Current World Environment Vol. **11**(2), 517-523 (2016)

Shift in Climate Class Over Tamil Nadu

S. PANNEERSELVAM*, S. KOKILAVANI, A. P. RAMARAJ, G. A. DHEEBAKARAN and T. N. BALASUBRAMANIAN.

Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore-641 003, India.

http://dx.doi.org/10.12944/CWE.11.2.20

(Received: March 29, 2016; Accepted: May 12, 2016)

ABSTRACT

Climate being a significant driver for best selection of crops in a region, allocation of similar climatic zones has always received plunge.Twenty per cent or more precipitation decrease is anticipated for many parts of the arid regions in the next century. Rainfall is a crucial agro-climatological factor in the seasonally arid parts of the world and its analysis is an essential prerequisite for agricultural planning in India. Ninety years (1911-2000) of both South West Monsoon (SWM) and North East Monsoon (NEM) rainfall data of Tamil Nadu (excluding urbanite Chennai) and potentialevapotranspiration data were collected and analysed. The moisture index (Im) was computed based on Thornthwaite and Mather model. Based on the moisture index value of the SWM and NEM, the districts were classified under different climate groups.Over 90 years study, seven districts comes under arid (E), 17 under semi-arid(D), five under dry sub humid(C1) and one each in moist sub humid(C2) and per humid (A) class respectively(SWM period). During NEM no districts registered under (E) or (D) climate class. Further seven districtsfell each in (C1) and (C2) class respectively and12 districts comesunder Humid(B) and five districts under (A) climate class for Tamil Nadu.During SWM, both the data slice (30 years) and decadal (10 years) analysis explored Trichy district might experience severe moisture stress compared to the past. Madurai, Perambalur and Virudhunagar showed a change from (B1) to (C2) during NEM which showed there might be a change in reduction in soil moisture status among the data slice period. Remaining districts fell within the same climate group.

Keywords: climate class, climate shift, NEM, SWM.

INTRODUCTION

Climate being a significant driver for best selection of crops in a region, allocation of similar climatic zones has always received plunge. It paves a way for identifying potential productivity zones for various crops. [6], [7], and [1] delineated climatic zones of India using Thornthwaite and Mather approach [4]. There is now a strong unanimity that climate change presents a fundamental challenge to the well-being of all countries, with potential of being most harsh on developing countries. Water scarcity is a persistent issue in arid and semi-arid countries.

Despite technical advances, weather and climate play a key role in agricultural productivity. Hence, it is necessary to understand the changing climate over a period to feed the growing population. Rainfall is one of the utmost significant ultimate physical parameter among the climate as it governs the environmental factor of the particular region which distresses the agricultural productivity. It is also useful in the planning and management of agriculture and any change in this variable can influence the sustainable food production and water availability for the agriculture. A noteworthy impact of climate change in the recent years is on precipitation arrays on regional scale. Regional and local rainfall

analyses are therefore important for country like India because regional variations get masked in a country wide analysis[2].

The Southwest Monsoon (SWM) has been studied by the researchers throughout the world to understand its dynamics, predictability, cloud physics and tele-connection aspects which brings about 80% of the total precipitation over the country. North East Monsoon (NEM) rainfall (Oct-Dec) is the sustenance monsoon for Tamil Nadu. However, only five districts of Tamil Nadu alone (Salem, Dharmapuri, Krishnagiri, The Nilgiris, and Kanyakumari) are highly benefitted (32 per cent of the annual mean rainfall) from SWM for crop production. This uni-model (SWM alone or NEM alone) and bi-model (both SWM and NEM) rainfall patterns that prevail over Tamil Nadu create variability in soil moisture storage and accordingly the crops productivity and cropping pattern do vary significantly.

MATERIALS AND METHODS

Ninety years (1911-2000) of both SWM and NEM rainfall data in respect of 32 districts of Tamil Nadu were obtained from India Meteorological Department and used for analysis after excluding the rainfall data of urbanite Chennai region. The potential evapotranspiration data of 31 districts of Tamil Nadu were collected from the published report [5]. The acquired data was sliced into three data periods (S1 – 1911-1940), (S2 – 1941-1970) and (S3 – 1971-2000) and again the same has been marked into ten decade (D1: 1901-1910; D2: 1911-1920; D3: 1921-1930; D4: 1931-1940; D5: 1941-1950; D6: 1951-1960; D7: 1961-1970; D8: 1971-1980; D9: 1981-1990; D10: 1991-2000). Simple descriptive statistics such mean and Co-efficient of Variation (CV) was analysed for different seasons and on annual basis.

Table 1: Thornthwaite and Mather] classification on Im

Im values	Category
>(-66) to (-)100	Arid (E)
(-)66 to (-)33	Semiarid (D)
(-)33 to 0	Dry Sub Humid (C1)
0 to 20	Moist Sub Humid (C2)
20 to 40	Humid (B1)
40 to 60	Humid (B2)
60 to 80	Humid (B3)
80 to 100	Humid (B4)
> 100	Perhumid (A)

The moisture index (Im) was computed based on the model of Thornthwaite and Mather (1955) as given below.

$$Im = (P-PE/PE)*100$$

Table 2: Seasonal Moisture Index (Im) of different districts of Tamil Nadu (1911-2000)

S.No	Districts	SWM	NEM
1	Ariyalur	-55.7	48.1
2	Coimbatore	19.3	10.7
3	Cuddalore	-34.4	105.4
4	Dharmapuri	-45.6	-5.5
5	Dindigul	-52.0	33.6
6	Erode	-52.0	-4.8
7	Kancheepuram	-47.1	106.7
8	Kanyakumari	-4.9	29.6
9	Karur	-76.2	-14.8
10	Krishnagiri	-44.4	-13.8
11	Madurai	-52.0	16.6
12	Nagapattinam	-59.4	159.4
13	Nammakkal	-39.6	-16.2
14	The Nilgiris	108.4	185.2
15	Perambalur	-61.9	22.9
16	Pudukkottai	-62.3	13.6
17	Ramnathapuram	-86.1	50.4
18	Salem	-23.3	-0.3
19	Sivaganga	-65.9	21.9
20	Thanjavur	-62.1	59.3
21	Theni	-68.2	6.3
22	Tiruvallur	-51.6	93.4
23	Tiruvarur	-65.0	100.8
24	Tuticorin	-92.4	2.5
25	Trichy	-66.0	8.0
26	Tirunelveli	-81.2	30.6
27	Tiruppur	-70.9	-3.3
28	Tiruvannamalai	-21.2	40.8
29	Vellore	-26.5	14.3
30	Villupuram	-25.5	60.0
31	Virudhunagar	-80.0	23.7

Where, Im= Moisture index, P = Precipitation (mm), PE= Potential evapotranspiration (mm).

The moisture index was computed for SWM and NEM rainfall. The same was applied for data slice and decadal analysis to know the climatic shift over Tamil Nadu.

RESULTS AND DISCUSSION

The ninety years seasonal (SWM and NEM) rainfall data analysed for the dependability of rainfall indicated that except for Erode and Tiruppur districts which registered more than50 per cent of CV showed less dependable rainfall while remaining districts revealed less than 50 per cent of CV specified more dependable rainfall for SWM. During NEM invariably all districts ensured highly dependable rainfall for Tamil Nadu (Fig 1).

The computed moisture index values of each district for SWM and NEM season are presented in Table 2, 3, and 4. An attempt was made to categorize different district as per the climate model [8]. The moisture index is an indicator of the supply of water in an area relative to the demand under prevailing climatic condition [3] and [8]. The climate class analysed for different districts revealed that E indicating severe moisture stress (seven), D representing 50 per cent moisture stress (17), C1 specifying 20 per cent soil moisture stress +high temperature (five), C2 stating 20 per cent soil moisture stress +mild temperature (one) and A affirming excess soil moisture (one) registered for SWM.

In NEM, seven districts came under C1, another seven districts came under C2, six districts came under B1-humid climate (zero soil moisture stress), five districts came under B2humid climate (zero soil moisture stress), one district came under B4humid climate (zero soil moisture stress), and five district came under A-excess soil moisture. The results indicated that all the districts did come either under sub-humid climate or above and not under either semiarid or arid climate.

Reviewing the results given in the Table 2,3and 4 (integrating SW and NE monsoon Im), the results clearly indicated that The Nilgiris came under same climate class (A) in both the seasons. This indicated that this district had excess soil moisture during the two monsoon periods. It is also interpreted that severe moisture stress could rarely occur in this district but the excess moisture would trigger landslides and other physical disasters. Since Coimbatore district is at the foothills of Western Ghats, in both the seasons this district came under moist sub-humid climate(C2) indicating the existence of 20 per cent soil moisture stress with mild temperature. The district Salem had (C1) dry sub-humid climate (20 per cent soil moisture stress +high temperature) though it is 200 km away from Coimbatore towards the east. Bi-model

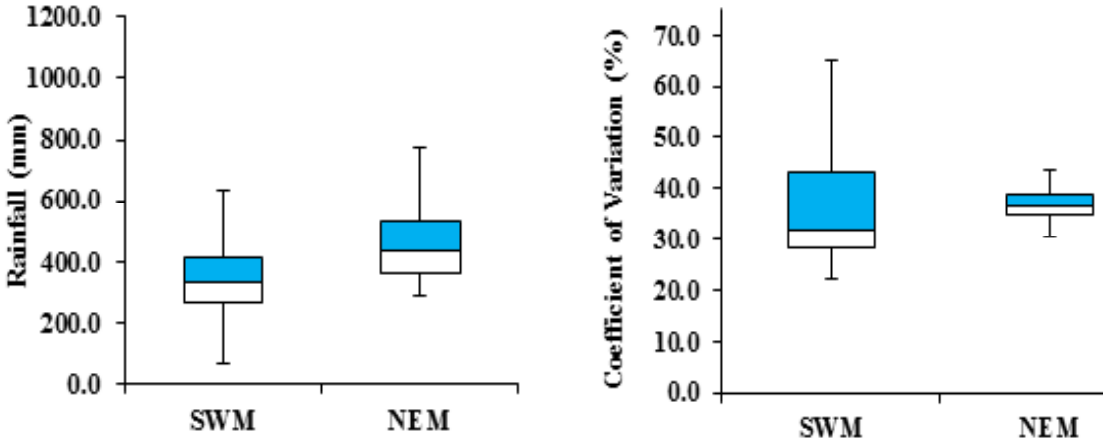

Fig. 1: Normal rainfall variability and CV of monsoon rainfall over Tamilnadu

Table 3: Categorization of district based on moisture index of Southwest monsoon season

Particulars	A (Perhumid)	B 4	B 3	B 2	B 1	C 2 (Moist sub-humid)	C 1 (Dry sub-humid)	D (Semiarid)	E (Arid)
Name of the district	The Nilgiris	-	-	-	-	Coimbatore	Kanya kumari, Salem, Thiruvannamalai, Vellore, Villupuram	Ariyalur, Cuddalore, Dharmapuri, Dindigul, Erode, Kancheepuram, Krishnagiri, Madurai, Nagappattinam, Namakkal, Perambalur, Pudukkottai, Sivaganga, Thanjavur, Thiruvallur, Thiruvarur, Trichy	Karur, Ramanathapuram, Theni, Tuticorin, Tirunelveli, Thiruppur, Virudhunagar
Number of the district	1	-	-	-	-	1	5	17	7

Table 4: Categorization of district based on moisture index of Northeast monsoon season

Particulars	A (Perhumid)	B4 (Humid)	B 3	B2 (Humid)	B1 (Humid)	C2 (Moist sub-humid)	C1 (Dry sub-humid)	D	E
Name of the district	Cuddalore, kancheepuram, Nagapattinam, The Nilgiris, Thiruvarur	Thiruvallur	-	Ariyalur, Ramanathapuram Thanjavur, Thiruvannamalai, Villupuram	Dindigul, kanyakumari, Perambalur, Sivagangai, Thirunelveli, Virudhunagar Vellore	Coimbatore, Madurai, Pudukkottai, Theni, Tuticorin, Trichy, Thriuppur	Dharmapuri Erode Karur Krishnagiri Nakammal Salem		
Number of the district	5	1	-	5	6	7	7	-	-

rainfall pattern was observed with Dharmapuri, Kanyakumari and Krishnagiri districts, eventhen, these districts did not come either under perhumid climate as observed for neither The Nilgiris nor dry sub-humid climates as observed for Salem district. These three districts Dharmapuri, Kanyakumari and Krishnagiri had differential appearance in the climate between two monsoons of study (Table 5).

The slice data analysis of three epochs for the SWMperiod (Table 6) revealed that out of 31 districts, nine districts showed shift in the climatic classviz Coimbatore from (C1) to (B1), Cuddalore and Namakkal from (D) to (C1) respectively. TheNilgiris from (A) to (B4), Sivaganga, Theni, Tiruvarur and Tiruppur from (E) to (D) and Trichy from (D) to (E).

The decadal analysis for the SWM period (Table 7) revealed that 10 districts explored the shift in climate from the base period. Ariyalur,Sivaganga, Tiruvarur and Trichyshowed a change from (D) to (E) impinging severe moisture stress compared to the base period.Coimbatore from (D) to (B1), Cuddalore from (C1) to (D) and Kanyakumari from (C1) to (B1), Krishnagiri from (D) to (C1) and

Table 5: Categorization of districts fall under same climate based on moisture index

Particulars	A (Perhumid)	B4 (Humid)	B3	B2 (Humid)	B1 (Humid)	C2 (Moist sub-humid)	C1 (Dry sub-humid)	D (Semiarid)	E (Arid)
Southwest monsoon	The Nilgiris	-	-	-	-	Coimbatore	Kanyakumari Salem Thiruvannamalai Vellore Villupuram	Ariyalur Cuddalore Dharmapuri Dindigul Erode Kancheepuram Krishnagiri Madurai Nagappattinam Namakkal Perambalur Pudukkottai Sivaganga Thanjavur Thiruvallur Thiruvarur Trichy	Karur Ramanathapuram Theni Tuticorin Tirunelveli Thiruppur Virudhunagar
Northeast monsoon	Cuddalore kancheepuram Nagapattinam The Nilgiris, Thiruvarur,	Thiruvallur	-	Ariyalur, Ramanatha, puram, Thanjavur, Thiruvan, namalai, Villupuram,	Dindigul kanyakumari Perambalur Thirunelveli Virudhunagar	Coimbatore Madurai Pudukkottai Theni Tuticorin Trichy Vellore	Dharmapuri Erode Karur Krishnagiri Nakammal Salem Thriuppur	-	-

Table 6: Data slice climate shift analysis for South west Monsoon

Districts/ Slice period	S1(1911 -1940)	S2(1941 -1970)	S3(1971 -2000)
Coimbatore	C1	B2	B1
Cuddalore	D	C1	C1
Nammakkal	D	D	C1
Nilgiris	A	B4	B4
Sivaganga	E	E	D
Theni	E	E	D
Tiruvarur	E	D	D
Trichy	D	E	E
Tiruppur	E	E	D

Theniand Tiruppur from (E) to (D). Seven districts registered transference in climate on both data slice and decadal analysis. The slice data and the decadal analysis disclose that the climate class shift from D to E occurred in Trichy district might experience severe moisture stress on both time scale period.

The data slice of three epochs for the NEM (Table 8) period revealed that out of 31 districts, 12 districts showed swing in the climatic class. Among the 12 districts, seven districts climate shift was with in the same class.Ariyalur, Dindigul, Thanjavur, Tirunelveli and Villupuram had a change among (B1 to B4) group which indicated that the soil moisture status will not deviate more in those districts. Theni and Tiruppur registered change between (C1) and

Table 7: Decadal climate shift analysis for South west Monsoon

Districts	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Ariyalur	D	D	D	D	D	D	D	D	D	E
Coimbatore	D	D	C1	B1	B3	B1	C2	B2	B1	B1
Cuddalore	C1	D	D	D	C1	D	C1	C1	C1	D
Kanyakumari	C1	C1	C2	C1	C1	C1	C2	C1	C1	B1
Krishnagiri	D	D	D	D	D	D	D	D	D	C1
Sivaganga	D	D	E	D	E	D	E	E	D	E
Theni	E	E	E	E	E	E	E	D	E	D
Tiruvarur	D	D	E	E	D	E	D	D	D	E
Trichy	D	D	E	D	D	E	D	E	D	E
Tiruppur	E	E	E	E	E	E	E	D	E	D

(C2) group. Madurai, Perambalur and Virudhunagar showed a change from (B1) to (C2) which showed there might be change in reduction in soil moisture status among the data slice period. In the long run (1911-2000) period also, the shift was noticed in Perambalur and Virudhunagar from (B1) to (C2) while Madurai being in the same climate group (C2). The climate swing was from (C2) to (B1) in Sivaganga and from (A) to (B4) in Tiruvallur district.

The decadal analysis for the NEM period (Table 9) revealed that 22 districts explored the shift in climate from the base period. Among the 22 districts, 13 districts climate shift was with in the same class. Moreover, the climate class shifts for the districts traverses within the less moisture stress (between C and B) climate group.

CONCLUSION

From the study, based on the moisture index value of the southwest monsoon rainfall, seven districts came under arid, 17 districts came under semiarid, five districts under dry sub-humid and one district each in moist sub-humid and perhumid respectively. Northeast monsoon rainfall had no districts falling underarid or semi- arid climate. The results were in favour of dry sub-humid for seven districts, seven under moist sub-humid, 12 districts under humid and five districts under perhumid climates. Further it was found that three districts *viz.*,TheNilgiris (perhumid), Coimbatore (moist sub-humid) and Salem (dry sub-humid) did come under the same climate during both monsoon seasons respectively. The decadal analysis for SWM showed

that Ariyalur, Sivaganga, Tiruvarur and Trichy showed a change from (D) to (E) impinging severe moisture stress compared to the base period. Considering the shift of climate type among the districts, Trichy district might experience severe moisture stress compared to the past slice period and also the decade wise analysis endorse the result obtained in the slice period.During NEM, Madurai, Perambalur and Virudhunagar showed a change from (B1) to (C2) which showed there might be change in reduction in soil moisture status among the data slice period. In the long run (1911-2000) period also, the shift was noticed in Perambalur and Virudhunagar from (B1) to (C2) while Madurai being in the same climate group (C2).

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