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BIO-CLIMATIC CHARACTERISTICS OF KERALA—A CASE STUDY

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ABSTRACT : The bio-climatic characterstics of Kerala have been discussed here by considering components like rainfall, precipitation effectiveness index, temperature effectivity index, evaporation loss and vegetation lypes. Finally an atlempt has been made to sythesise the information to delineate bio-elimatic zones.

INTRODUCTION

Bio-climatological study, a sub-branch of Bio-geography, is currently gaining importance in the present day context of environmental problems. Interference by man in nature's domain to satify his socio-economic needs has posed considerable threat to the eco-system, particularly to the flora and fauna. A large number of species have either fallen extinct or are in the verge of extinction. In order to help implementing eco-restoration programme it is imperative to study the relationship between biom and climatic parameters. Identification of different bio-climatic zones could facilitate rehabilitation of plant and animal communities according to their suitability.

Bio-climatology can be defined as a study of inter-relationship between biological realm ie., flora and fauna and the climatic condition of any region. The well established interlinkage between biom and climate, expressed through the spatial diversity of evolutionary process of development has become complex due to acquired technological skills of human society and its consequent growing adaptability. However, it is possible to trace out the bio-climatic regimes through careful analysis of climatic parameters and biotic data. The bio-climatic differentiation helps to reconstruct the past bio-complexes and point out the possible extent of damages undergone.

The present study is purported to analyse the climatic parameters like rainfall, precipitation effectiveness, temperature, evaporation etc. Attempts have been made to understand their spatial and seasonal variability. Their spatial association over the seasons have been dealt along with the vegetation pattern to identify bio-climatic zones. The bio-climatic zonation is type of ecological classification of land and may find application in landuse planning. According to Odum (1971) the application of ecological principles in land-use planning is undoubtedly the most important in the application of environmental sciences. The Canadian committee on ecological (biophysical) land classification has stressed upon the classification of land based on bio-climatic parameters and vegetation (Thie and Ironside, 1976, Davidson, 1982). Bioclimatic land classification of India has been brought out by the French Institute, Pondicherry (Gaussen et al, 1968) in maps of comparatively smaller scale. Gupta and Saxena (1971) and Gupta (1968) have also contributed in this line for limited areas in north India.

STUDY AREA

The study area, confined to the state of Kerala, located between 8°18′ and 12°84′N latitude and 74°52′E to 77°22′E longitude in the south western corner of Indian peninsula comes under the humid tropics (Garnier). According to Miller's classification it is tropical continental monsoon (Monsoon AMW) variety as per Koppen's scheme (Jarretta, 1977). The study area is characterised by rainfall of two seasons viz. in south-west and north-east monsoon separated by a short but distinct dry season

during October and November. Orographic influence on climate due to the hilly Western Ghats in the eastern part of the state is well manifested in distributional pattern of rainfall and temperature. Location of the state with respect to latitude, nearness to the sea and undulated topography have contributed significantly to the typical bio-climatological set up. Tropical climate with respect to latitudinal position has been further modified by the marine influence in the west and the high relief in the east within a short distance. The Palghat gap region almost in the central part of the Western Ghats in Kerala, has contributed to many micro-climatic peculiarities. Intricate Drainage network of 44 rivers (of which three are east flowing), with number of reservoirs and a chain of backwaters parallel to the coast also should have micro-climatic influence and host various habitats of flora and fauna.

However due to widespared expansion of cultural landscape these habitats are considerably interfered. As a result, the forest vegetation has been diminished to a mere 14% of the total geographical area (Chattopadhyay et al, 1986). The necessity and importance of eco-restoration programme is gaining wide appreciation and acceptance in this state.

METHODOLOGY

Analysis of climatic parameters like rainfall temperature, humidity, cloud, vapour pressure, wind etc. and compilation of their seasonal and spatial interrelationships are of primary necessity in bio-climatic study. While some data is readily available, some others were to be computed by applying emperical formulae. It was also necessary to investigate into the vegetation types, distribution of fauna, soil conditions, topo-sequences, and other related parameters.

For the present study main emphasis has been given to the analysis of climatic data, collected from the Indian Meteorological Department and Kerala State Electricity Board and interpretation of their seasonal and spatial interelations. Other parameters like flora and fauna have been discussed in brief.

To combine rainfall and temperature ombrothermic diagrams are drawn for each of the six meteorological stations by indicating a relationship of 2 : 1 for rainfall and temperature in the unit scale of millimetre and degree centigrade respectively. To understand P.E. (Precipitation Effectiveness) and T.E. (Temperature Effectivity) indices the following emperical formulae (Thorthwaite, 1948) are used.

P.E Index (Precipitation Effectiveness Index)

$$= \sum_{1}^{12} \left| \frac{P}{T-10} \right|^{10/9}_{n}$$

T.E. Index (Temperature effectiveness index) =

Where P = Precipitation in inches
T = Temperature in degrees Farrenheits
n = 1 (in terms of month)

To obtain evaporation loss for each month the empirical formulae derived by Khosla (Andhra Pradesh Planning Atlas, 1976, has been used).

As per this formulae, Evaporation Loss

$$E.L. = \frac{T - 32}{9.5}$$

where Evaporation loss is in inches and T = Temperature in degrees farenheit.

All these parameters are graphically re presented on same base for each station. To understand the interrelationship among different parameters, inter-correlation matrices have been computed for selected stations by using Spearman's Rank correlation method.

Finally bio-climatic zones are identified based on precipitation, temperature, and potential vegetation types, after integrating them spatially.

ANALYSIS OF BIO-CLIMATIC COMPONENTS

The bio-climatic components like rainfall, Precipitation Effectiveness (P.E.) index, Temperature Effectivity (T.E.) index, Evaporation loss and vegetation types have been discussed here before synthesising them to delineate bio-climatic zones. Analysis of individual parameters will bring forth an over all picture for the state as a whole along with their peculiarities.

RAINFALL AND P.E. INDEX

The state is well endowed with monsoonal rainfall having an annual average of more than 300 cm. In general precipitation increases from coast to inland and the maximum (400–500 cm) is recorded along the foot hills around Neriyamangalam–Palai stretch in the south and Kuttiyadi area in the north. The Palghat gap, lying almost in the central part of the western ghats of Kerala, disrupts the isohyetal trend due to abrupt reduction in relief, resulting in considerably low rainfall. Rainfall is less than 100 cm in the eastern slopes of the Anamudi around Chinnar and north Marayur due to their position in the leeward side It is observed that the Malabar coast receives more rainfall than coastal zone between Cochin and Quilon.

Although south-west monsoon is the main season for rainfall, recording more than 60% of the total precipitation, north-east monsoon also contributes significantly in some parts. Effect of north-east monsoon decreases towards north. As a result, the northern stations are characterised by a single peak during June–July. Conversely in the southern stations (south of Palghat gap) two rainfall peaks are prominant in the months of June–July and October. The June–July peak is higher in several stations except in Chinnar, where the highest peak is in the month of October, denoting the predominance of north-east monsoon. Rainfall and number of rainy days correspond to each other for almost all the stations. This indicates low variability of rainfall intensity. Rainfall variability worked out for 1961-79 period shows that there are considerable variations between normal and actual rainfall at several places. The general variability changes with season. The northern part, especially Kasaragod Cannanore area, records high variability around 50% during dry season.

Precipitation Effectiveness (P.E.) indices calculated for Trivandrum, Cochin, Calicut, Punalur, Palghat and Alleppey indicate that the low seasonal variations of temperature have rendered the rainfall as the major controlling factor. The highest P.E. index, value has been recorded in Calicut during the month of July. Comparing the month-wise data for all the stations it is observed that variations of P.E. values are highest in Calicut and lowest in Trivandrum. From this observation it can be inferred that annual moisture availability in Trivandrum is less variable than in other stations. It should be noted here that this observation however does not indicate the state of moisture availability in these stations.

TEMPERATURE AND T.E. INDEX

The state records an annual average temperature of 28°C and experience low diurnal and seasonal variations below six degrees centigrade due to marine influence. However on account of orographic influence temperature comes down to below 15°C around Anamudi covering Chinnar-Munnar area. Mean iso-thermal contour of 20°C (limit of tropical climate) runs close to the western ghats crest and is marked in three patches :

(1) a continuous belt stretching from foothills of the Anamalai to the northern part of the Agasthiamalai,
(2) Areas around Kunda hills, and
(3) The eastern part of Wayanad Plateau.

TABLE 1

Correlation Matrix (Monthwise and Stationwise)

Month	Trivandrum					Cochin					Calicut				
	P	P.E	T (F°)	T.E	E.L.	P	P.E	T (F°)	T.E	E.L.	P	P.E	T (F°)	T.E	E.L.
Jan.	22	.0086	80.04	12.01	129	23	.0090	80.01	12.00	128	117	.0537	80.01	12.00	128
Feb.	21	.0078	80.94	12.25	131	25	.0097	81.34	12.34	132	8	.0029	80.98	12.25	131
Mar.	39	.0152	82.89	12.72	136	52	.0211	83.64	12.91	138	19	.0066	83.86	12.97	139
April	1106	.046	83.71	12.93	138	114	.0498	83.61	12.90	138	87	.0361	85.73	13.43	144
May	208	.0986	82.60	12.65	135	302	.1480	83.35	12.81	137	262	.1255	83.80	12.95	138
June	356	.1847	80.17	12.04	129	731	.4088	80.44	12.11	130	823	.4691	80.04	12.01	129
July	223	.1113	79.03	11.76	126	614	.3424	79.07	11.77	126	851	.4963	78.35	11.59	124
Aug.	146	.0691	79.21	11.80	126	380	.2000	79.38	11.85	127	440	.2343	79.75	11.94	128
Sep.	138	.0646	79.88	11.97	128	244	.1232	78.87	11.72	125	220	.1083	80.01	12.00	128
Oct.	273	.1382	79.74	11.94	128	326	.1655	81.10	12.28	131	263	.1303	80.0	12.25	131
Nov.	206	.1003	80.08	12.02	129	187	.0892	81.12	12.28	131	157	.0733	81.21	12.30	132
Dec.	75	.0326	80.13	12.03	129	48	.0200	80.02	12.01	128	31	.0120	80.47	12.12	130
Annual					1563					1571					1575

TABLE 1—*Contd.*

Month	Punalur					Palghat					Alleppey				
	P	P.E	T (F°)	T.E	E.L.	P	P.E	T (F°)	T.E	E.L.	P	P.E	T (F°)	T.E	E.L.
Jan.	20	.0074	80.38	12.09	129	9	.0031	81.03	12.26	131	10	.0034	80.87	12.22	131
Feb.	38	.0151	82.32	12.59	135	12	.0042	84.00	13.00	139	71	.0300	82.13	12.53	134
Mar.	104	.0446	84.65	13.16	141	20	.0070	87.46	13.87	148	80	.0337	84.24	13.06	140
April	218	.1016	84.67	13.17	141	59	.0231	87.71	13.93	149	169	.0760	85 14	13.29	142
May	292	.1430	83.10	12.79	137	185	.0853	84.38	13.09	140	256	.1227	83.52	12.88	138
June	580	.3176	80.08	12.02	129	395	.2082	79.61	11.90	127	706	.3926	80.60	12.15	130
July	542	.^982	78.93	11.73	126	546	.3066	77.47	11.37	122	576	.3202	78.78	11.70	125
Aug.	340	.1772	79.25	11.81	126	302	.569	78.31	11.58	124	470	.2540	79.21	11.80	126
Sept.	253	.1262	80.08	12.02	129	178	.0859	79.90	11.98	128	331	.1701	80.17	12.04	129
Oct.	432	.2288	79.99	11.99	128	167	.0787	80.91	12.23	131	285	.1428	80.83	12.21	131
Nov.	272	.1371	79.81	11.95	128	100	.0445	81.46	12 37	132	256	.1259	81.50	12.38	132
Dec.	704	.0303	79.81	11.95	128	37	.0149	80.58	12.15	130	65	.0276	81.12	12.28	131
Annual					1575					1601					1589

The northern part of the state is drier compared to the south. The Palghat gap being a converging zone experiences hot weather. Following the distribution of temperature, Temperature Effectiveness (T.E.) Index is also less variable. The highest values of T.E. in all the stations are marked in the month of March, April and range between 12.91 in Cochin to 13.93 at Palghat.

EVAPORATION LOSS

Potential evaporation loss, worked out by using Khosla's formulae, provides an idea about the temperature effectiveness. The annual average evaporation loss stands to be 1580 mm, slightly higher than the value (1450 mm) worked out by Rao and Vamadevan (1982) using Penman's equation (modified). The maximum potential evaporation loss (1600 mm) is recorded in Palghat station followed by Alleppey (1588 mm).

However it is observed from a study of Rao, Vardhan and Vamadevan (1985) that actual evapotranspiration loss in Palghat is higher than that in Alleppey. Difference between actual and potential evapotranspiration is higher for all the northern stations compared to the southern stations. And this is primarily attributable to the environmental condition like vegetation coverage, presence of waterbodies and exposure of rock surfaces.

To synthesise the above climatic aspects and also to understand their relative position graphs are drawn (Fig. 1) for six stations depicting Precipitation, Temperature, P.E. Index and evaporation loss, correlation table matrices (Table 1) are also prepared for selected stations.

Analysis of these graphs bring out that potential evaporation loss exceeds precipitation from 2nd half of October till the end of April in an year. In case of Palghat and Punalur this period is least from November end to early April. This period with exceeding potential evaporation loss prevails through out the state for a period of 3 to 4 months generally during December to April. Punalur and Alleppey stations are comparatively more humid and experience the assured humid period from 13th week from the beginning of a year. This humid period falls in the 19th week in the case of Trivandrum and Calicut (Rao and Vamadevan, 1982.) Index of moisture adequacy worked out by Ram Mohan and Subrahmanyam (1983) for south India also indicates the water deficiency in pre-monsoon months for this part of the country.

However, it is observed that annual moisture index value of more than 80% is recorded for the state of Kerala as a whole. During December to February the value ranges between 60% to 90% and during March to May the index value comes down to 60% to 80%. While this lower value restricts seasonal crop culture in rainfed condition, it does not affect tree crops with sufficient root penetration capacity.

Correlation co-efficients for PE, TE and EL in the context of each station have been presented in Table 1. It is observed that PE is negatively correlated with TE and EL which should be so. However, the negative relationship varies from –0.33 for Cochin to –0.71 for Calicut in the case of PE and EL. And in the case of PE and TE the value varies from –0.30 in Cochin to –0.69 in the case of Palghat. Comparing these values with original data (Appendix–I) and the graphs (Fig. 2). In other words incidence of dry spell controls the negative relationship of PE, EL and TE.

It is imperative that spatial variations of climatic characteristics and their inter-relations are attributable to a number of environmental factors like distance from the coast, orographic condition, vegetation cover etc. Accordingly various habitats have developed in the potential framework of the environment which has further been modified due to human intervention.

FLORA AND FAUNA

The state is well endowed with natural vegetation and wild life. Moist tropical forest is the main vegetation type. Due to physiographic impact, dry deciduous sub-tropical montane type of vegetation can be marked in patches having low temperature and meagre rainfall. The main vegetation types are wet evergreen, semi-evergreen, moist deciduous, subtropical montane and temperate with varying areal coverage. Besides, various plantations ranging from cardamom, tea and coffee to rubber and coconut are prevalent throughout the state in different ecological settings. Along the coast and the nearby estuarian margins mangrove vegetations are traceable.

TABLE 2

Vegetation Type and Area

Type of vegetation	Area in per cent to the total forest area
Wet evergreen & Semi evergreen	50.5
Moist deciduous	33.4
Dry deciduous	1.8
Montane subtropical & tempe-	1.7
rate Shola Plantation & others	12.6

Source : Forest Resource Survey, Department of Forest, Government of Kerala, 1973.

VEGETATION TYPE AND AREA

Continuous vegetation stretches, which were dominant in the state till last century have been widely stripped off. As per 1973 records natural vegetation cover has come down to 17 per cent from as much as 44 per cent in 1905 (Chattopadhyay, 1985). At present the natural vegetation is mainly confined to the rugged slopes of the western ghats. The evergreen forests are characterised by tall trees in the upper storey followed by dense second storey and undergrowth of numerous ferns and tall herbs. The moist deciduous type is less dense compared to the evergreen forests but contains several commercially valuable species like teak, rose wood etc. Evergreen, semi-evergreen and deciduous forest types are located in the rainfall zone of 2500 mm to 3500 mm and above with temperature more than 20°C. These areas generally fall above 300 m of elevation. Dry deciduous type is limited to the Pamba valley to the north-east of Anamalai. This is a rain shadow region, where annual rainfall is recorded as less than 1000 mm and temperature in winter is considerably low ($<10°C$).

The sub-tropical or temperate shola occurs in the valleys of High ranges. Grass lands are found in few isolated patches throughout the state. Some of these patches are due to climatic climax and some others are due to human intervention. Grass lands along the western ghat crest have been developed in the stretches of forest clearance for laying down ridal paths in the last century. Lateritic mounds in the north are occasionally covered by grass lands.

Due to physico-climatic diversity, the state can boast of a unique habitat for a wide varieties of wild animals like elephant, gaur, sambar, spotted deer, barking deer, wild boar, tiger, panther, bear, Nilgiri taur, Nilgiri langur, lion tailed macaque etc.

The wild lives are mostly confined to the natural forest areas, hence vegetation zonation will automatically respond to the distribution of the major fauna also.

BIO-CLIMATIC ZONES

Analysis of the climatic parameters and biom (flora and fauna) have brought out that, even though the state enjoys tropical climate, there are micro-climatic assemblages to delineate different habitats. The western ghats mountain chain with deep valleys and high altitudes widely modify the tropical climate. More over, the Palghat gap, almost in the central part of the western ghats in Kerala and having very low altitude (less than 144 m) governs the local climatic and vegetational pattern.

Rainfall and temperature are two climatic elements, whose interplay causes all the major variations. Accordingly these two parameters are selected to demarcate climatic zones. Considering the rainfall distribution, variability and their spatial trend, two critical rainfall values, 2500 mm and 3500 mm, are selected. Hence there are four rainfall zones. Similarly for temperature, 20°C is taken as the critical value, which practically delimits the tropical area. Now with respect to the combination of four rainfall categories, < 2500, > 2500, < 3500 and > 3500, and two temperature categories, $< 20°C$ and $> 20°C$, it is theoretically possible to identify eight bio-climatic zones.

Analysis of the annual rainfall curves for all the rainfall stations (Centre for Earth Science Studies, 1984) it is observed that three patterns are evident. These are :

(1) rainfall curves with peak in southwest monsoon–exhibited by the stations mainly in the north of Palghat gap with exceptions like Calicut;

(2) rainfall curves having two peaks with the higher one in southwest monsoon–characteristic feature of almost all the southern stations excluding the Anamalai region and whole of Alleppey, and

(3) rainfall curves having two peaks with the higher one in the northeast monsoon–typically featured in Chinnar in the rainshadow eastern part of Anamalai region.

The rainfall patterns exhibited in the State are mainly governed by the Orographic layout.

From the potential vegetation point of view, the state can be divided into three zones–

(1) area under moist tropical;
(2) area under tropical attenuated and
(3) area under tropical montane.

Potentially the state is endowed with tropical forest. But development of cultural landscape from the coast to inland has caused wide-spread forest clearence. And the entire coast and midland are virtually devoid of natural vegetation cover. These areas are marked Attenuated tropical.

Considering these parameters as well 12 bio-climatic zones can be indentified (Fig. 2). While rainfall and temperature combination have been marked by shading, the potential vegetation and rainfall pattern are denoted by letter symbols. It emerges from the figure no. 2 that to the north and south of the Palghat gap there is some amount of sembalance of bio-climatic zones, determining the orographic control on vegetation types.

CONCLUSION

Analysis of the individual parameters and their synthesis in a spatial scale as done in this study, have brought out the bio-climatic assemblages. Even though there are large number of factors which control the biom and climatic relationship, the principal contributors are rainfall and temperature. Again these two factors are governed by orography, vegetation cover, and geographical location of the area.

It also emerges from this analysis, though in a limited manner, that reconstruction of bio-climatic sites is possible with the available data. This helps to identify areas for suitable vegetation rehabilitation. For example, the entire coastal areas are found to be capable of holding moist tropical forests. Similarly in the north the zones denoted as R.A. which is at present devoid of natural vegetation can be aforesaid with tropical moist deciduous types.

This exercise is an open ended one with a limited data base. However, it provides significant information about bio-climatic assemblages based on which eco-restoration plans could be effectively programmed and can be suitably developed with proper field checks. It is important to investigate each one of these twelve bio-climatic zones separately in a microlevel to frame operational planning.

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REFERENCES

Centre for Earth Science Studies (1984) : Resource Atlas of Kerala, Trivandrum.

Chattopadhyay, S. (1985) : Deforestation in parts of Western Ghats, Kerala (India). Jour. of Env. Management, London. V. 20, pp. 219–230.

Chattopadhyay, S., Velayutham, S. and Salim, M. B. (1986) : Trends of deforestation in Kerala with case studies in the upper catchment of Valapatanam river and Mangalam–Gayathripuzha basin. Proceedings of the seminar on " Environmental Aspects of Geology " (Underpublication).

Department of Geography, Osmania University (1974) : Andhra Pradesh Planning Atlas Hyderabad.

Davidson, D. A. (1982) : The assessment of Landuse capability : In proceedings of the First International Symposium on Soil, Developing countries. Bangkok, pp. G2.1—G2.57.

Gauseen, H., Legris, P. and Meher-Homji, V. M. (1968) : International map of vegetation and environmental conditions—India, sheet—Cape Comorin. French Institute—Pondicherry, India.

Gupta, R. K. and Saxena, S. K. (1971) : Integrated ecological survey for agricultural development in the arial zones of India. 1. Chohtan community development block in Barmer district, Rajasthan, Ann. of Arial zone, pp. 85–98.

Gupta, R. K. (1978) : Ecological distribution and amplitude of some indigenous species vis–a–vis their role in afforestation of the arial regions of N. W. India. Environ. Physiol. Ecol. Plants. pp. 423–436.

Jarrett, H. R. (1977) : Tropical geography—An introductory study of the humid tropics. Macdonald and Evans Ltd. Plymouth, U.K.

Odum, E. P. (1971) : Fundamental of Ecology, London.

Rao, A. S. and Vamadevan, V. K. (1982) : A climatic study of water availability periods in Kerala. Ann. of the National Asso. of Geographers, India. Vol. 2, pp. 1–7.

Ram Mohan, H. S. and Subramanyam, V. P. (1983) : Application of water balance in agricultural planning and operations in south India. The National Geographical Journal of India. Vol. 29, pp. 30–34.

Rao, A. S., Varthan, K. M. and Vamadevan, V. K. (1985) : Evaporative index for scheduling irrigation in plantation crops : Mausam, Vol. 36, pp. 205–208.

Thoruthwaite, C. W. (1931) : Climates of North America. Geographical Review. Vol. 21 pp. 633–655.

Thie, J. and Ironside, G. (1976) : Ecological (biphysical) land classification in Canada : Ecological land classification series No. 1, Lands Directorate, Environment, Canada.

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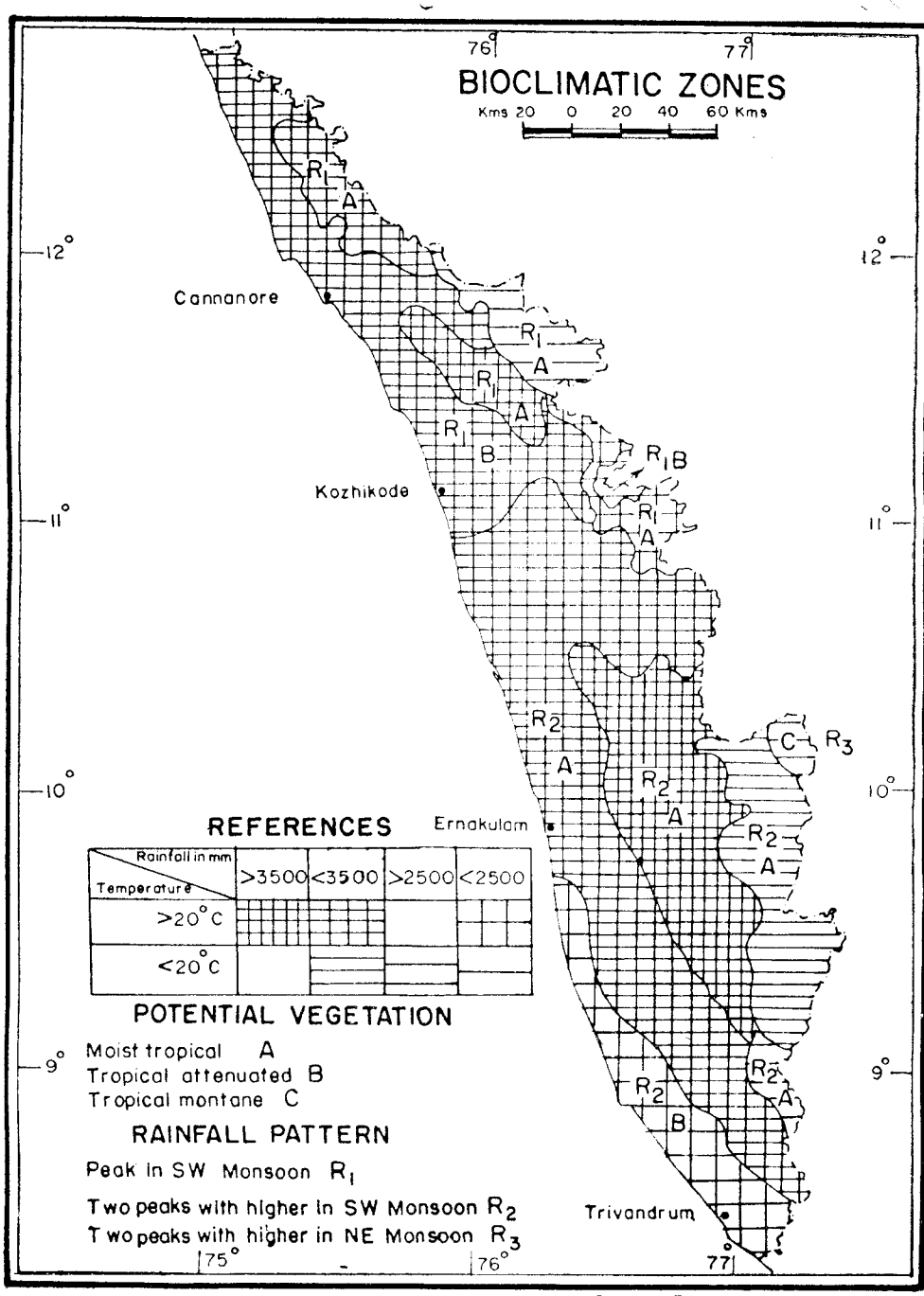

Source: Resource Atlas of Kerala

Fig. 1

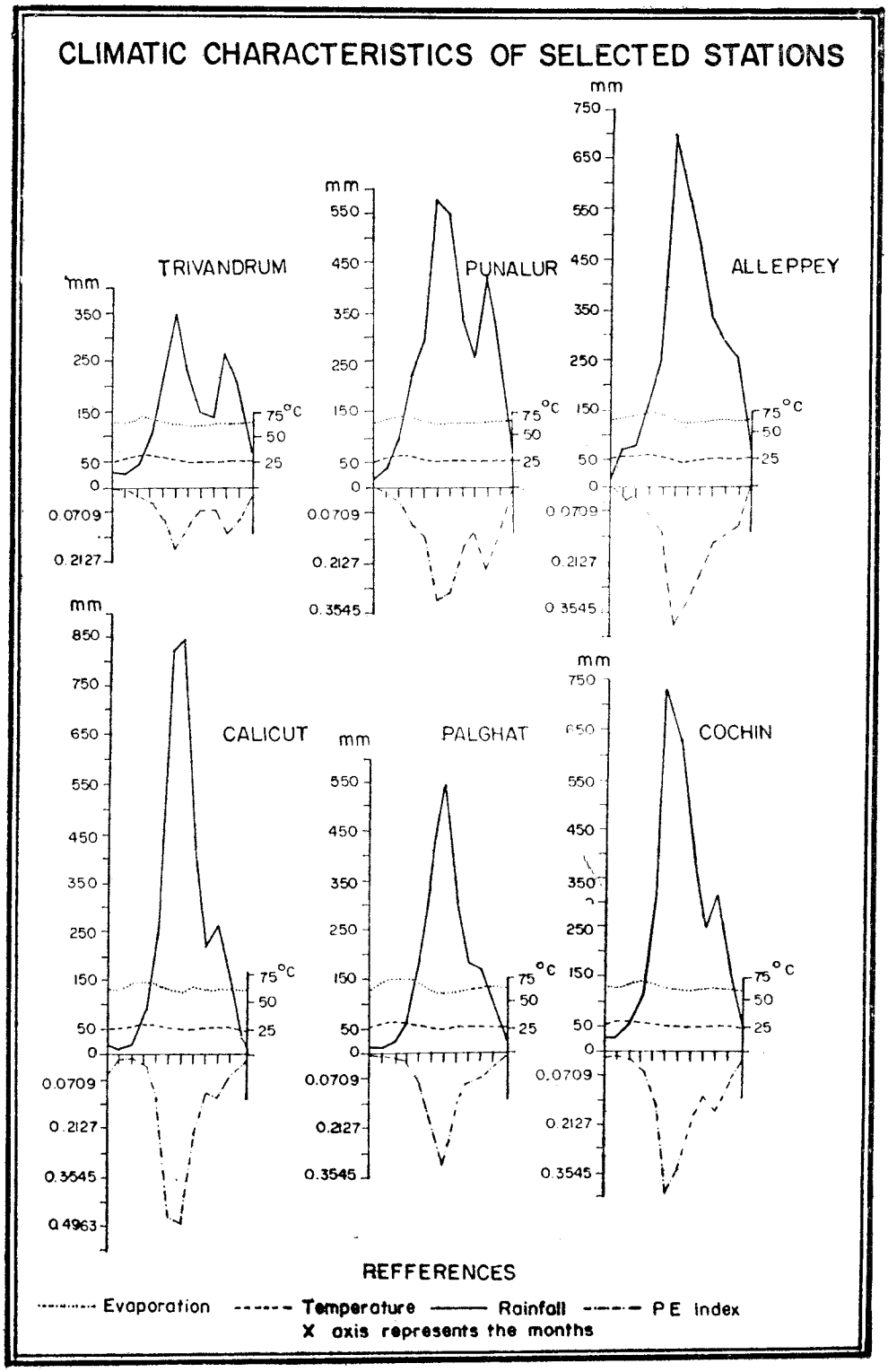
CLIMATIC CHARACTERISTICS OF SELECTED STATIONS
TRIVANDRUM
PUNALUR
ALLEPPEY
CALICUT
PALGHAT
COCHIN
mm
°C
75
50
25
0.0709
0.2127
0.3545
0.4963
REFFERENCES
Evaporation
Temperature
Rainfall
P E Index
X axis represents the months

Fig. 2