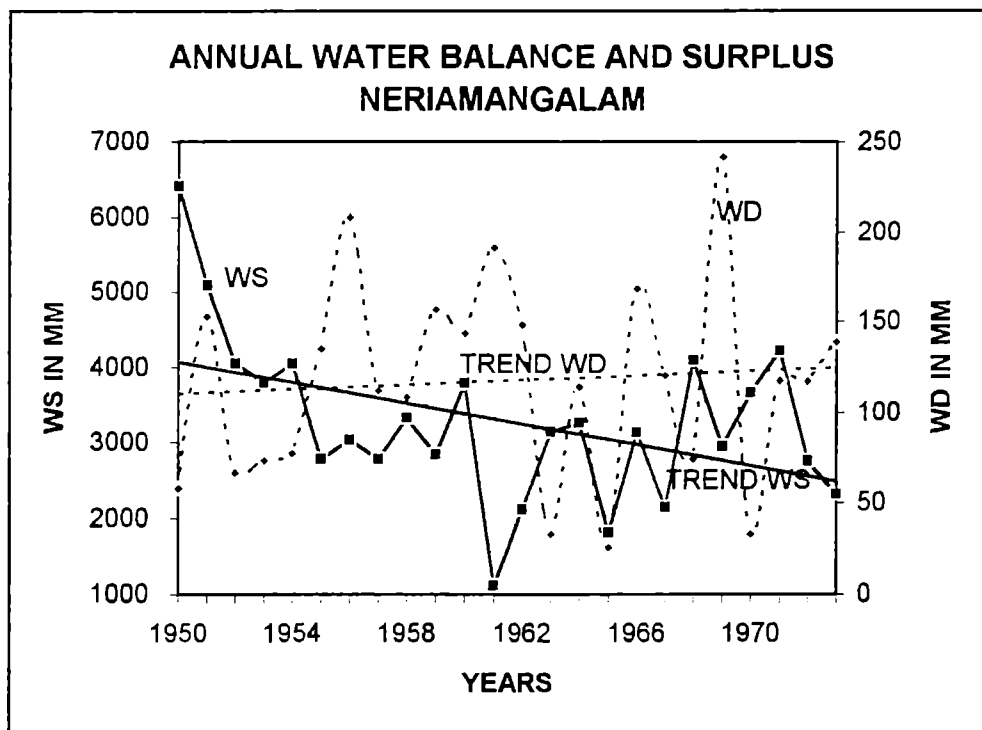


Fig. 4.3.8c. ANNUAL WD & WS - NERIAMANGALAM

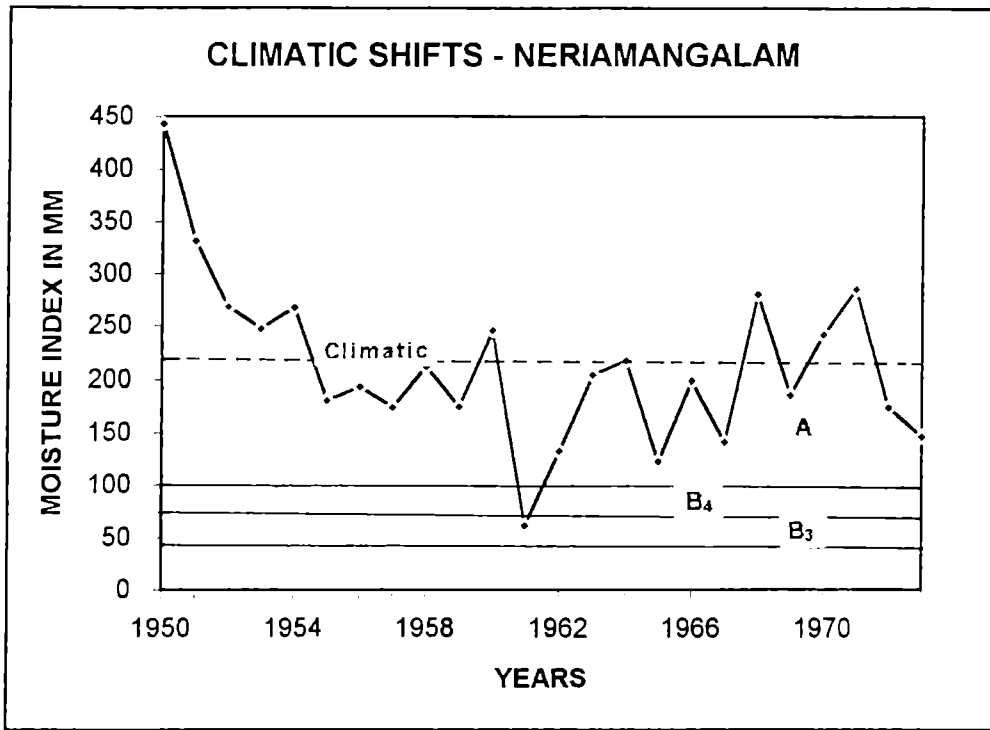


Fig. 4.3.8d. CLIMATIC SHIFTS - NERIAMANGALAM

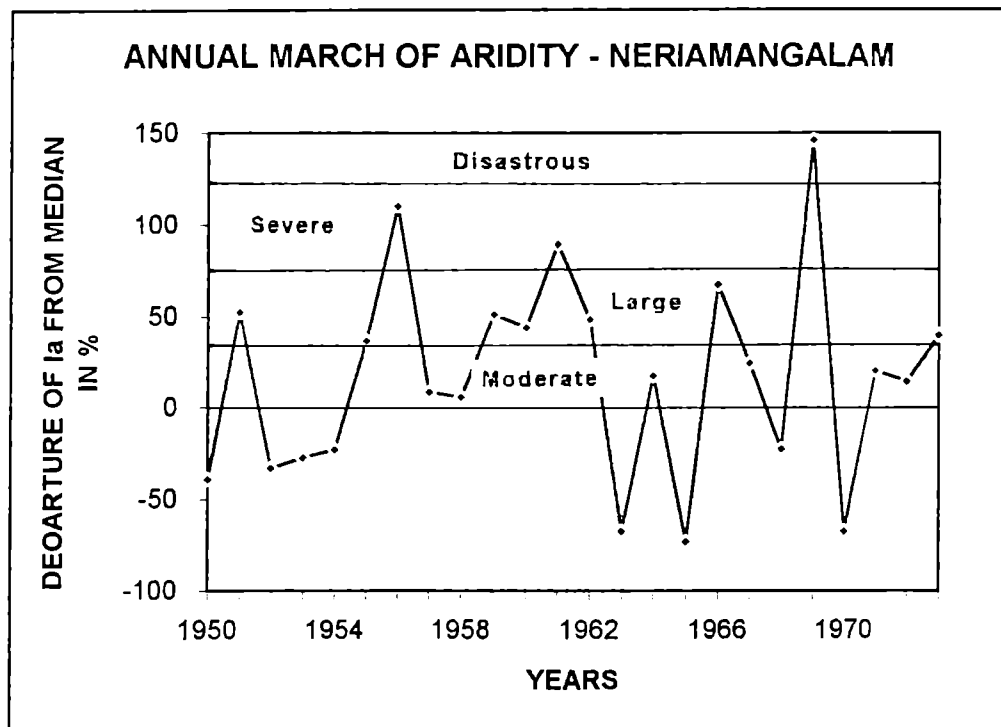


Fig. 4.3.8e. ANNUAL MARCH OF ARIDITY INDEX  
NERIAMANGALAM

#### 4.3.9. KOTTAYAM

Located at  $9^{\circ}35'N$  and  $76^{\circ}32'E$ , Kottayam is a midland station. It receives 2995 mm. of mean annual rainfall. With wide inter-annual variations, Kottayam also displays a declining trend in annual rainfall.(Fig.4.3.9a). Maximum annual rainfall of Kottayam was 4076 mm recorded in 1976 and the lowest was in the year 1965 (2016 mm).

The PE at this station shows an increasing trend. (Fig.4.3.9b), but no trend was observed in the AE. The highest annual PE was 1817 mm recorded in the years 1983 and 1986. The AE was lowest during 1971 and 1983.

Same pattern of trend is observed in the case of WS and WD. Annual WS shows a declining trend while the WD displays an increasing trend. (Fig.4.3.9c).

Kottayam experiences a humid type of climate. Fig.4.3.10d shows the inter-annual climatic shifts of Kottayam. Most of the shifts had occurred within the humid sub categories. During the period 1950-1986, 11 years show a shift towards per humid (A) type.

There were comparatively less number of droughts in Kottayam. (Fig.4.3.9e). In all there were 2 disastrous droughts (1978 and 1983) and three severe droughts (1953, 1973 and 1982.). Apart from this there were 5 large and 8 moderate droughts during this period.

#### 4.3.10. ATTINGAL

Located at  $8^{\circ}42'N$  and  $76^{\circ}49'E$ , Attingal experiences a moist sub-humid type of climate. It receives a mean annual rainfall of 1771 mm. During the period 1950-1986, the year 1960

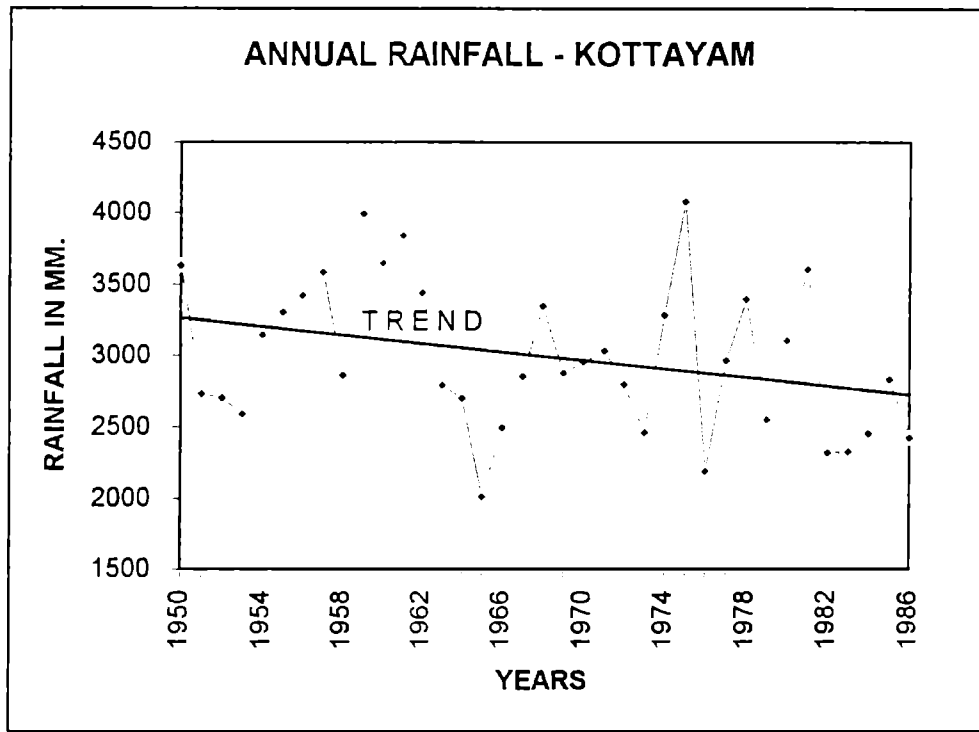


Fig. 4.3.9a. ANNUAL RAINFALL - KOTTAYAM

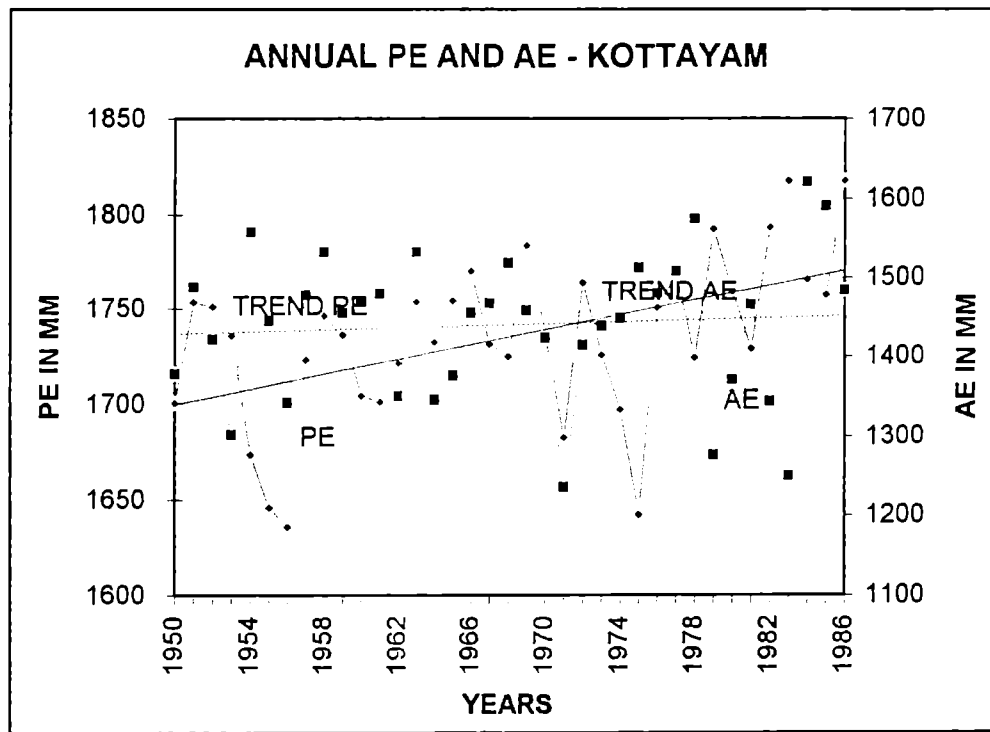


Fig. 4.3.9b. ANNUAL PE & AE - KOTTAYAM

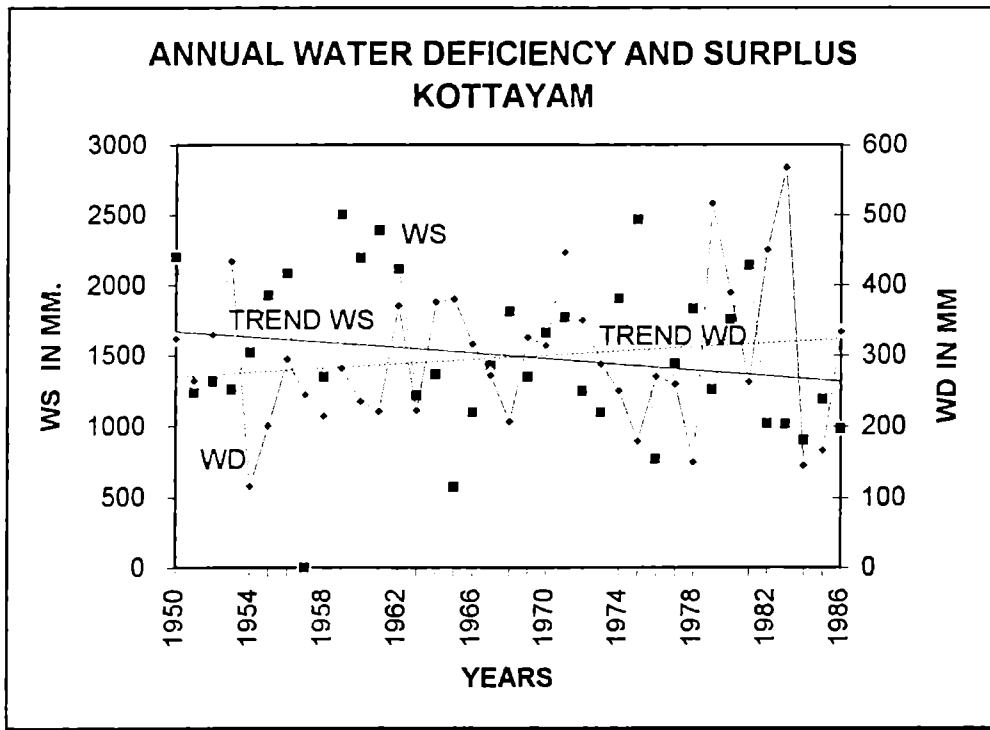


Fig. 4.3.9c. ANNUAL WD & WS - KOTTAYAM

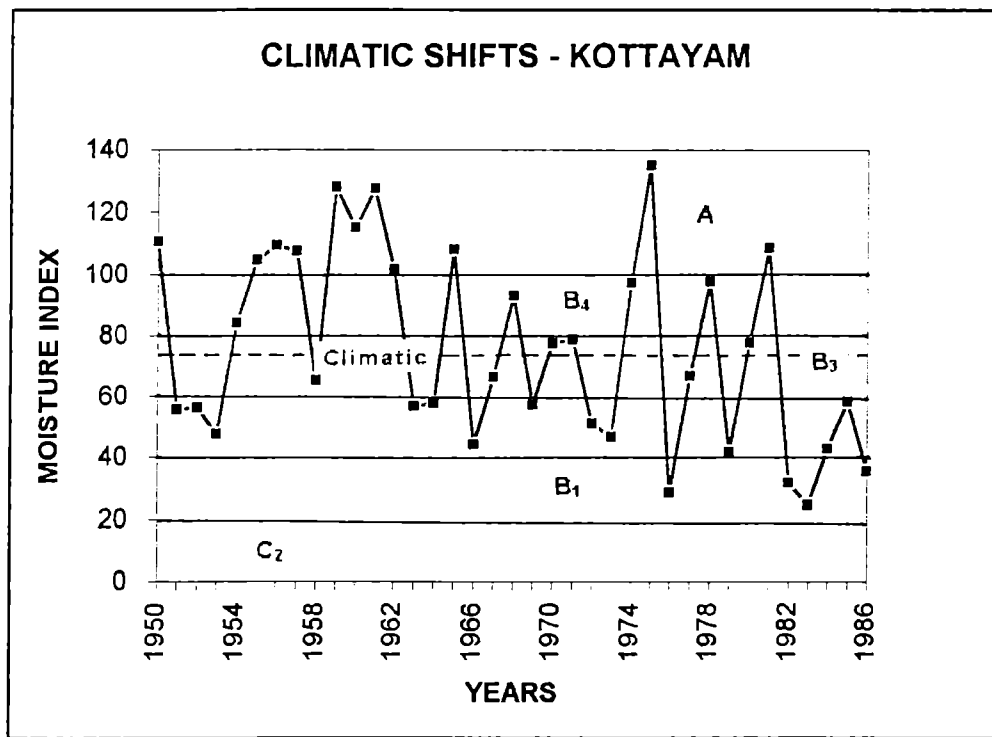


Fig. 4.3.9d. CLIMATIC SHIFTS - KOTTAYAM

was the wettest year, when it recorded 2880 mm. annual rainfall. The driest year was 1983 when the annual rainfall dropped down to a paltry 310 mm. The marked declining trend of annual rainfall in Attingal is clearly displayed in Fig.4.3.10a. Nearly 50% of the years had below normal rainfall.

A conspicuous increase in annual PE and corresponding decrease in annual AE is vividly portrayed in Fig.4.3.10b. The year 1983 had the highest water need (PE) - 1841 mm. Subsequently the lowest AE (312 mm.) was also in the same year.

Following the pattern of rainfall, the annual water surplus of Attingal also shows a declining trend. (Fig.4.3.10c). Maximum water surplus was recorded in the year 1960, when the annual WS was 1487 mm. During the period of observation, two more years had more than 1000 mm. Water surplus- in 1973 and 1985. In contrast to this the annual water deficit shows an increasing trend. It was above 1000 MM. during 1981,1982 and 1983. The highest WD was 1529 mm. recorded in the year 1983, which was the driest year of the station.

With the fluctuations in annual rainfall, the climate of a region is also expected to oscillate. It is obvious from Fig.4.3.10d that the general shift in climate of Attingal is towards the drier side. During the period 1950-1986, two years experienced shift towards arid (E) type and four years towards semi-arid (D) type. All these major shifts had occurred during the last decade.

The major climatic shifts towards drier side is also evident from Fig.4.3.10e, which indicates the type of droughts that occurred in Attingal. There were three years of disastrous droughts and two years of severe droughts during the period

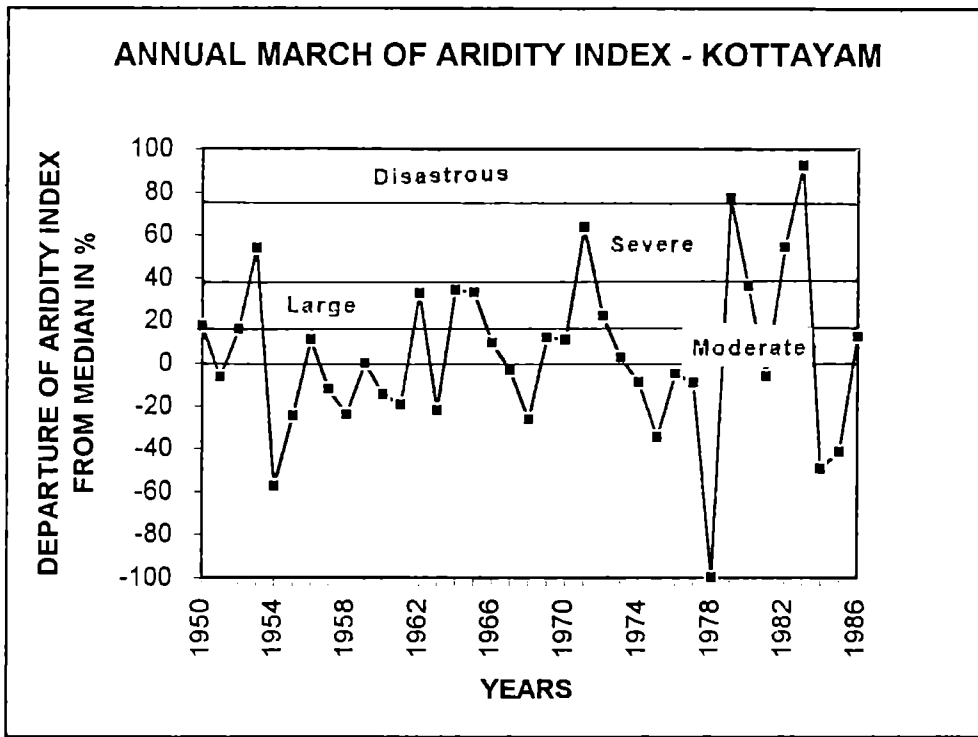


Fig. 4.3.9e. ANNUAL MARCH OF ARIDITY INDEX  
KOTTAYAM

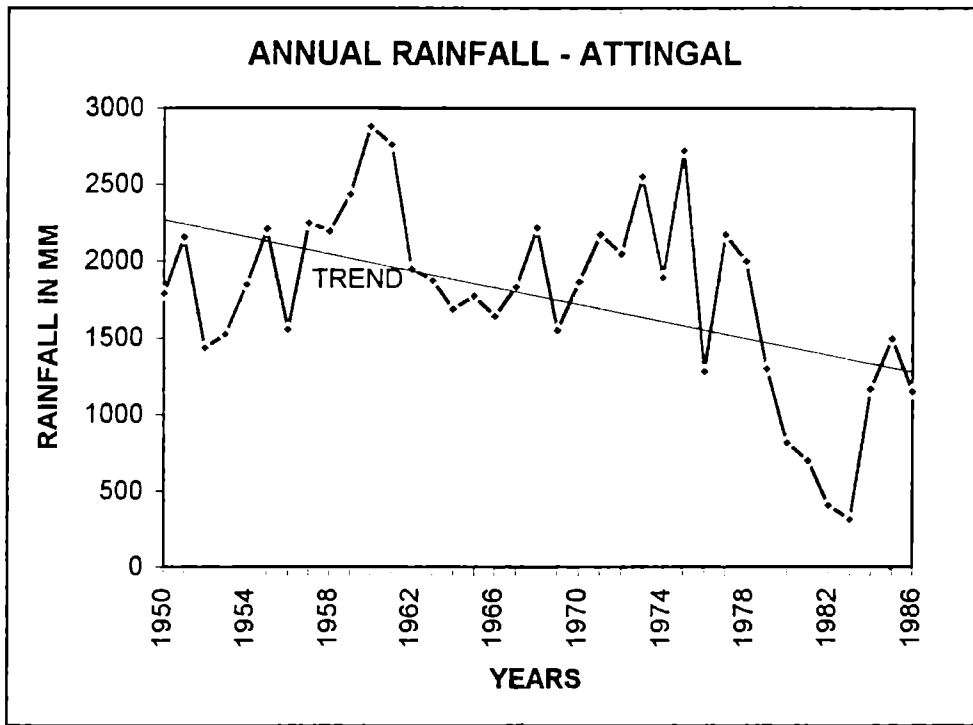


Fig. 4.3.10a. ANNUAL RAINFALL - ATTINGAL

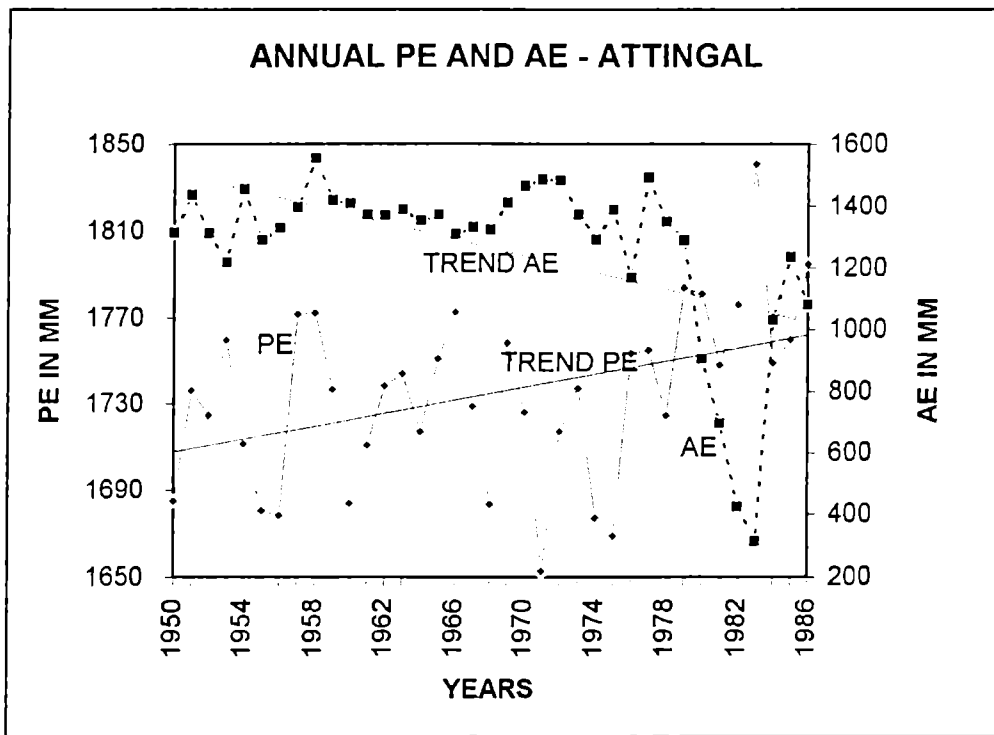


Fig. 4.3.10b. ANNUAL PE & AE - ATTINGAL

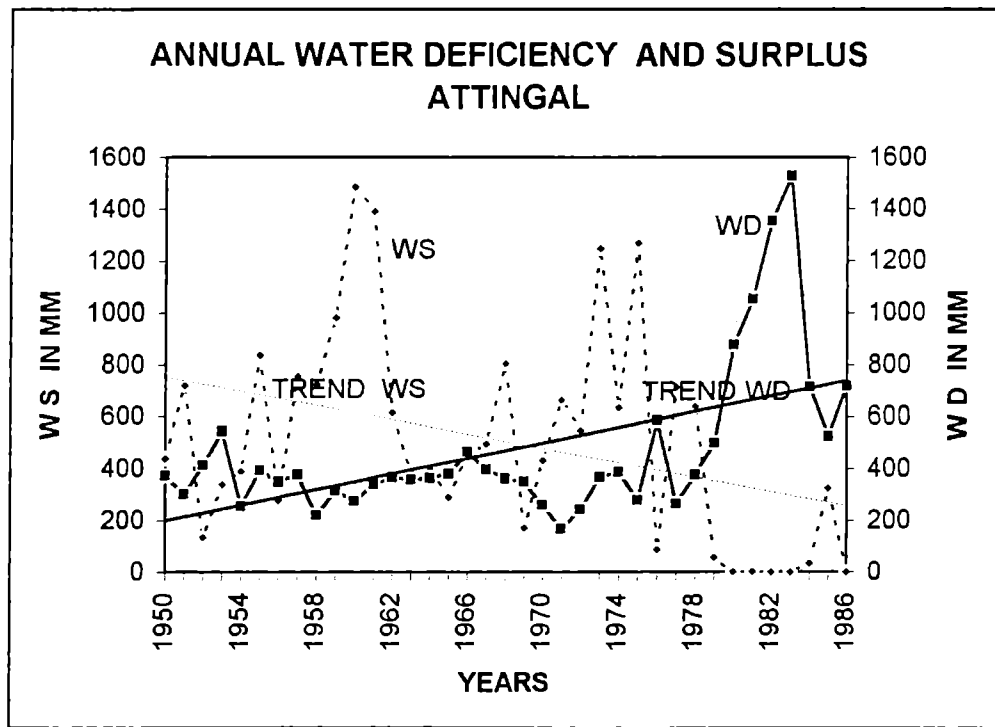


Fig. 4.3.10c. ANNUAL WD & WS - ATTINGAL



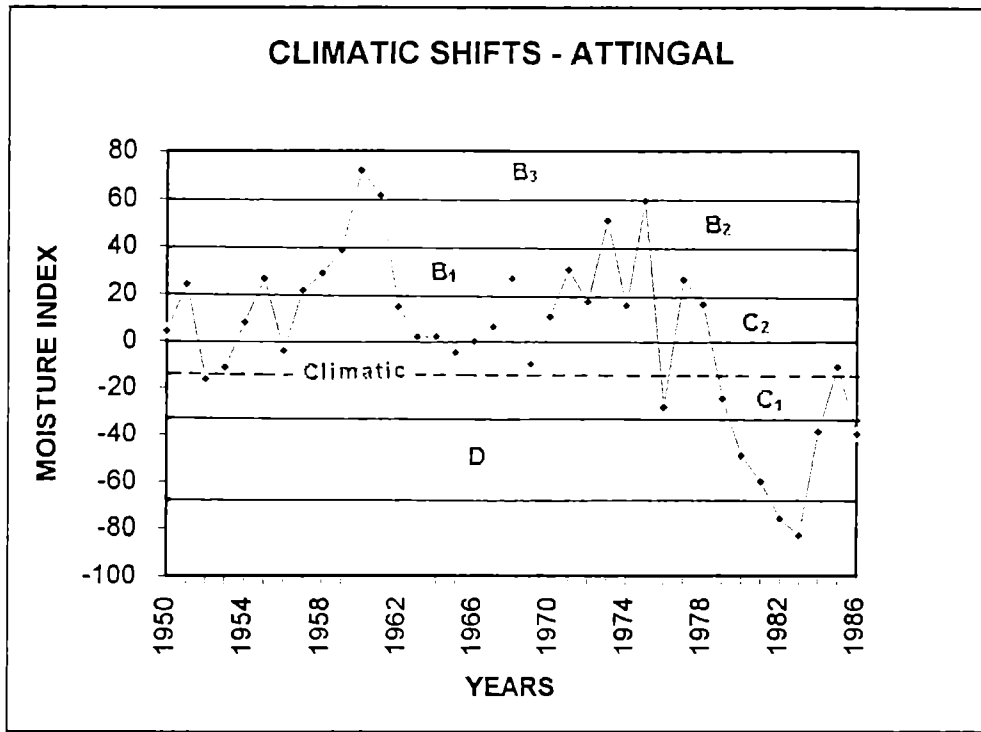


Fig. 4.3.10d. CLIMATIC SHIFTS - ATTINGAL

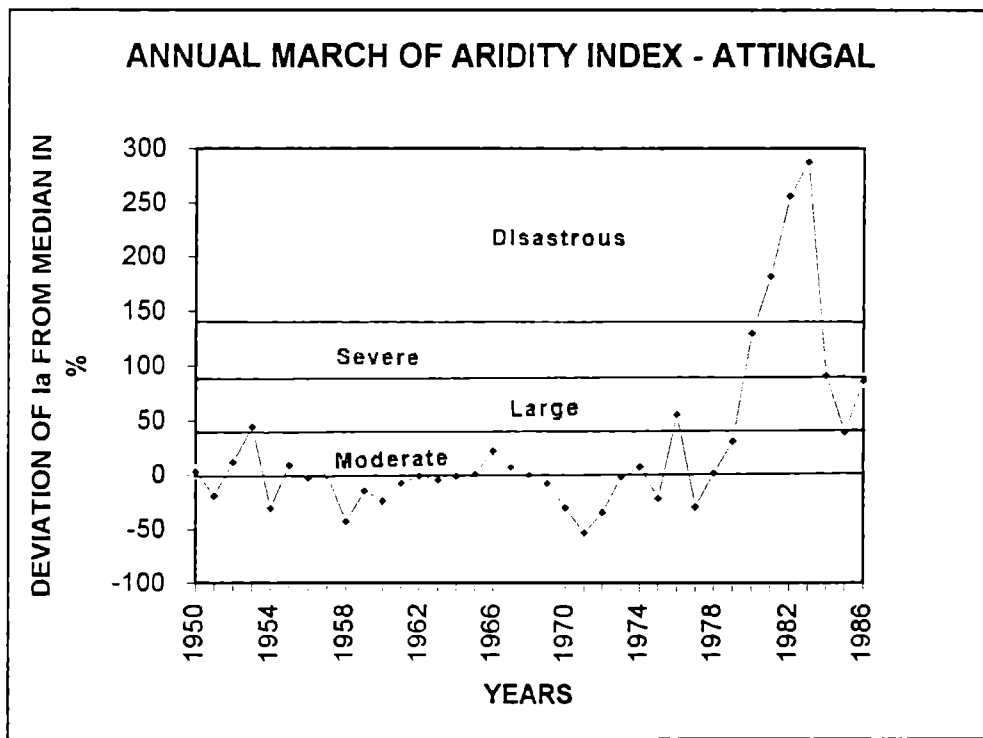


Fig. 4.3.10e. ANNUAL MARCH OF ARIDITY INDEX  
ATTINGAL

1980-1986. It is also evident that about 50% of the years had drought conditions of different magnitudes.

#### 4.3.11. THIRUVANANTHAPURAM

Thiruvananthapuram is located at  $8^{\circ} 29'$  N and  $76^{\circ} 57'$  E. It receives 1821 mm. of mean annual rainfall. Though there were wide fluctuations in the annual rainfall during the period 1950-1980, no trend is observed. (Fig.4.3.11a). However, during this period, 18 years recorded below normal rainfall. The highest rainfall received in Thiruvananthapuram was 2419 mm. the year 1961, and the lowest was 1127 mm. in 1976.

The annual water need (PE) shows an increasing trend, while the AE shows no trend. (Fig.4.3.11b). The highest PE recorded in Thiruvananthapuram was 1753 mm.- 1979.

The years 1961 and 1976 showed maximum annual water surplus and deficit respectively. (Fig.4.3.11c). During the years 1956, 1969 and 1976, the annual water surplus was zero.

Thiruvananthapuram experiences moist sub-humid type of climate ( $C_2$ ). With the fluctuations in annual rainfall the climate shifted between humid ( $B_3$ ) to semi-arid (D) type. (Fig.4.3.11d). During the period 1950-1980, 9 years experienced shifts towards dry sub-humid type ( $C_1$ ), 13 years experienced shift towards moist sub-humid and 7 years shifted to wetter humid side (B). (Fig.4.3.11d).

The analysis of droughts experienced in Thiruvananthapuram reveals that there were 17 drought years of different magnitudes during the period of 31 years of investigation. The highest water deficit year 1976 experienced disastrous drought (Fig4.3.11e).

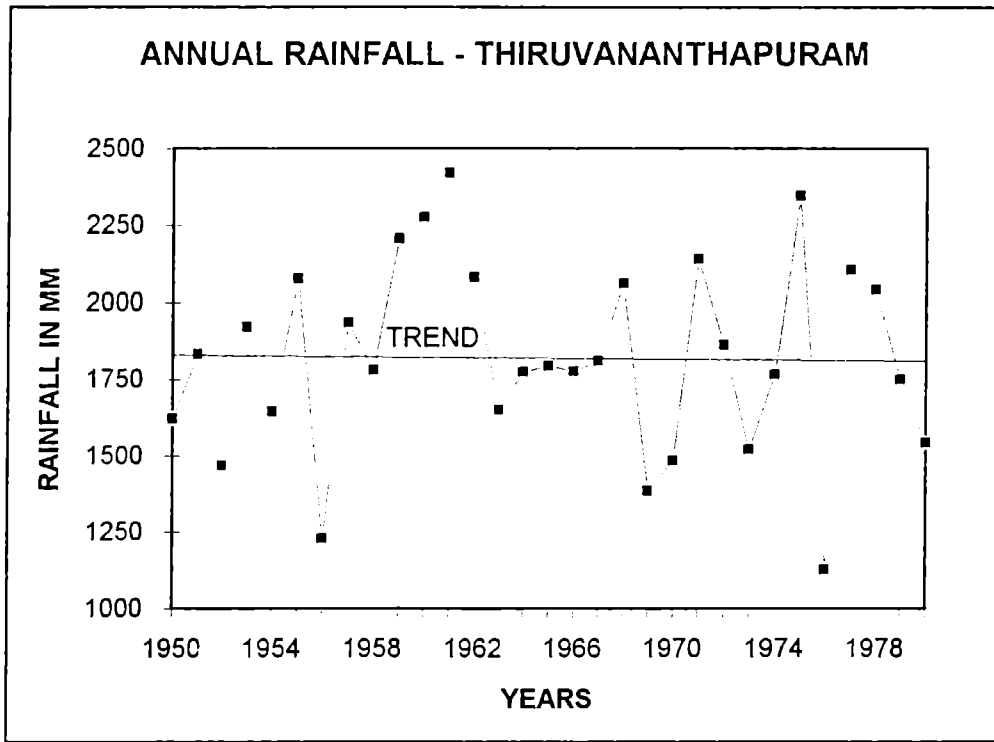


Fig. 4.3.11a. ANNUAL RAINFALL - THIRUVANANTHAPURAM

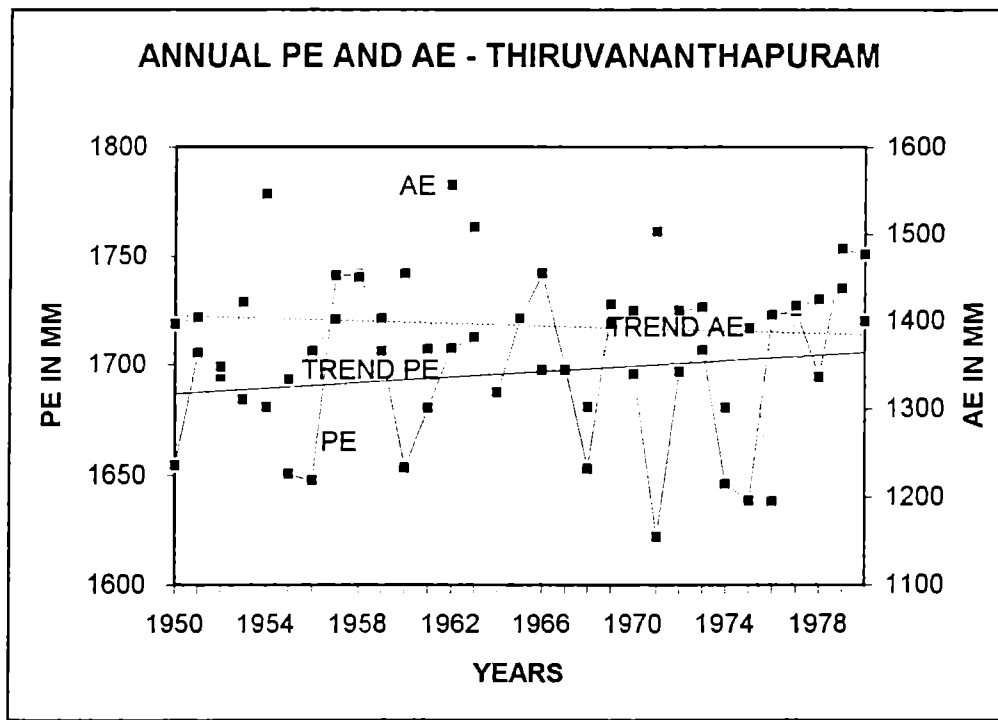


Fig. 4.3.11b. ANNUAL PE & AE - THIRUVANANTHAPURAM

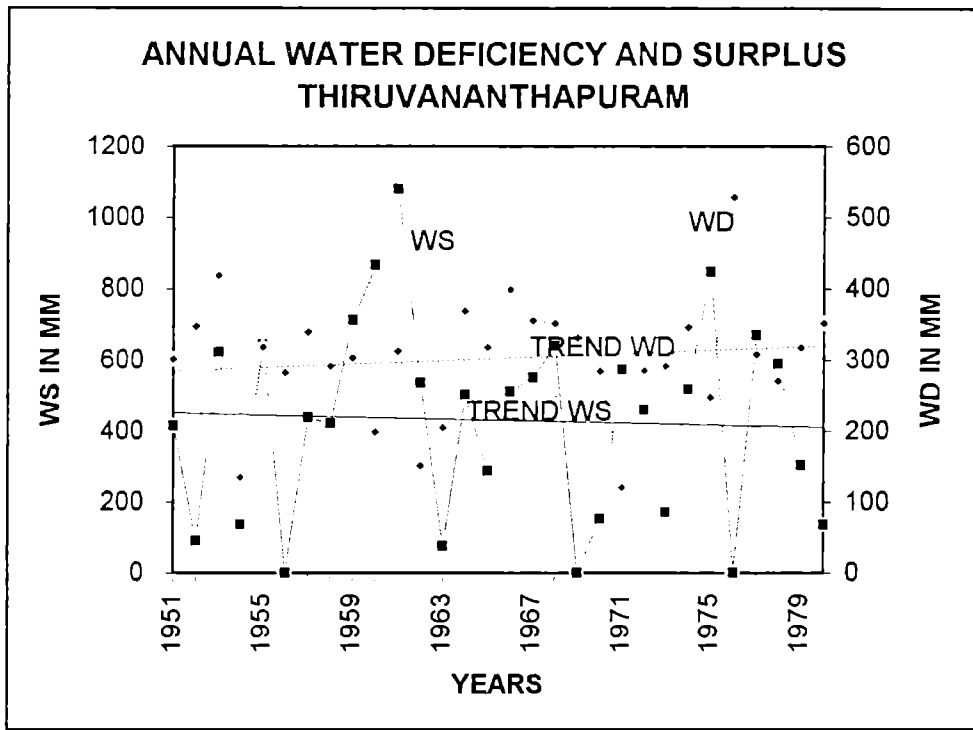


Fig. 4.3.11c. ANNUAL WD & WS - THIRUVANANTHAPURAM

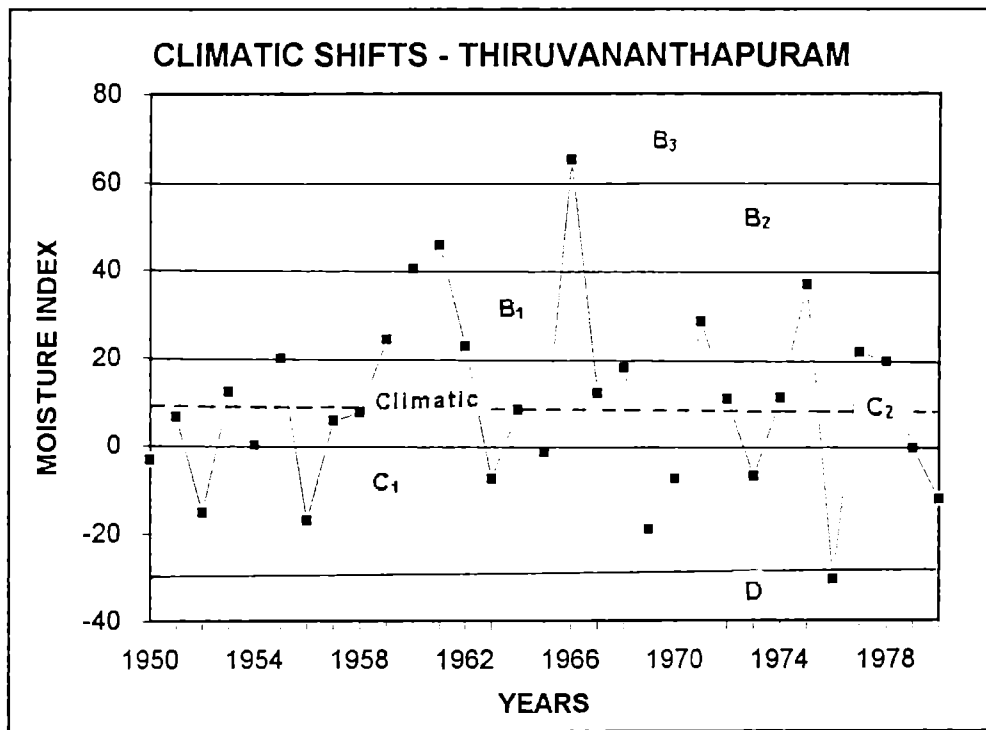


Fig. 4.3.11d. CLIMATIC SHIFTS - THIRUVANANTHAPURAM

## **D. HIGH ALTITUDE ZONE**

### **4.3.12. MANANTHAVADY**

Mananthavady is a highland station and is located at 11°48' N and 76° 01' E. The mean annual rainfall is 2582 mm. Having more than 50% of years below normal rainfall, a declining trend in the annual rainfall pattern can be noticed. (Fig.4.3.12a).

Like most of the stations, Mananthavady also has a n increasing trend in PE and decreasing trend in AE. (Fig.4.3.12b).

Marked increase in WD and decrease in WS is the main feature of its water balance. (Fig 4.3.12c).

It comparatively had fewer major climatic shifts. Majority of the shifts were towards upper humid side. (Fig.4.3.12d).

Although the total number of droughts was less, it experienced two disastrous and four severe droughts .There were also five moderate and seven large droughts during the period 1950-1986.(Fig.4.3.12e).

### **4.3.13. VYTHIRI**

This highland station located at 9°34' N and 76°59' E. receives 4143 mm of mean annual rainfall which is the second highest in Kerala, after Neriamangalam. The highest annual rainfall of 8259 mm.was recorded in 1961. Like many stations of Kerala, Vythiri also shows a declining trend. (Fig.4.3.13a).

The annual PE and AE values atVythiri indicate no trend. (Fig.4.3.13b).

Following the rainfall pattern the WS shows a declining trend , while the WD displays an increasing trend (Fig.4.3.13c). The abnormal year 1961 recorded highest WS.

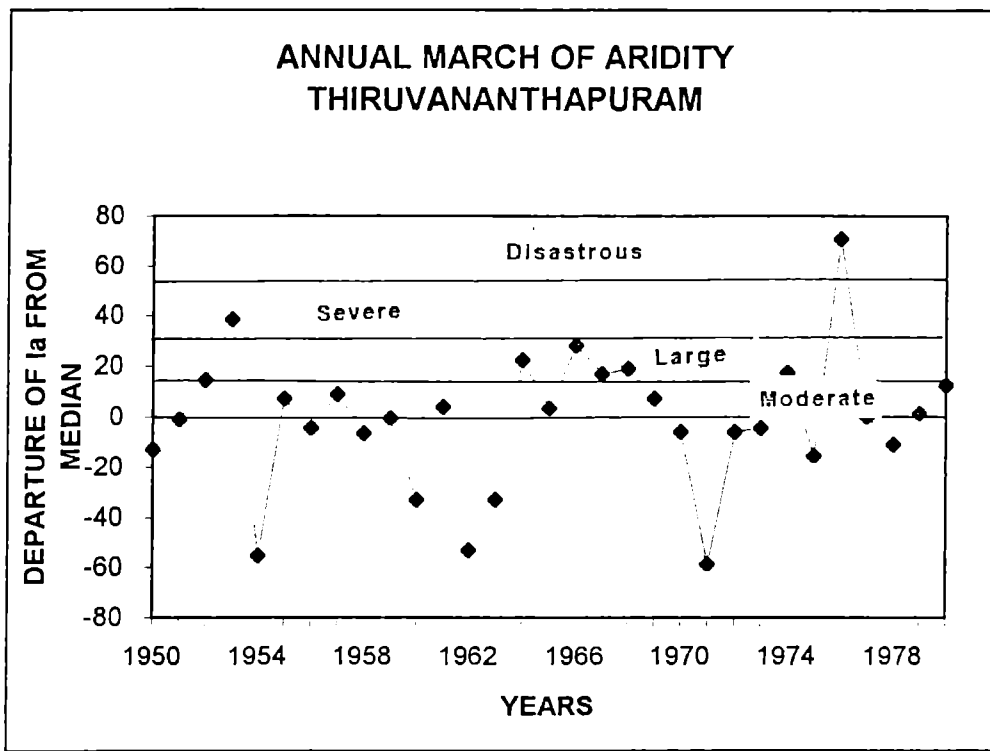


Fig. 4.3.11e. ANNUAL MARCH OF ARIDITY INDEX  
THIRUVANANTHAPURAM

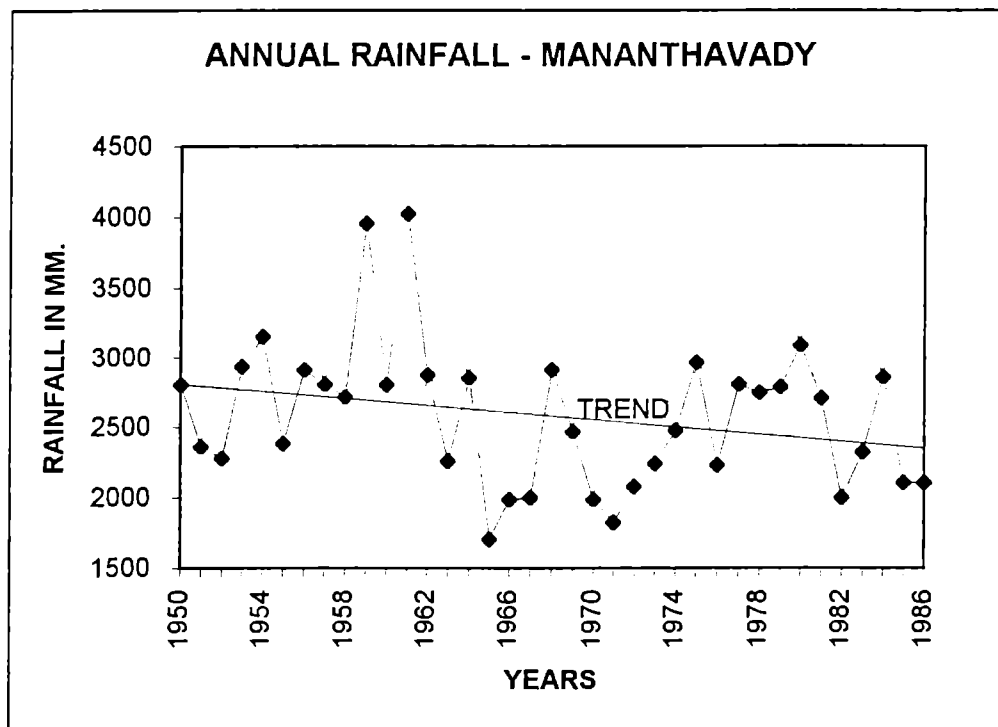


Fig. 4.3.12a. ANNUAL RAINFALL - MANANTHAVADY

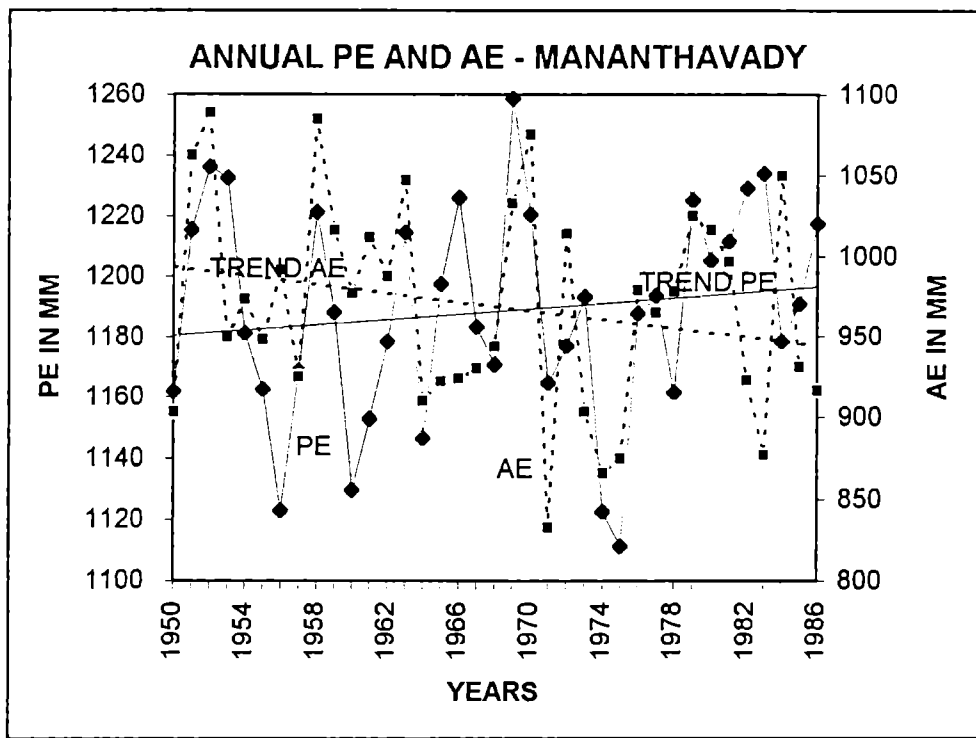


Fig. 4.3.12b. ANNUAL PE & AE - MANANTHAVADY

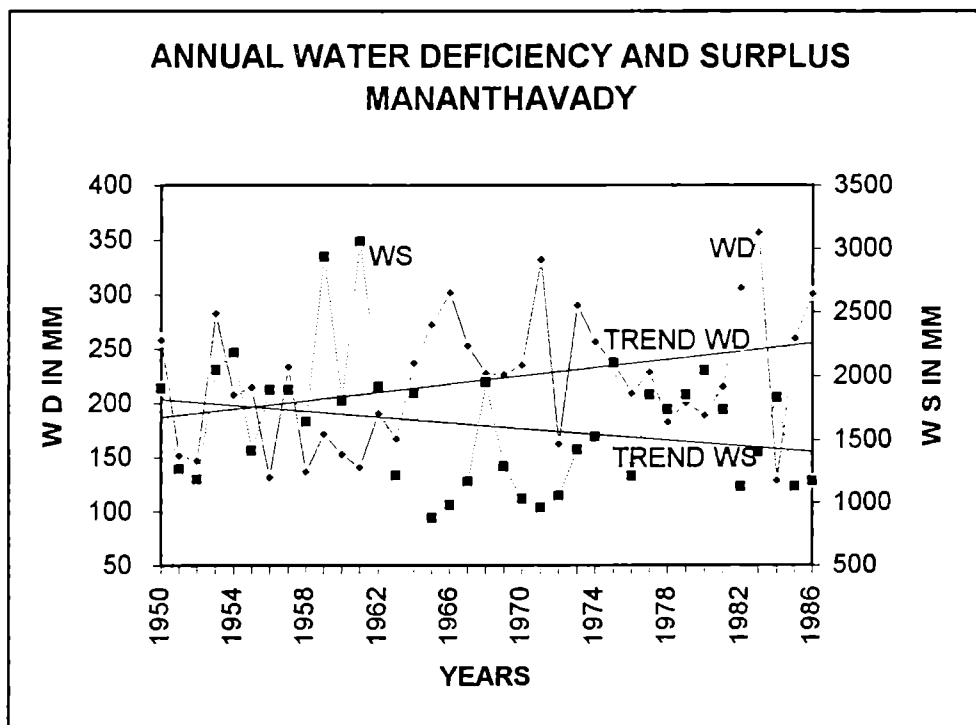


Fig. 4.3.12c. ANNUAL WD & WS - MANANTHAVADY

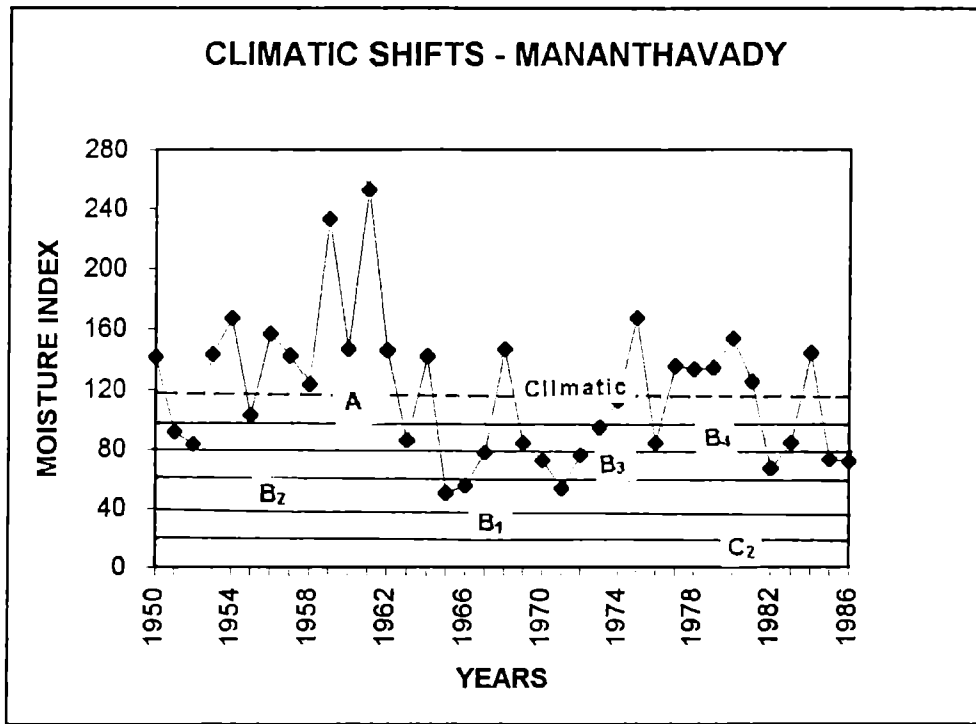


Fig. 4.3.12d. CLIMATIC SHIFTS - MANANTHAVADY

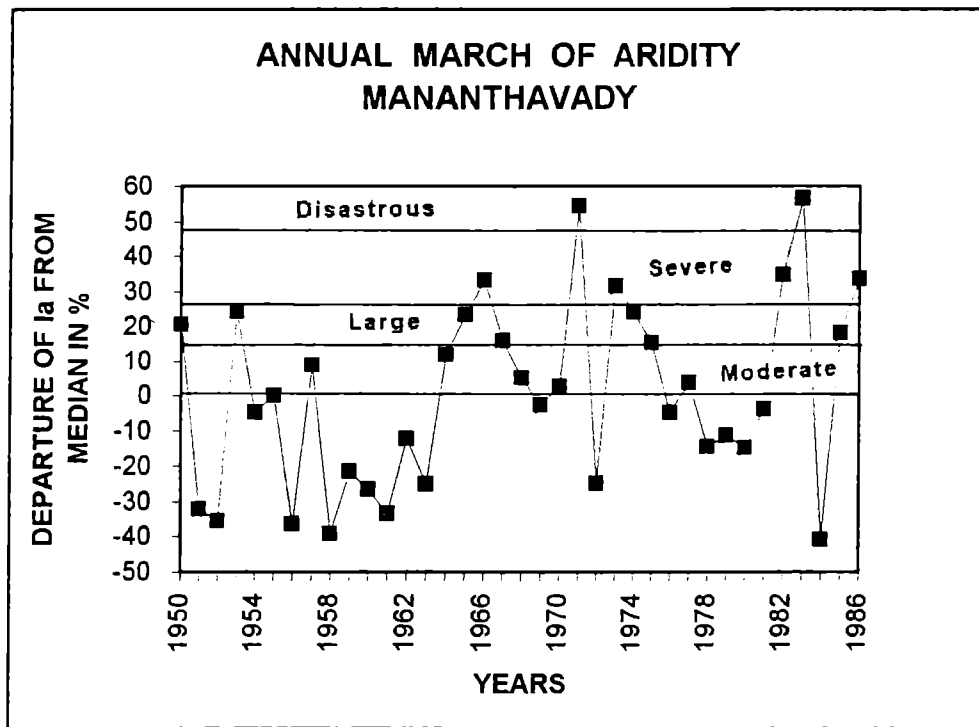


Fig. 4.3.12e. ANNUAL MARCH OF ARIDITY INDEX  
MANANTHAVADY



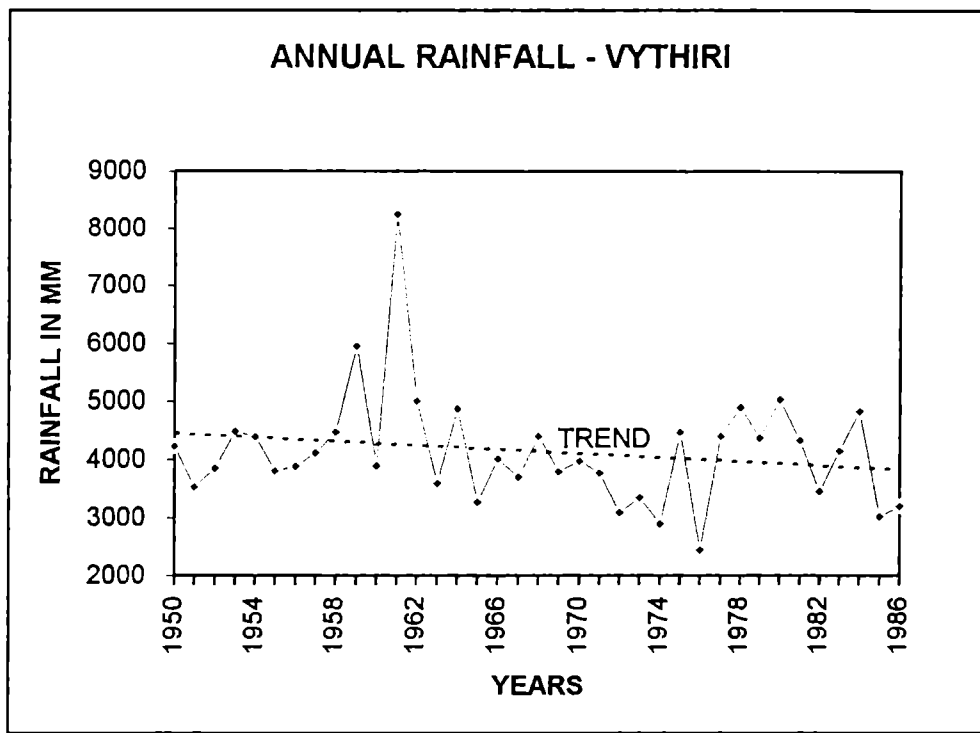


Fig. 4.3.13a. ANNUAL RAINFALL - VYTHIRI

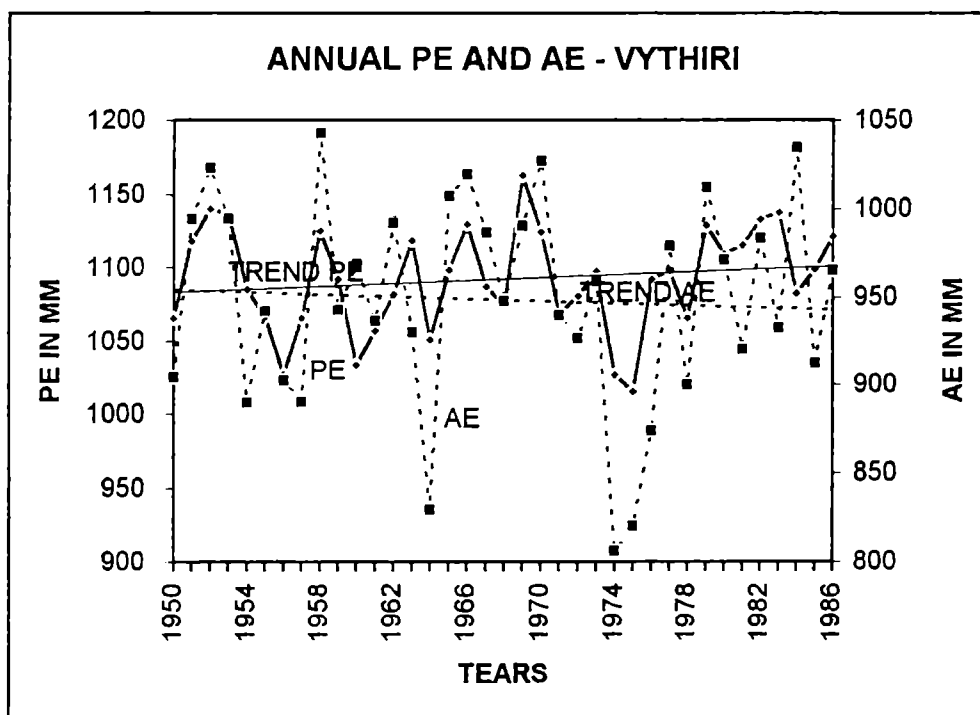


Fig. 4.3.13b. ANNUAL PE & AE - VYTHIRI

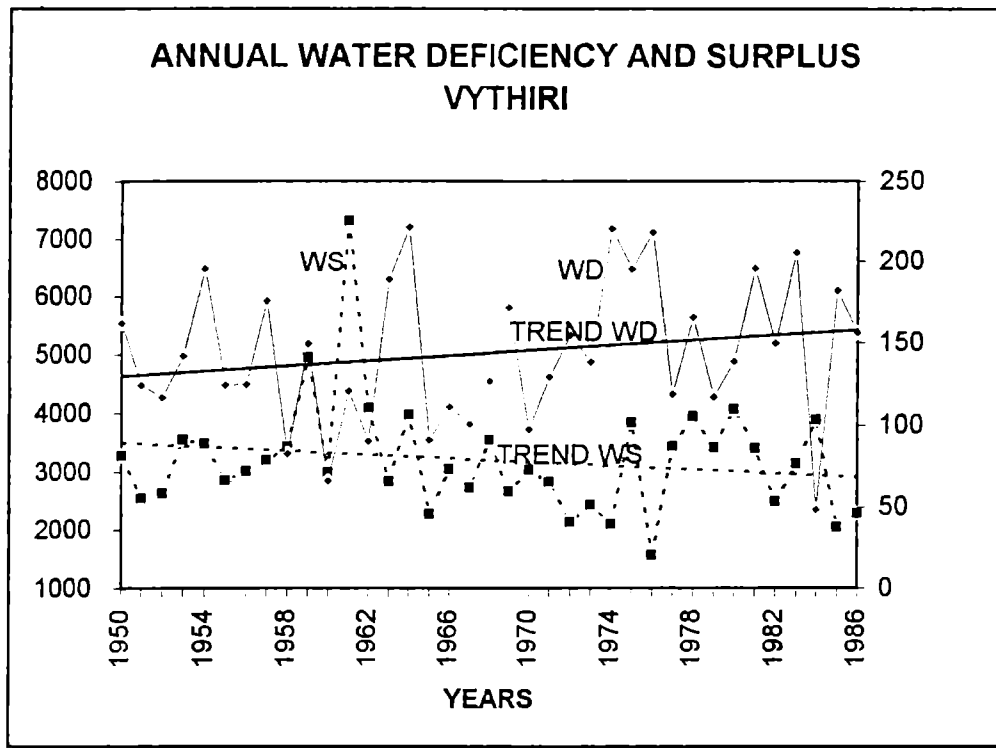


Fig. 4.3.13c. ANNUAL WD & WS - VYTHIRI

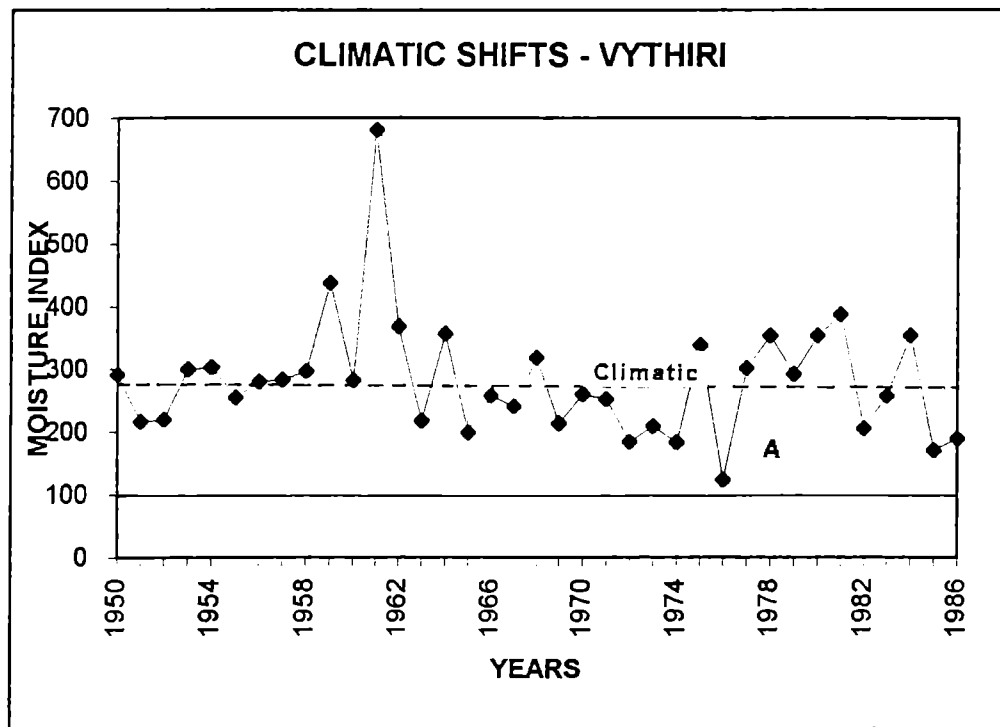


Fig. 4.3.13d. CLIMATIC SHIFTS - VYTHIRI

The moisture index value at Vythiri was always above 100, indicating the absence of any climatic shifts from its perhumid type.(Fig.4.3.13.d).

In contrast to this, the fluctuations in rainfall caused drought conditions in Vythiri also. (Fig.4.3.13e). There were even two disastrous and six severe droughts. Moderate and large droughts were comparatively less.

#### **4.3.14. MARAYOOR**

Marayoor is located in the rain shadow region of Kerala at 10<sup>0</sup>16' N and 77<sup>0</sup>09' E. It receives 1332 mm. of annual rainfall. In contrast to other stations in Kerala, Marayoor shows an increasing trend in annual rainfall pattern. (Fig. 4.3.14a). The highest rainfall of Marayoor was recorded in the year 1970, when the annual value was 2668 mm.

Like Devikulam, Marayoor also shows an increasing trend in PE and AE. (Fig. 4.3.14b).

Marayoor is the only station in Kerala which shows increase in WS and Decrease in WD. (Fig. 4.3.14c).

Marayoor experiences a humid (B<sub>1</sub>) type of climate. This fluctuated between semi-arid and perhumid type during the period 1950-1980. (Fig. 4.3.14d). Majority of the shifts were within the humid type. Climate shifted to semi-arid type in 1962 and 1963, and to perhumid type in 1970.

Moderate drought conditions prevailed over Marayoor in 11 years, apart from 2 severe and 1 disastrous droughts. (Fig. 4.3.14e).

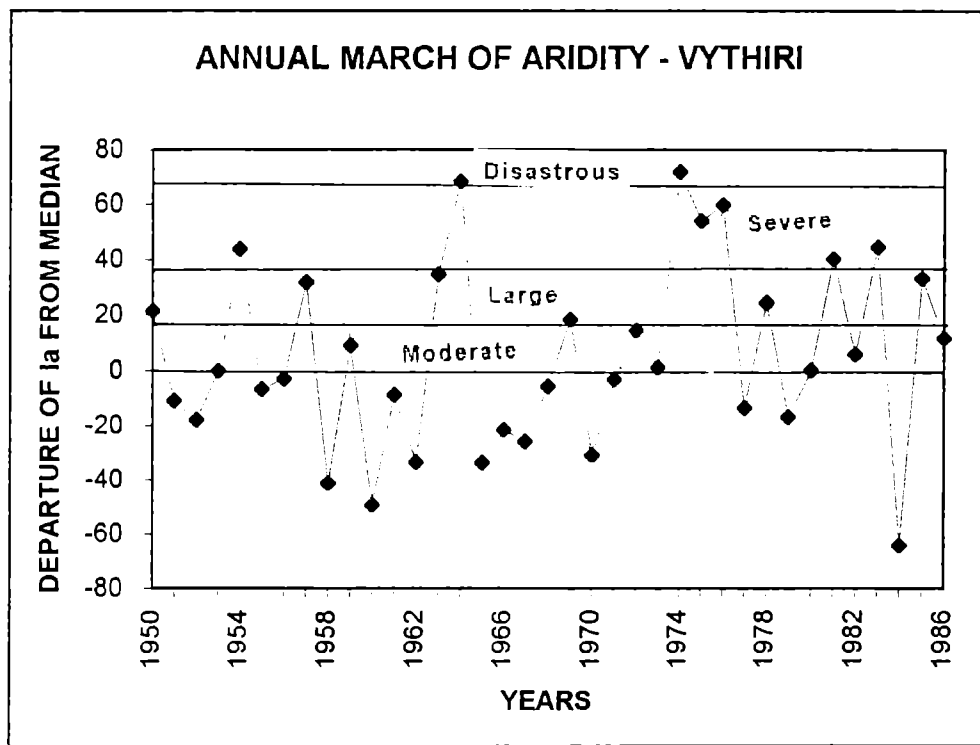


Fig. 4.3.13e. ANNUAL MARCH OF ARIDITY INDEX - VYTHIRI

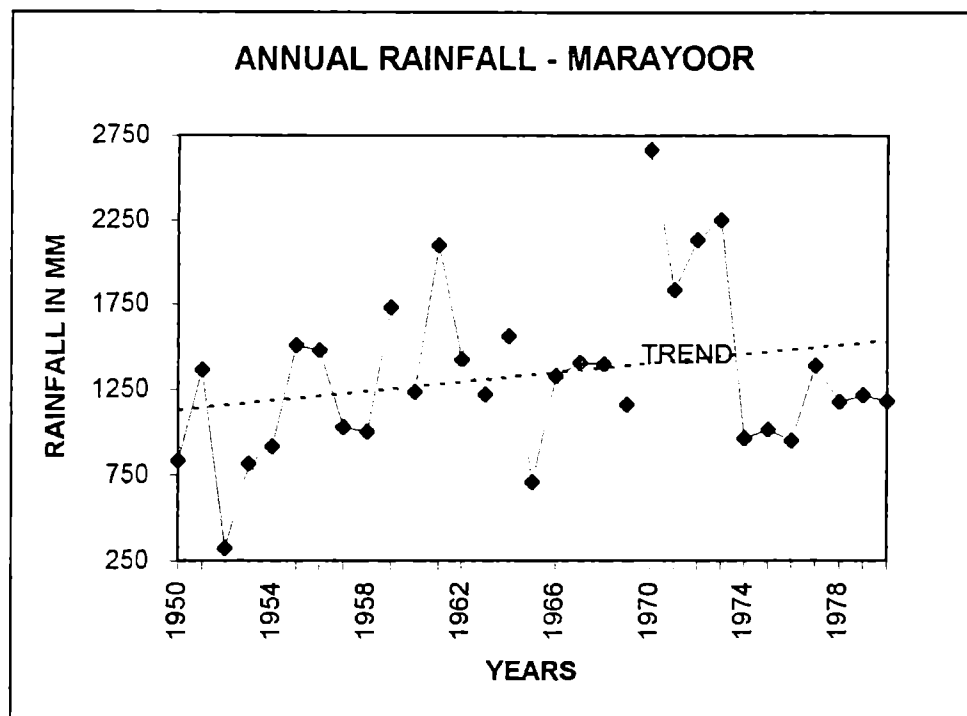


Fig. 4.3.14a. ANNUAL RAINFALL - MARAYOOR

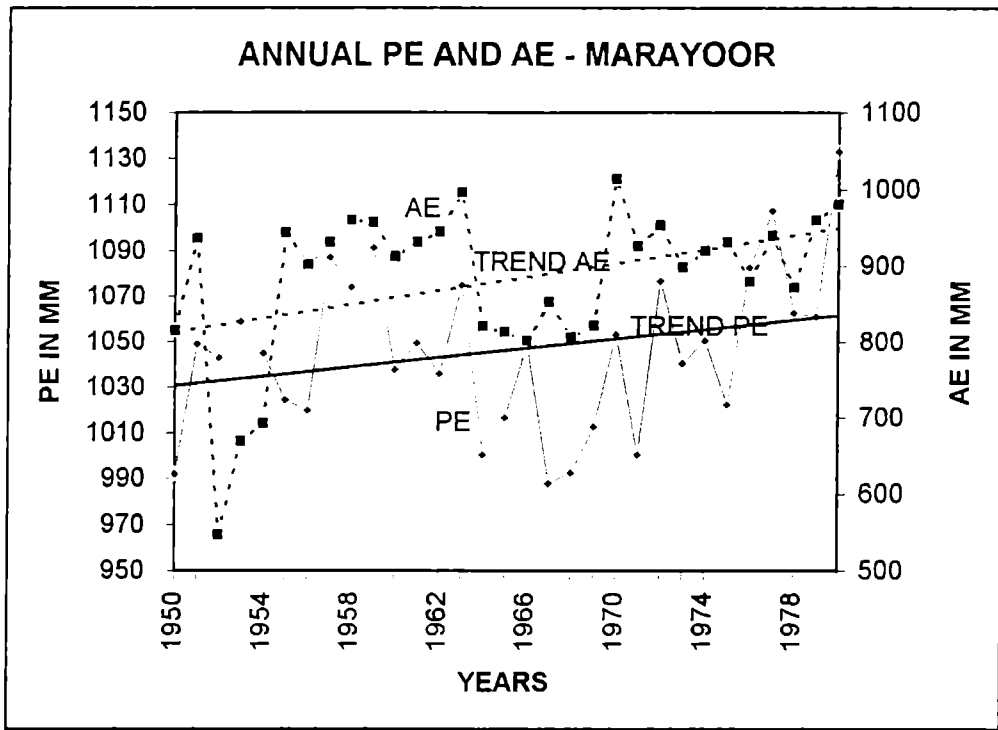


Fig. 4.3.14b. ANNUAL PE & AE - MARAYOOR

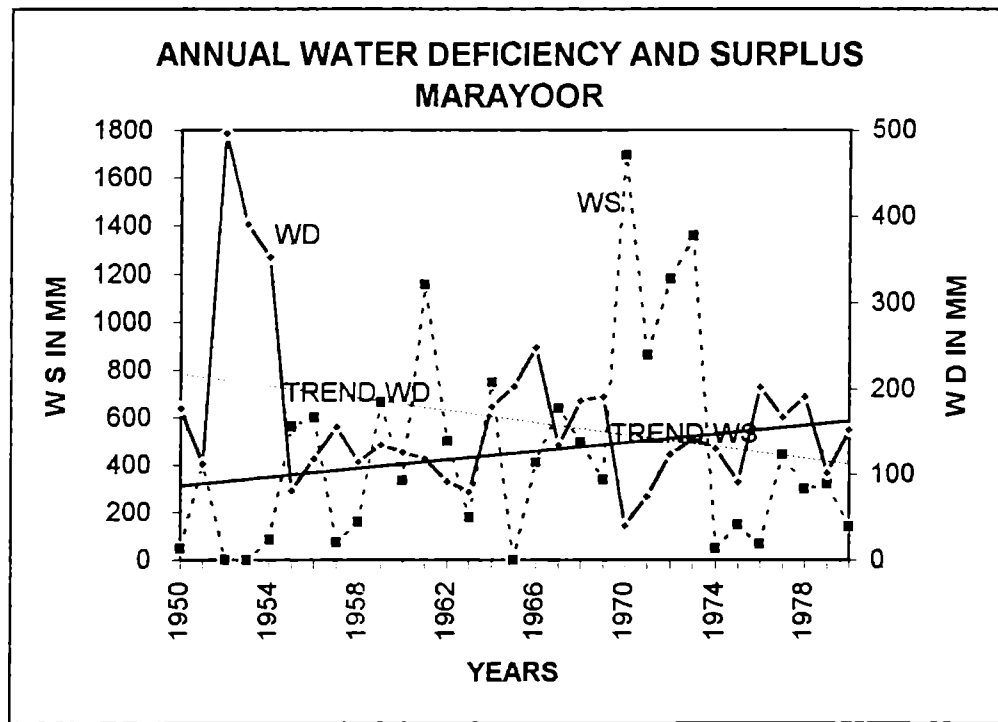


Fig. 4.3.14c. ANNUAL WD & WS - MARAYOOR

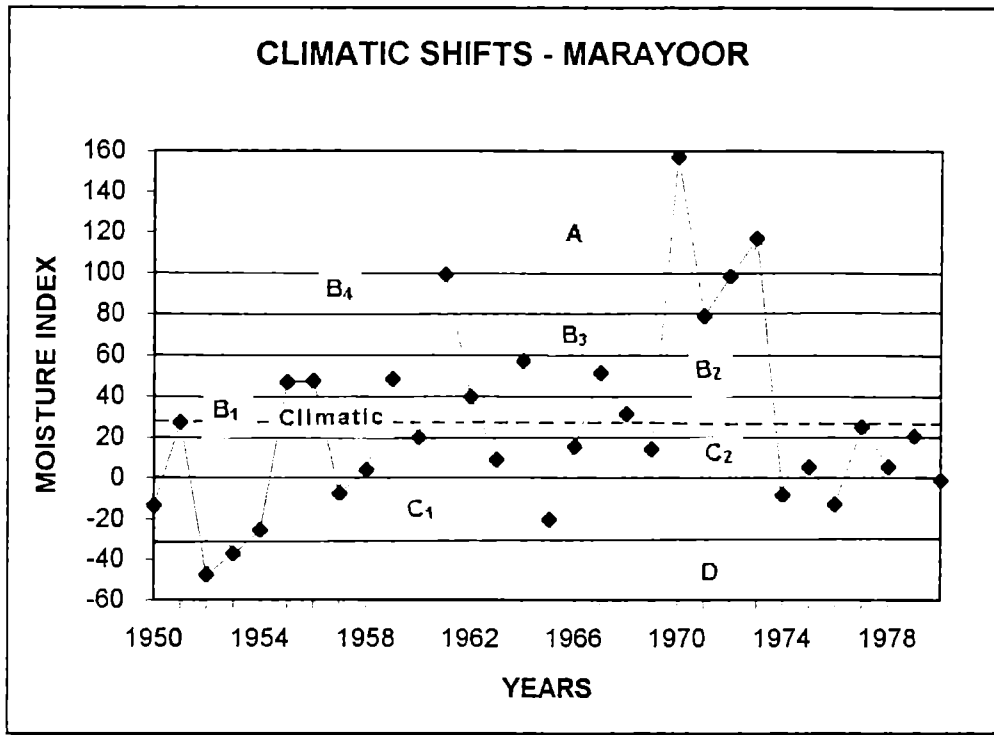


Fig. 4.3.14d. CLIMATIC SHIFTS - MARAYOOR

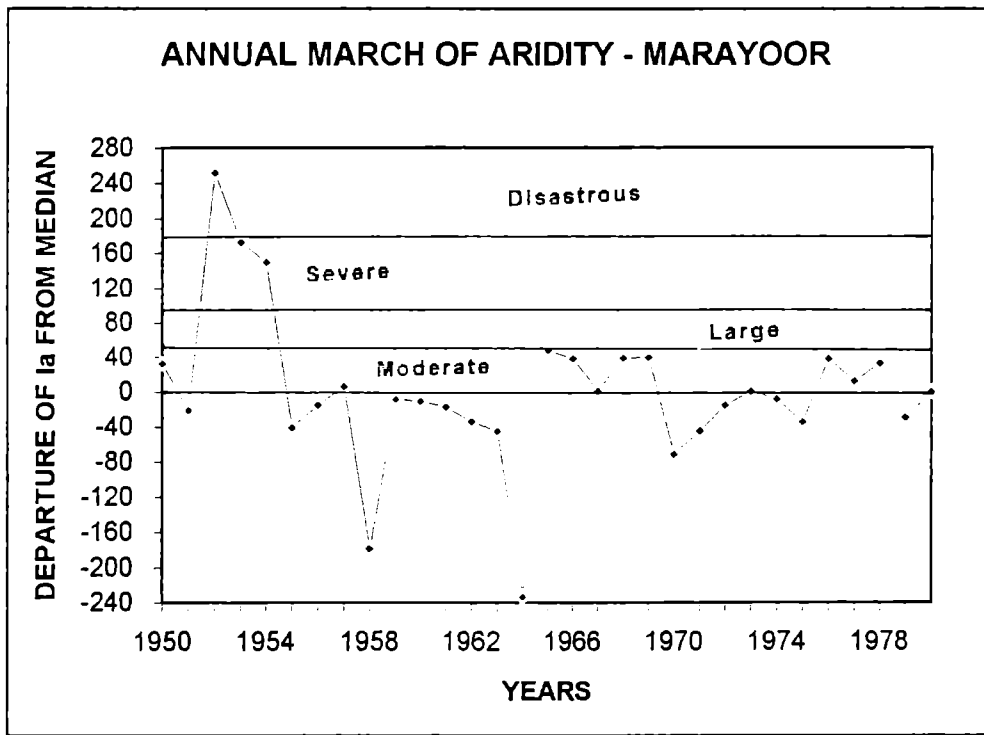


Fig. 4.3.14e. ANNUAL MARCH OF ARIDITY INDEX  
MARAYOOR

#### 4.3.15. DEVIKULAM

Devikulam also is a highland station and is located at  $10^{\circ} 04'$  N and  $77^{\circ} 06'$  E. It receives an annual rainfall of 2526 mm. Although 15 years during the period 1950-1980 had below normal rainfall in Devikulam, the annual pattern does not show any trend.(Fig.4.3.15a).

The Actual Evapotranspiration and the Potential Evapotranspiration show a slight increasing trend. (Fig.4.2.15b).

Though, the mean annual water deficit is comparatively less in Devikulam, it shows an increasing trend. (Fig.4.3.15.c). Devikulam also experiences comparatively high water surplus.

Devikulam experiences a perhumid type of climate. Absence of any major shift in climate is a conspicuous feature of Devikulam. Only one year, 1967, shifted to  $B_3$  type.(Fig. 4.3.15d).

Fig. 4.2.15e shows the annual march of aridity index in Devikulam. It is obvious that even though there were no major climatic shifts, the inter-annual variations of rainfall caused drought conditions, even of disastrous magnitude. The year 1968 experienced a severe drought and 1969 had a disastrous drought. There were also 8 moderate droughts, of which 6 were consecutive years from 1972, and 5 large droughts in Devikulam during the period 1950-1980.

#### 4.3.16. KARIKODE

Karikode is located at  $9^{\circ} 50'$  N and  $76^{\circ} 40'$  E. The mean annual rainfall of Karikode is 3086 mm. Marked declining trend in the annual rainfall is evident from the Fig.4.3.16a. 15 years

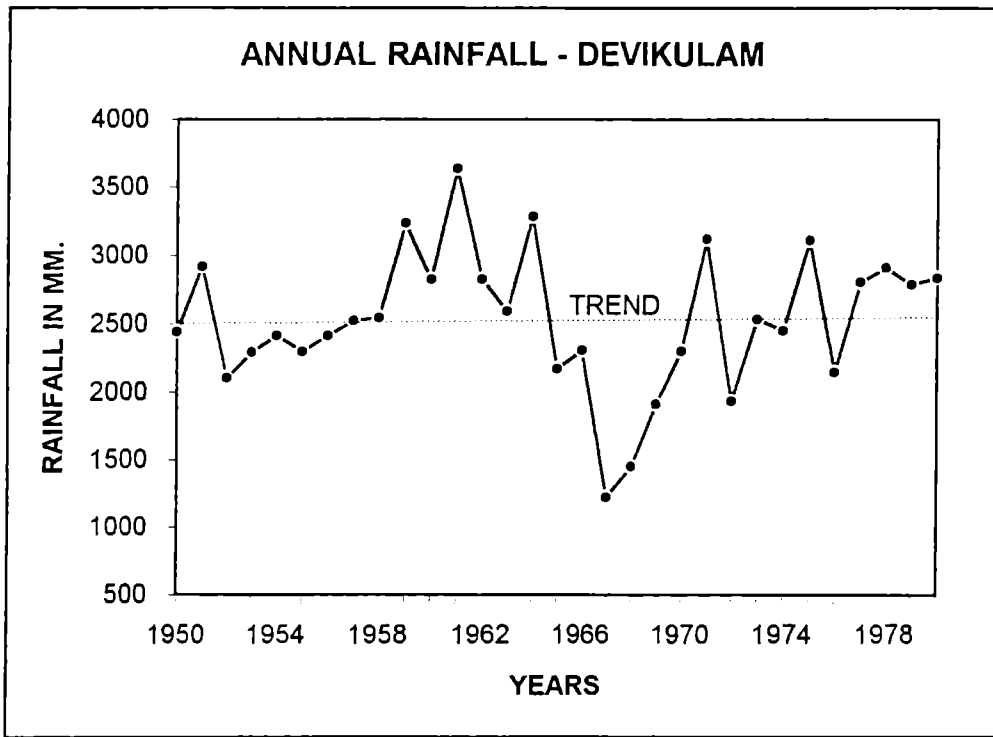


Fig. 4.3.15a. ANNUAL RAINFALL - DEVIKULAM

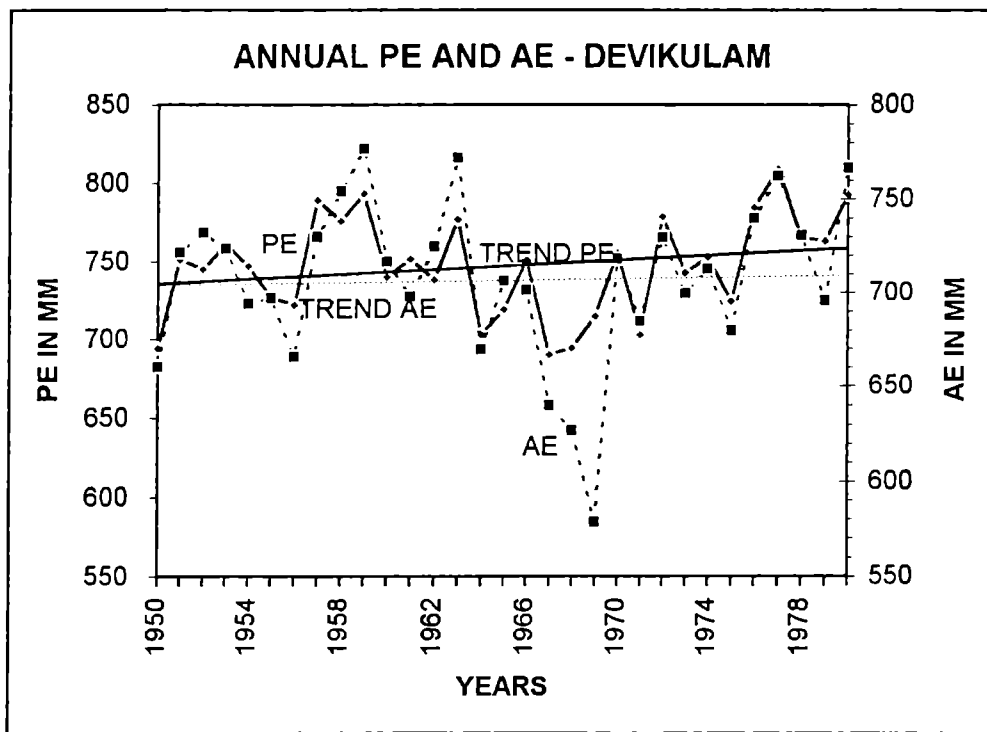


Fig. 4.3.15b. ANNUAL PE & AE - DEVIKULAM



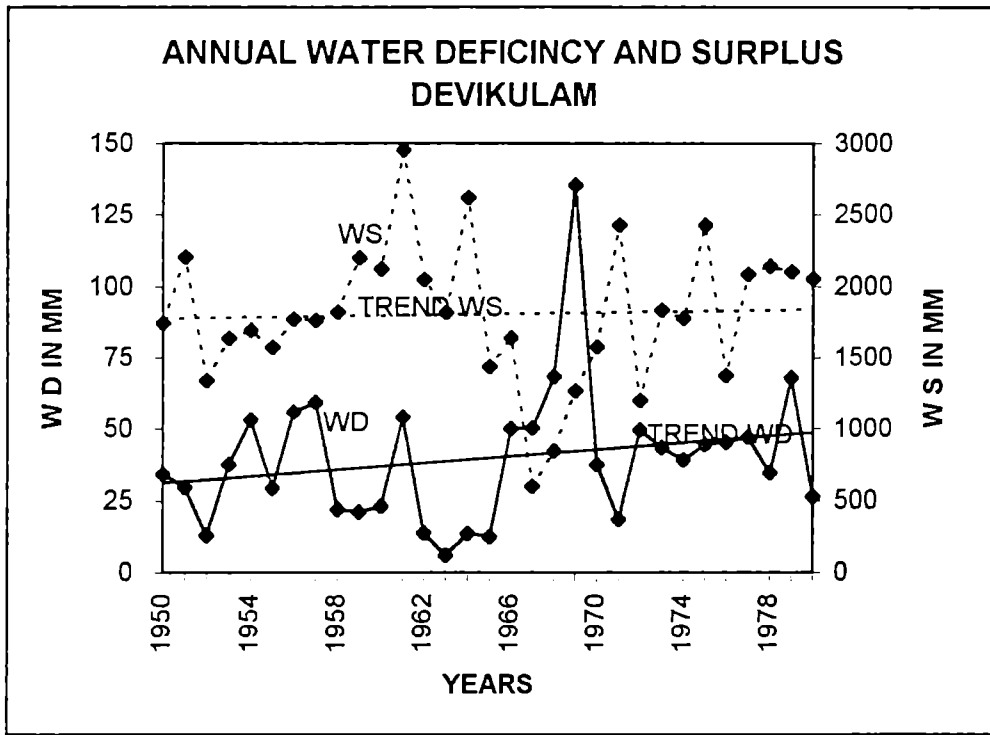


Fig. 4.3.15c. ANNUAL WD & WS - DEVIKULAM

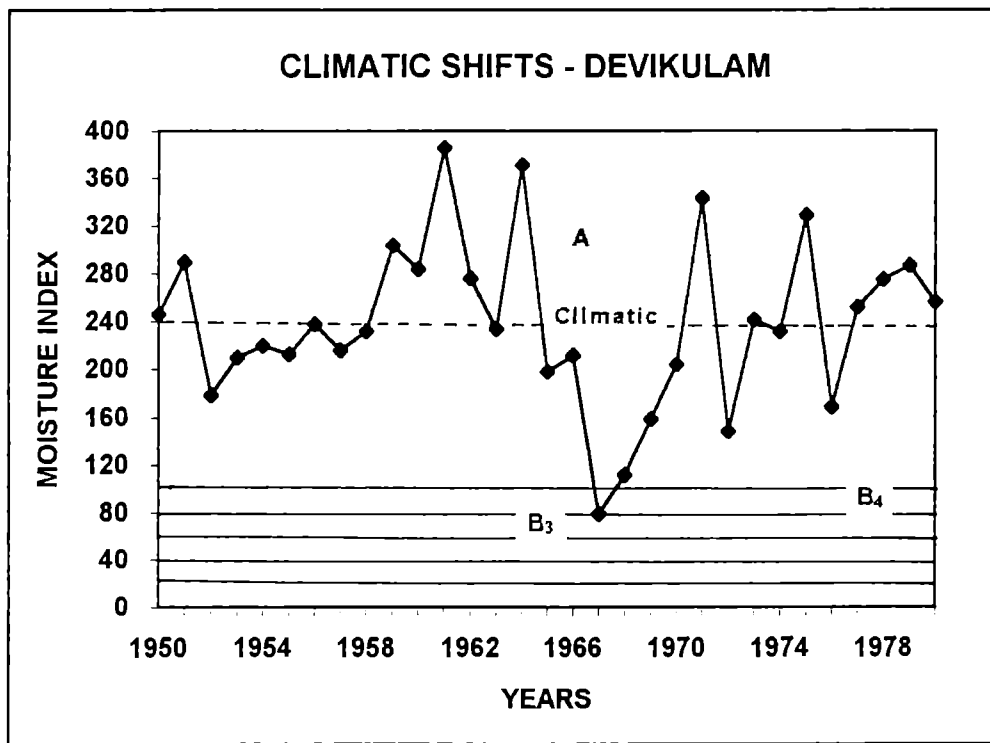


Fig. 4.3.15d. CLIMATIC SHIFTS - DEVIKULAM

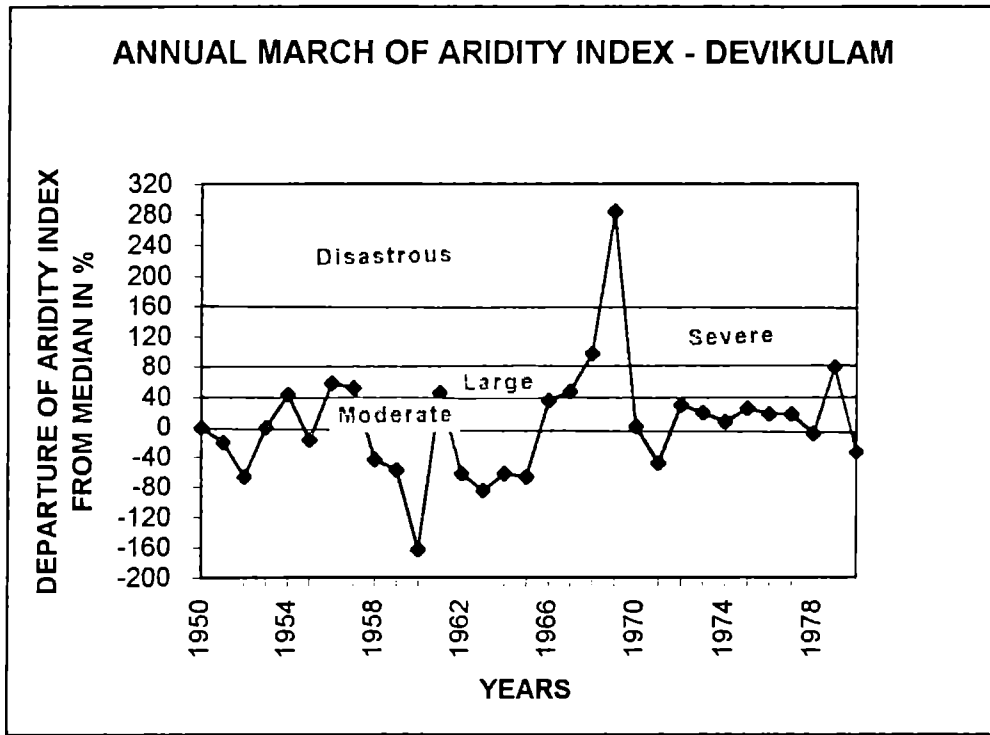


Fig. 4.3.15e. ANNUAL MARCH OF ARIDITY INDEX  
DEVIKULAM

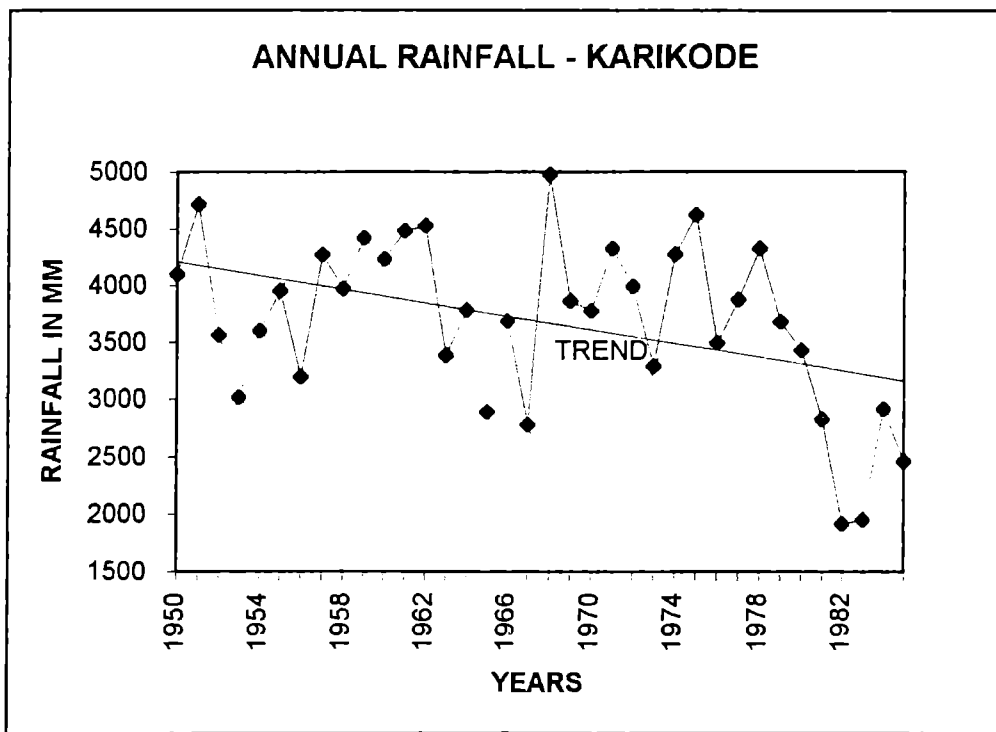


Fig. 4.3.16a. ANNUAL RAINFALL - KARIKODE

during the period 1950-1985 received below normal rainfall, the lowest being 1919 mm. in 1982.

One peculiarity of Karikode is that there were no wide fluctuations in the annual PE, even though it shows an increasing trend. Contrary to other stations, where the AE shows a decreasing trend, Karikode displays an increasing trend. (Fig.4.3.16b).

With the increasing PE and declining rainfall, the annual water surplus is bound to decrease. This is clearly visible in Karikode also.(Fig.4.3.16c). The water surplus varied between 536 mm to 3432 mm. Although there are wide fluctuations in the water deficit, it shows no trend.

Karikode experiences a perhumid type of climate. In most of the years the shifts were within the perhumid type.(Fig.4.3.16d). A progressive shift towards drier side is noticed from 1978 onwards.

Like Vandanmedu, Karikode also had a few droughts. (Fig.4.3.16e). There were only two severe and two disastrous droughts in Karikode during the period 1950-1985.

#### **4.3.17. VANDANMEDU**

This highland station is located at  $9^{\circ} 43'N$  and  $77^{\circ} 08'E$ . It receives 2018 mm. mean annual rainfall. Even though there were wide fluctuations in the annual rainfall, no trend is noticed in its pattern. (Fig.4.3.17a). Annual rainfall was lowest (1253mm.) in the year 1967, and the highest (2873 mm.) was recorded in the year 1961. Vandanmedu received below normal rainfall during 13 years in the period 1950-1980.

Vandanmedu also shows an increasing trend in PE, while

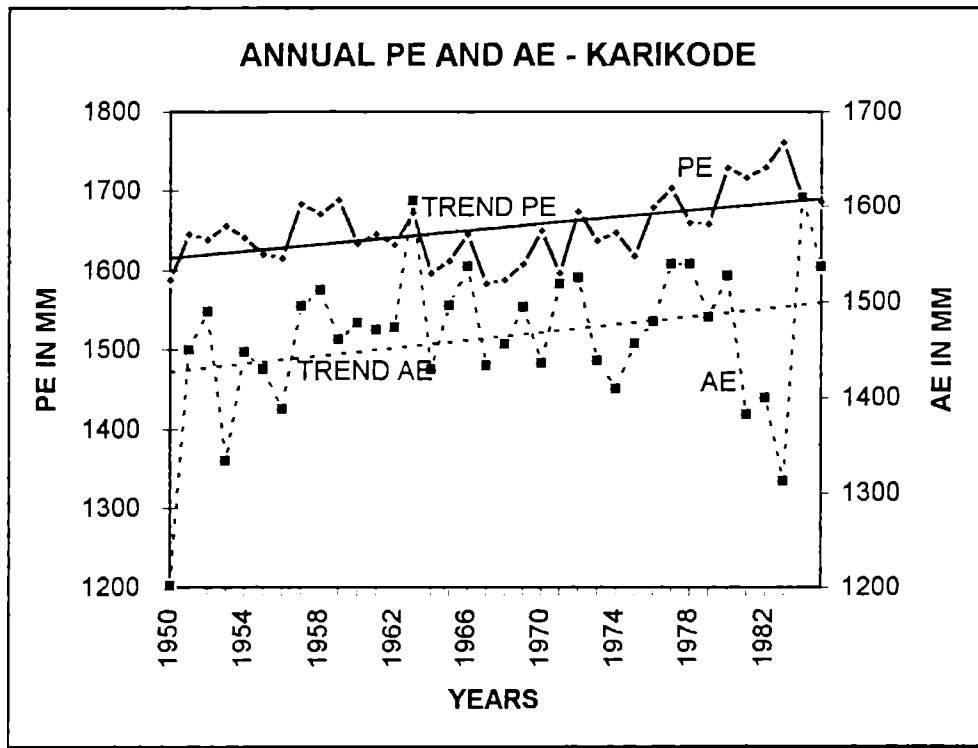


Fig. 4.3.16b. ANNUAL PE & AE - KARIKODE

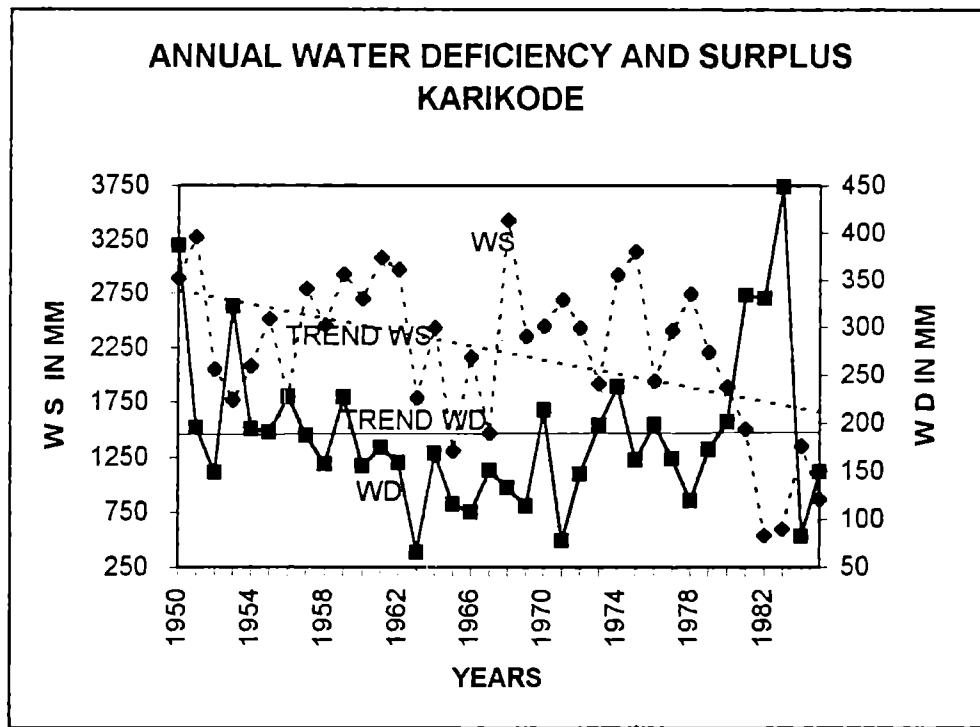


Fig. 4.3.16c. ANNUAL WD & WS - KARIKODE

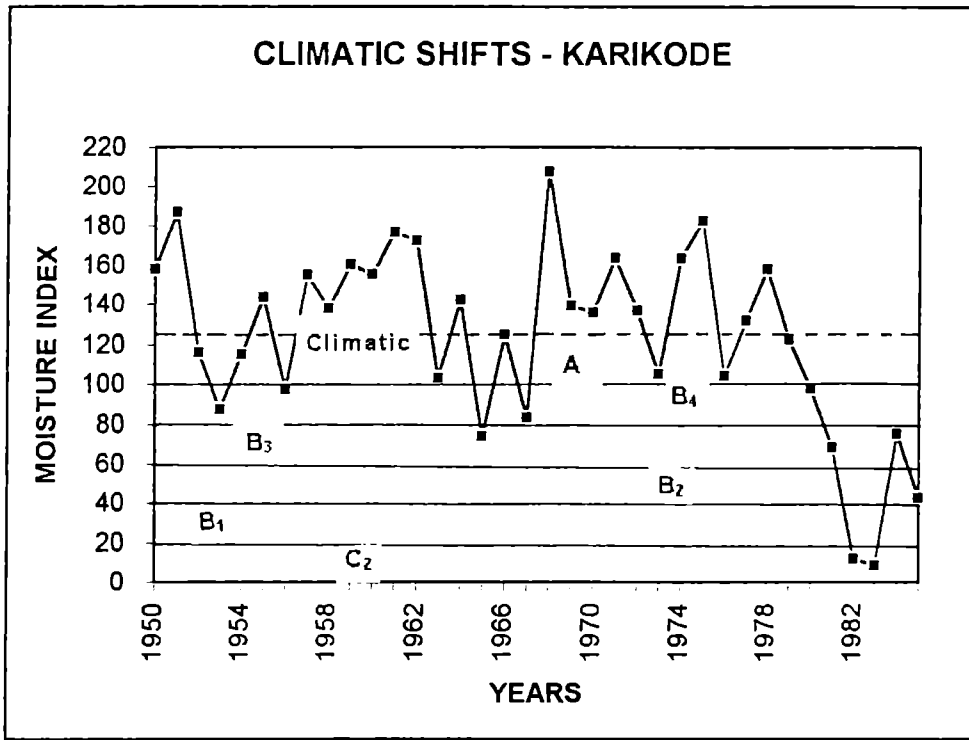


Fig. 4.3.16d. CLIMATIC SHIFTS - KARIKODE

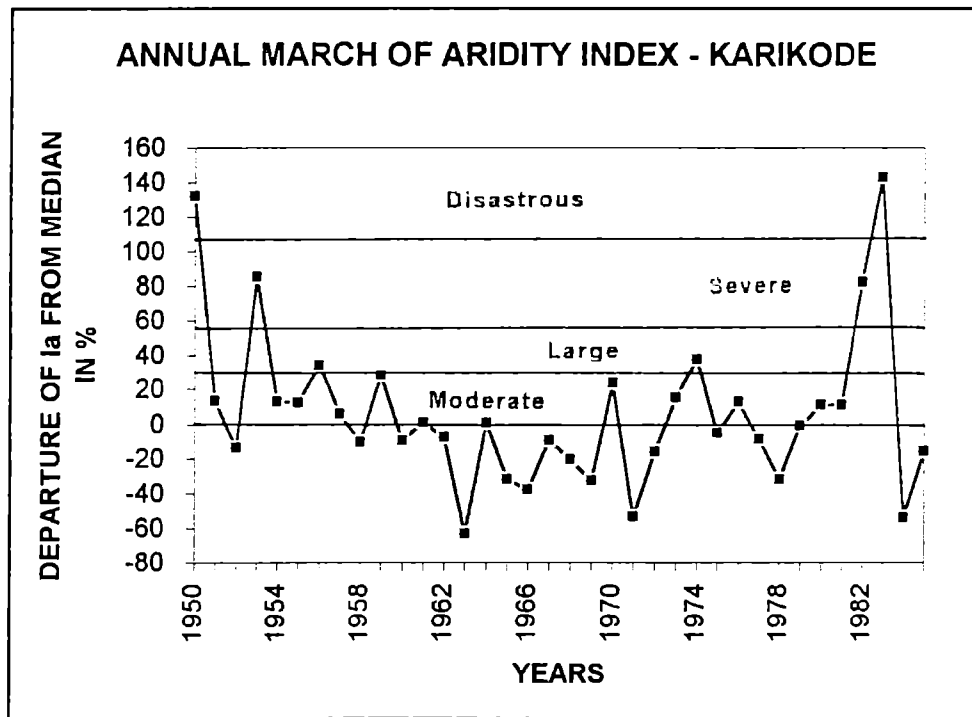


Fig. 4.3.16e. ANNUAL MARCH OF ARIDITY INDEX  
KARIKODE

the AE displays no trend. (Fig.4.3.17b). The year 1980 had the highest water need (1133 mm).

The annual water deficiency of Vandanmedu is increasing (Fig.4.3.17c), while the WS shows no trend.

A humid type of climate prevails in Vandanmedu. It is obvious from Fig.4.3.17d that most of the climatic shifts experienced by Vandanmedu is within the sub categories of B type. 14 years experienced shift towards per humid type.

There were no disastrous droughts in Vandanmedu. The total number of droughts was also comparatively low here, only 7 moderate, 2 large, and 6 severe droughts. (Fig.4.3.17e).

#### **4.3.18. PEERMED.**

Located at 9<sup>0</sup>34' N and 76<sup>0</sup>59' E, Peermed has a perhumid type of climate. It receives a high mean annual rainfall of 4094 mm..(Fig.4.3.18a). Very high rainfall (8426 mm.), was recorded in the year 1968.

The annual PE of Peermed displays an increasing trend, while the AE shows no trend.(Fig.4.3.18b). Conspicuous increasing trend of WS and decreasing trend of WD is obvious from Fig.4.2.18c. Consequent on receiving highest amount of annual rainfall, the year 1968 had the highest water surplus.

The noticeable feature at Peermed is the absence of any climatic shifts. The moisture index value fluctuated between 142 and 779, indicating that all the years had per humid type of climate.(Fig.4.3.18d). Since the mean moisture index value is 301, these fluctuations are enough to create drought conditions even of disastrous magnitude. (Fig.4.3.18e). There were 13 disastrous droughts in Peermed during the period 1950-1986.

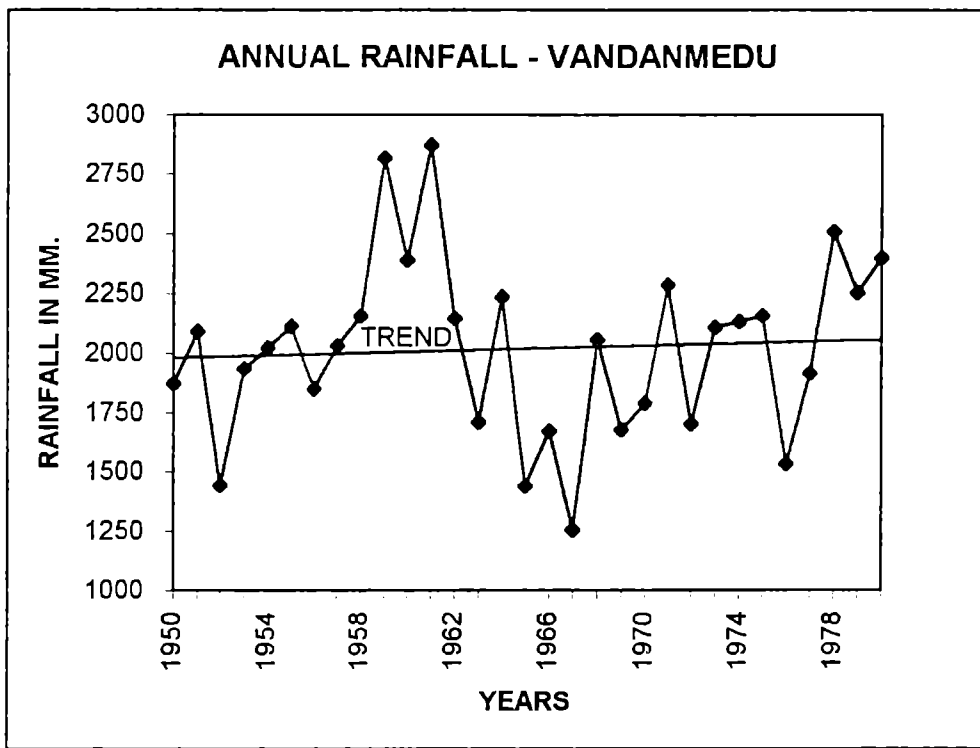


Fig. 4.3.17a. ANNUAL RAINFALL - VANDANMEDU

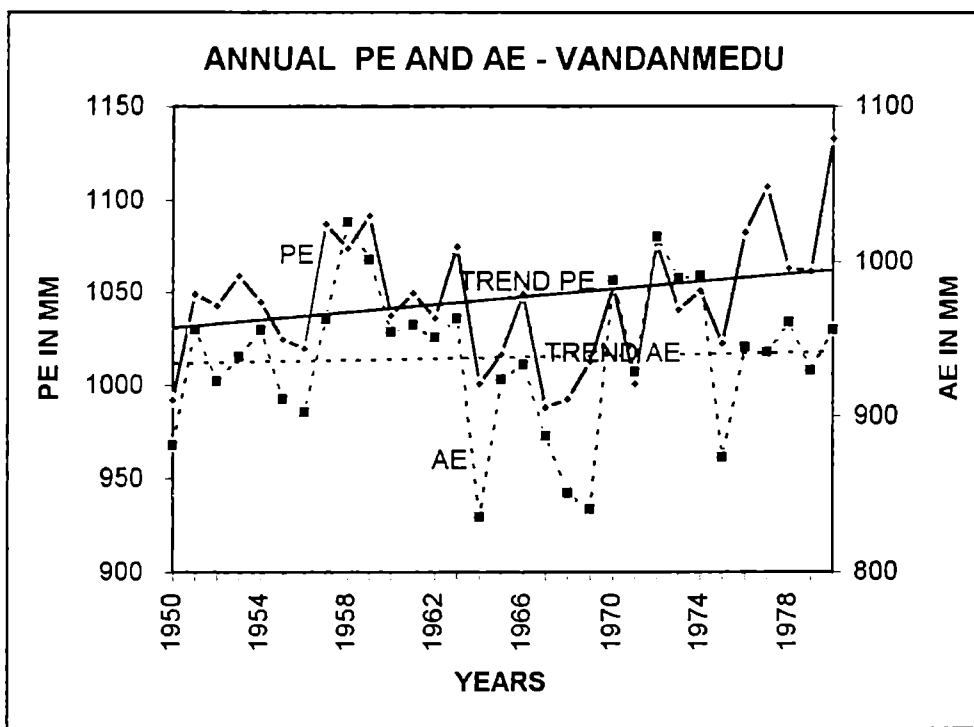


Fig. 4.3.17b. ANNUAL PE & AE - VANDANMEDU

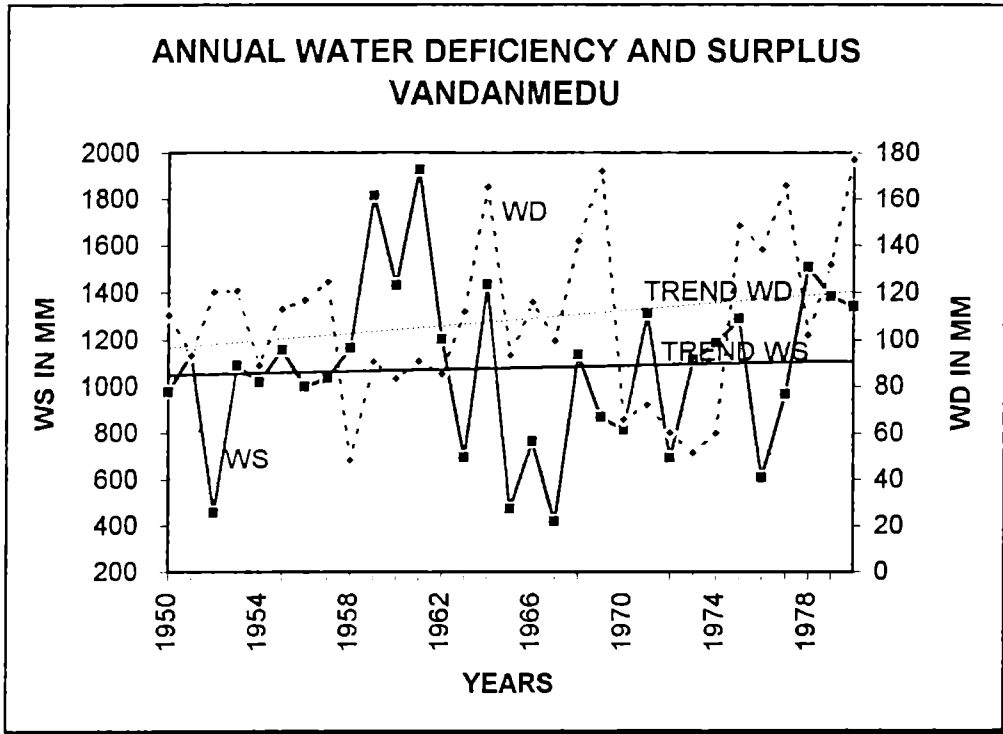


Fig. 4.3.17c. ANNUAL WD & WS - VANDANMEDU

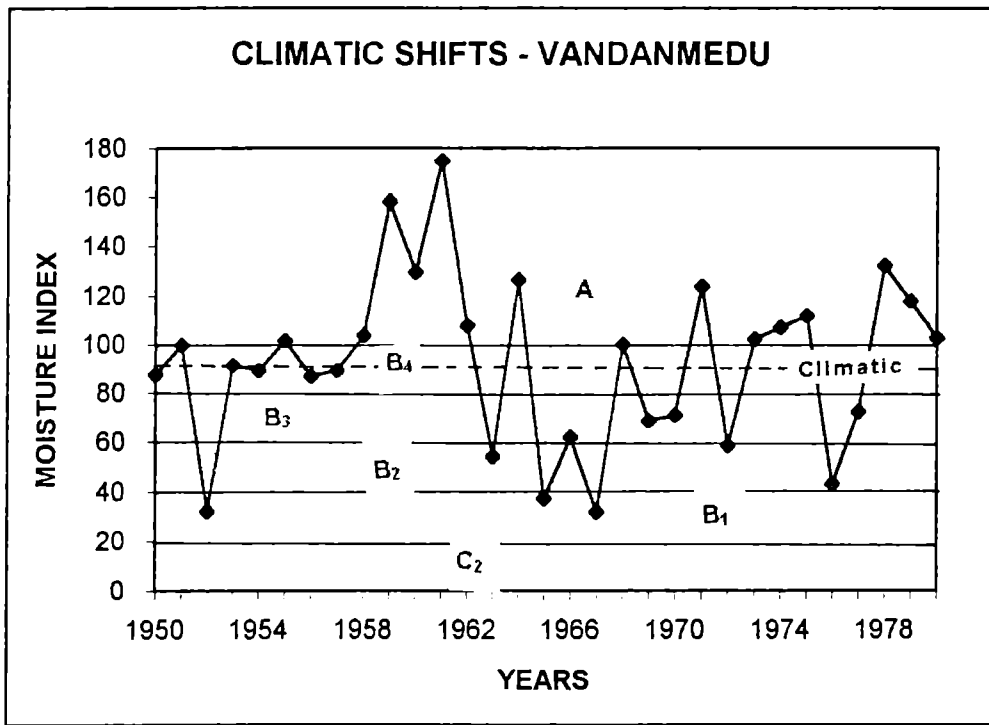


Fig. 4.3.17d. CLIMATIC SHIFTS - VANDANMEDU



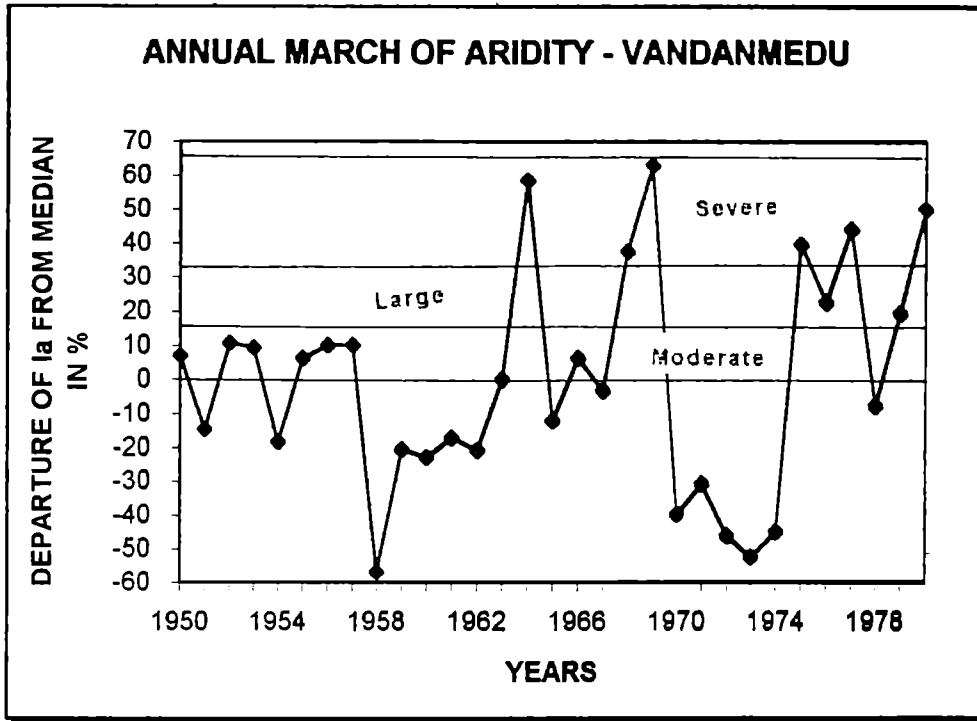


Fig. 4.3.17e. ANNUAL MARCH OF ARIDITY INDEX  
VANDANMEDU

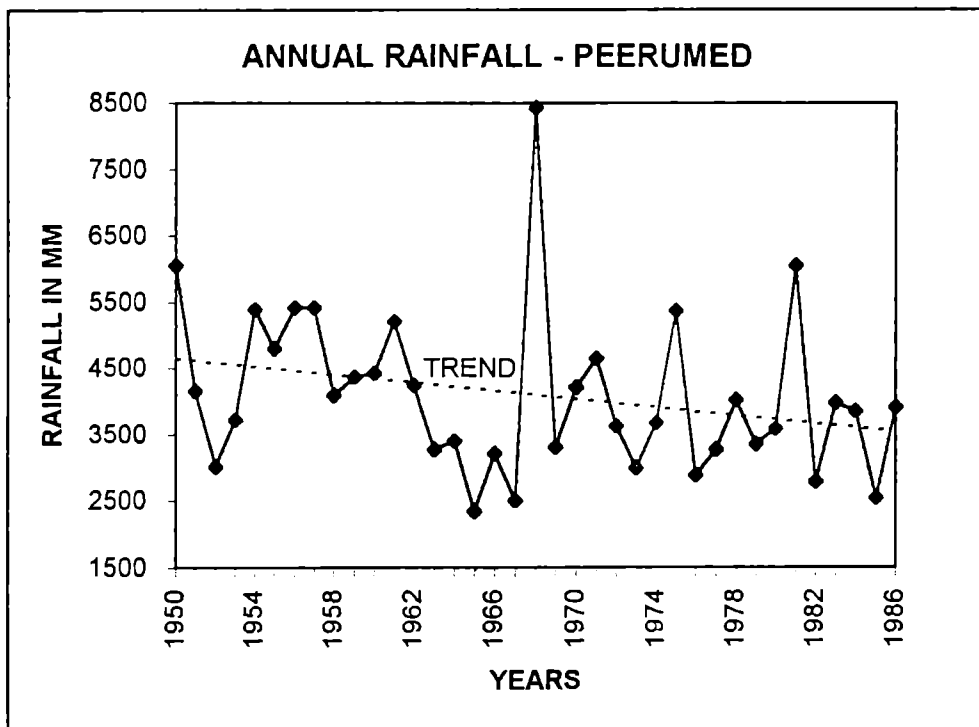


Fig. 4.3.18a. ANNUAL RAINFALL - PEERUMED

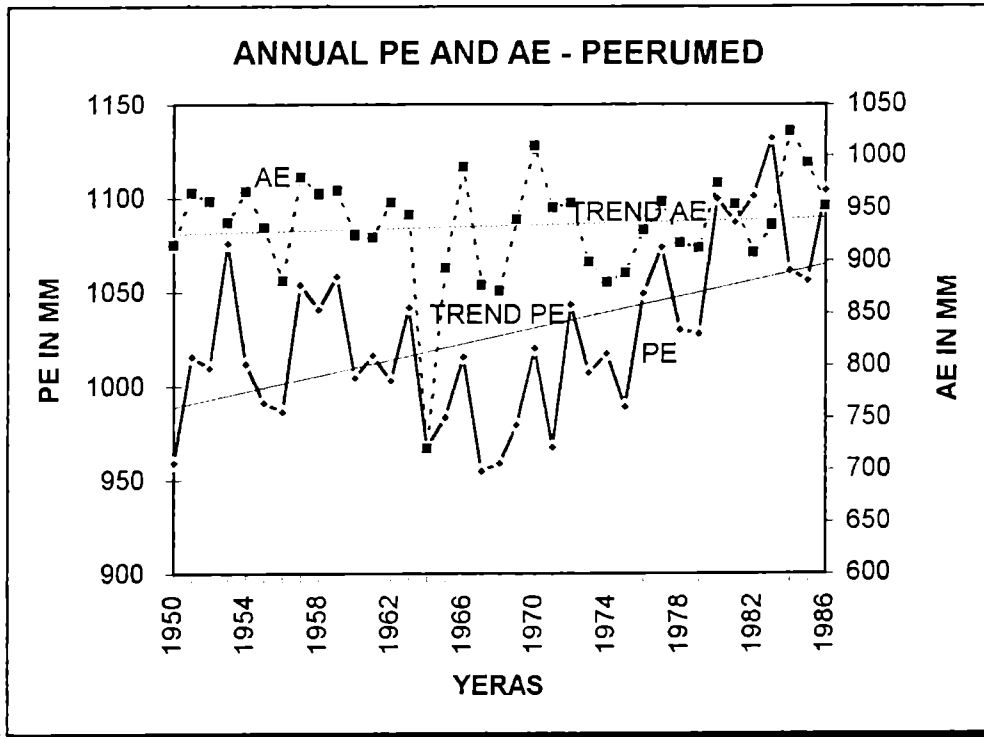


Fig. 4.3.18b. ANNUAL PE & AE - PEERUMED

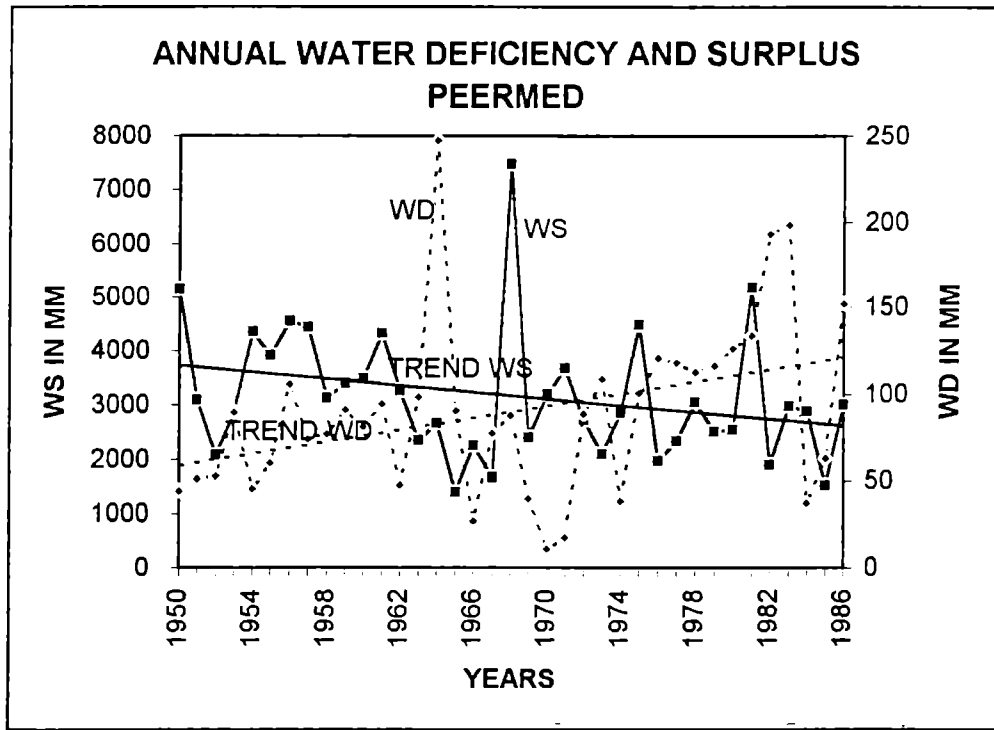


Fig. 4.3.18c. ANNUAL WD & WS - PEERMED

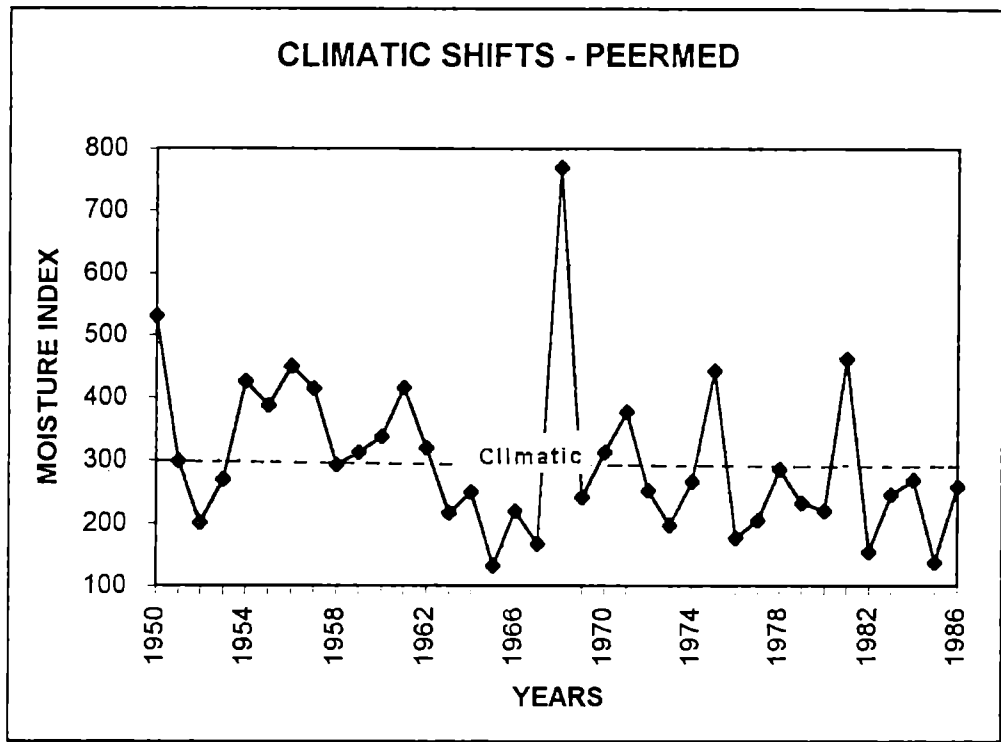


Fig. 4.3.18d. CLIMATIC SHIFTS - PEERMED

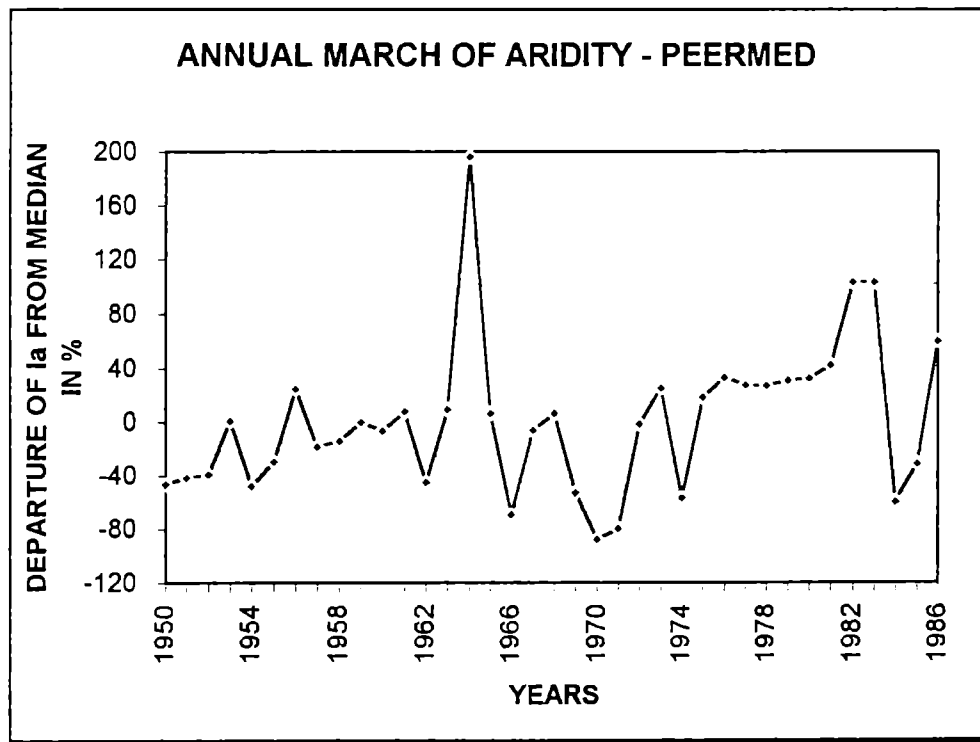


Fig. 4.3.18e. ANNUAL MARCH OF ARIDITY INDEX  
PEERMED

## E. PROBLEM ZONE

### 4.3.19. CHERTHALA

Cherthala is located at  $9^{\circ} 42'N$  and  $76^{\circ} 20'E$ . This coastal station receives an annual rainfall of 2779 mm. The annual rainfall pattern shows a declining trend. (Fig.4.3.19a). The highest annual rainfall of this station was 3911 mm. recorded in 1962, and the lowest was 1668 mm. 1983.

A marked increase in annual PE and decrease in AE are the prominent features of the water balance of Cherthala. The highest PE and lowest AE were recorded in 1983. (Fig.4.3.19b)

In consequence to the rainfall pattern, the annual water surplus also shows a declining trend. The year 1962 had the highest water surplus (2367mm.). The annual water deficiency displays an increasing trend. (Fig.4.3.19c). Cherthala experienced highest water deficiency in the year 1983, when the it was 768 mm.

Cherthala experiences humid ( $B_3$ ) type of climate. A majority of the shifts experienced by Cherthala was within the humid categories. During two years (1983 and 1986) the climate shifted towards dry sub-humid ( $C_1$ ) type. Moist sub-humid ( $C_2$ ) type was experienced in 1976, 1982, 1984 and 1985. During 1950, 1957, 1959, 1960, 1961, 1962, 1968 and 1975, the moisture index was above 100, indicating the climatic shift towards Perhumid (A) type. (Fig.4.3.19d).

There were no disastrous droughts in Cherthala, but it experienced one severe, two large and seventeen moderate droughts during the period 1950-1986. (Fig.4.3.19e.)

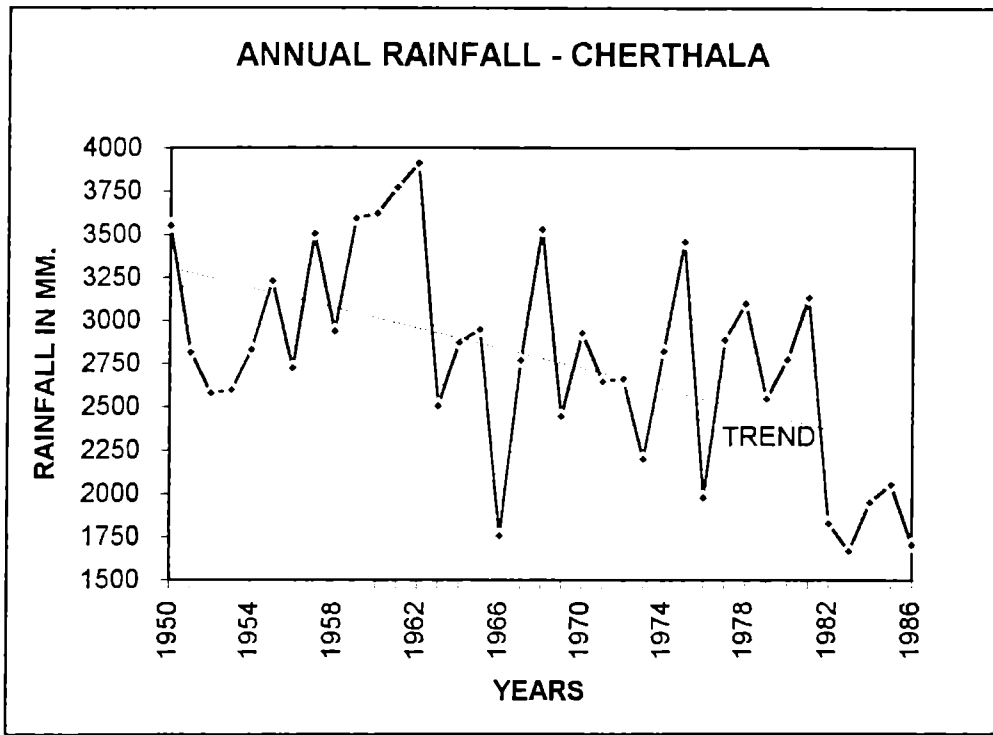


Fig. 4.3.19a. ANNUAL RAINFALL - CHERTHALA

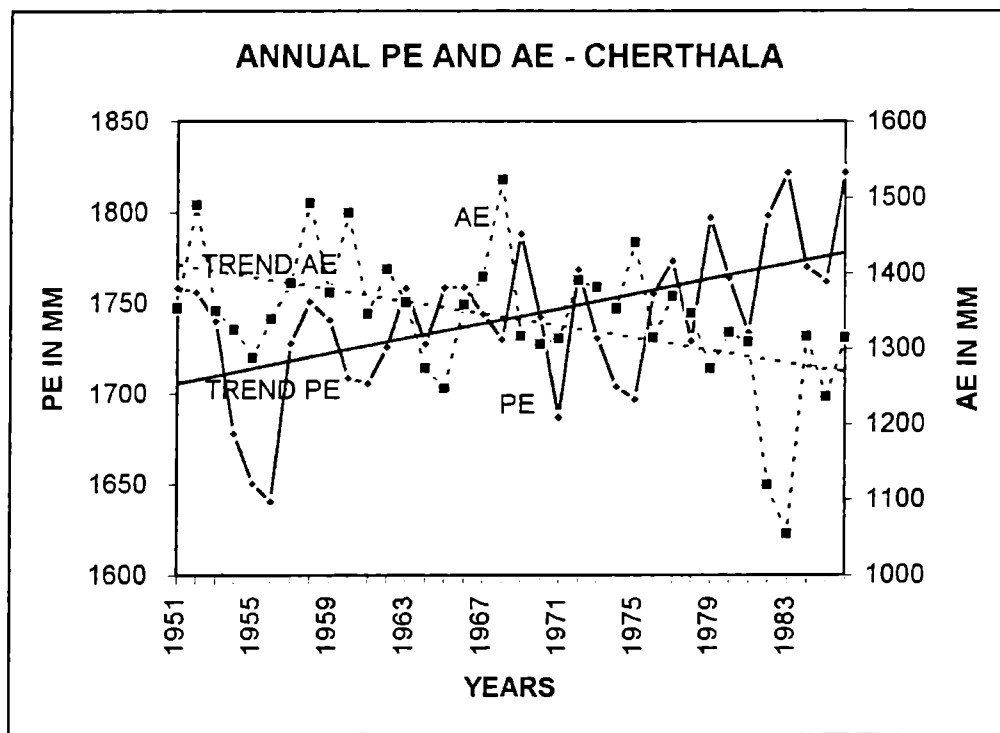


Fig. 4.3.19b. ANNUAL PE & AE - CHERTHALA

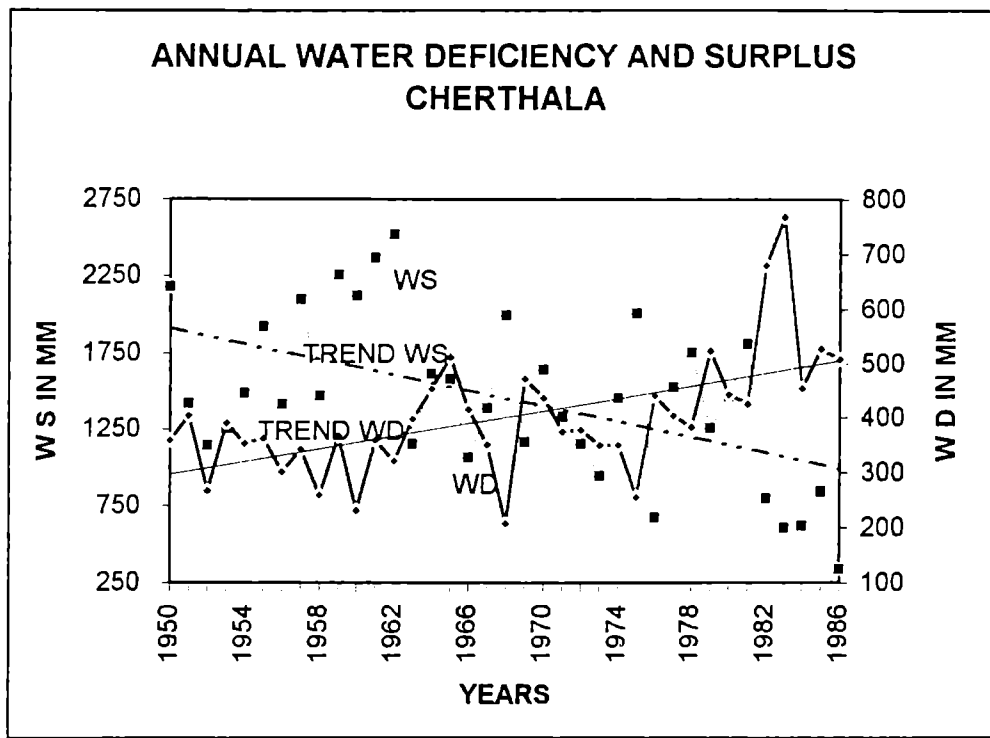


Fig. 4.3.19c. ANNUAL WD & WS - CHERTHALA

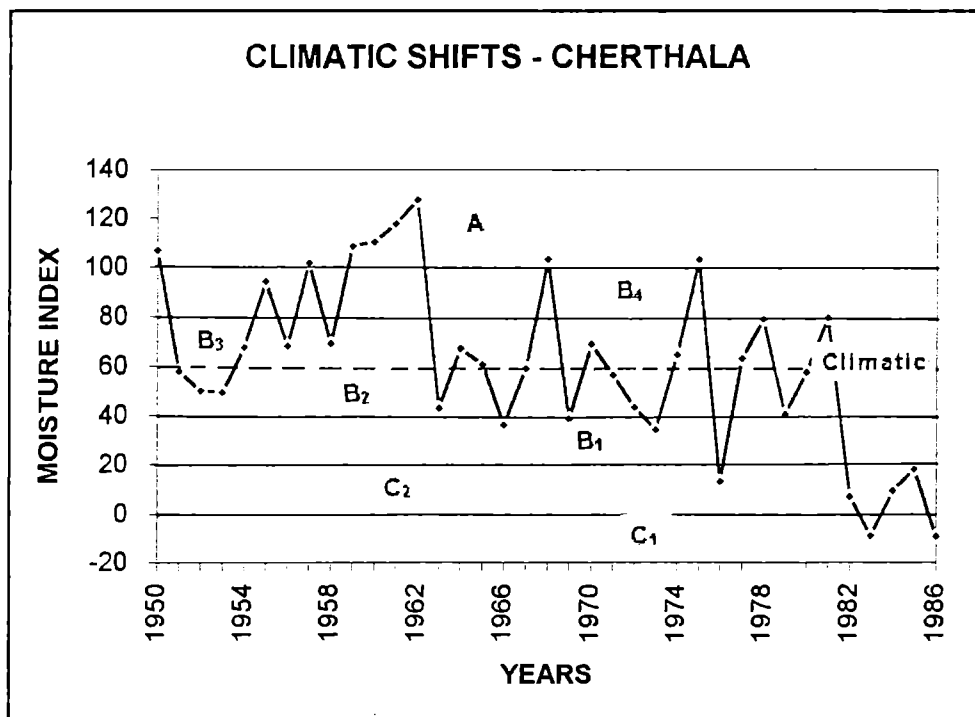


Fig. 4.3.19d. CLIMATIC SHIFTS - CHERTHALA

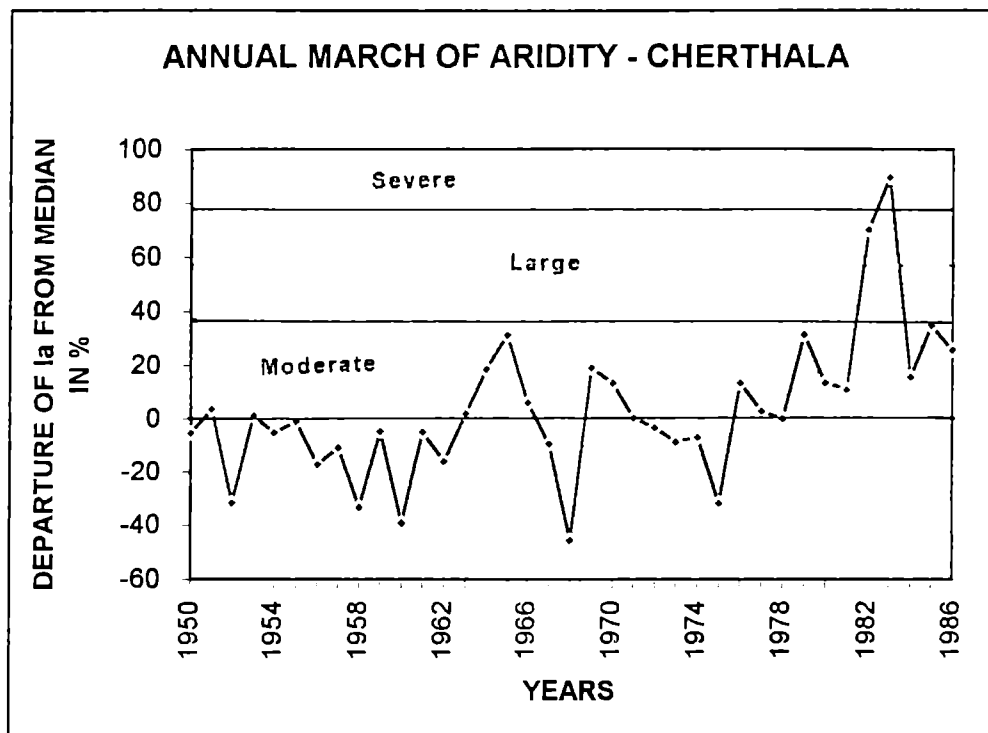


Fig. 4.3.19e. ANNUAL MARCH OF ARIDITY INDEX  
CHERTHALA

The above analysis reveals the following facts.

1. Annual rainfall of Kerala is declining. This is proved from the fact that almost all the stations showed a declining trend in annual rainfall. In this study the simple technique of fitting regression trend line was adopted to observe the linear trend. The declining rainfall trend of the State has also been proved by James (1991), using the power spectrum analysis.

2. Rainfall distribution is more critical than the annual amount. This is evident by the fact that most of the perhumid stations, which do not show any major climatic shifts, had drought conditions, even of disastrous magnitude.