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Thermal regions in Sri Lanka

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सार — इसमें श्रीलंका के गरम क्षेत्रों के वस्तुनिष्ठ वर्गीकरण की आवश्यकता पर बल दिया गया है। श्रीलंका की गरम जलवायु का संक्षिप्त विवरण दिया गया है। खंड, गुच्छ, तथा त्रिभेदी विश्लेषण का प्रयोग करते हुए तापीय घटकों पर आधारित परिमाणात्मक रूप से क्षेत्रीय वर्गीकरण करने का प्रयास किया गया है। गुच्छ के तीन वर्गों को चुना गया है और उनका मानचित्रण किया गया है। इसमें परिणामों की व्याख्या की गई है तथा इनकी तुलना श्रीलंका के ज्ञात तापीय स्वरूप से की गई है।

ABSTRACT. The need for an objective classification of the thermal regions of Sri Lanka is emphasised. A brief account of the thermal climate of Sri Lanka is given. Regionalization based on thermal factors has been attempted quantitatively using factor, cluster and discriminant analysis. Three groups of cluster have been selected and mapped. The results are interpreted and related to the known thermal patterns of Sri Lanka.

Key words — Thermal climate, Altitude, Regionalization, Clusters.

1. Introduction

Sri Lanka is an island situated between latitudes 5°55′ to 9°55′N and longitudes 81° to 83°E. Due to its location, high solar intensity and high temperatures prevail in the lowlands throughout the year. Variability in temperatures is caused by altitudinal effects and the seasonal cloudiness cycle of the monsoons. Identification of homogeneous thermal regions would have significant practical use for the diverse land utilisation of the island. Clarification of the distribution of the thermal regions will assist in planning for agriculture and crop production, especially as Sri Lanka is paying particular attention to the promotion of non-traditional crops in the plantation areas and diversification in lowland agricultural areas.

Previous investigations into the thermal classification of Sri Lanka have been made by Cook (1953), de Silva (1954), Thambyahpillay (1955) and Domros (1974). Only the study by Thambyahpillay (1955) attempted to identify thermal regions. Two basic regions were classified by him as follows :

A — lowlands thermal region,

B — highlands thermal region.

These two regions were demarcated on the basis of the 77°F (25°C) mean annual isotherm. Both of these areas were further sub-divided into five thermal regions on the basis of annual, seasonal and monthly temperatures and temperature ranges. Fig. 1 shows the details of the thermal regions (Thambyahpillay 1955). These thermal regions have been identified subjectively by considering a single isotherm for the major grouping and other thermal characteristics for the minor groupings. The western plateau region (B4) is shown as a 'hypothetical region' that has not been represented by a single temperature recording station. The homogeneity of the eastern highland region (B2) would seem to be open to question as considerable topographical variation exists between the western and eastern slopes of this region. There are a number of boundaries where the regions could be debated.

Therefore, a classification of thermal regions for Sri Lanka should be provided using an objective scheme that would enable all available recorded data to be used as input variables. Such a scheme should give more realistic results. Thus the prime aim of this paper is to determine the homogeneous thermal regions of Sri Lanka in an objective manner. Before such an attempt is made, a brief account of the thermal climate of Sri Lanka is desirable in order to provide a better understanding of the interpretation of thermal regions (Fig. 1) given as follows :

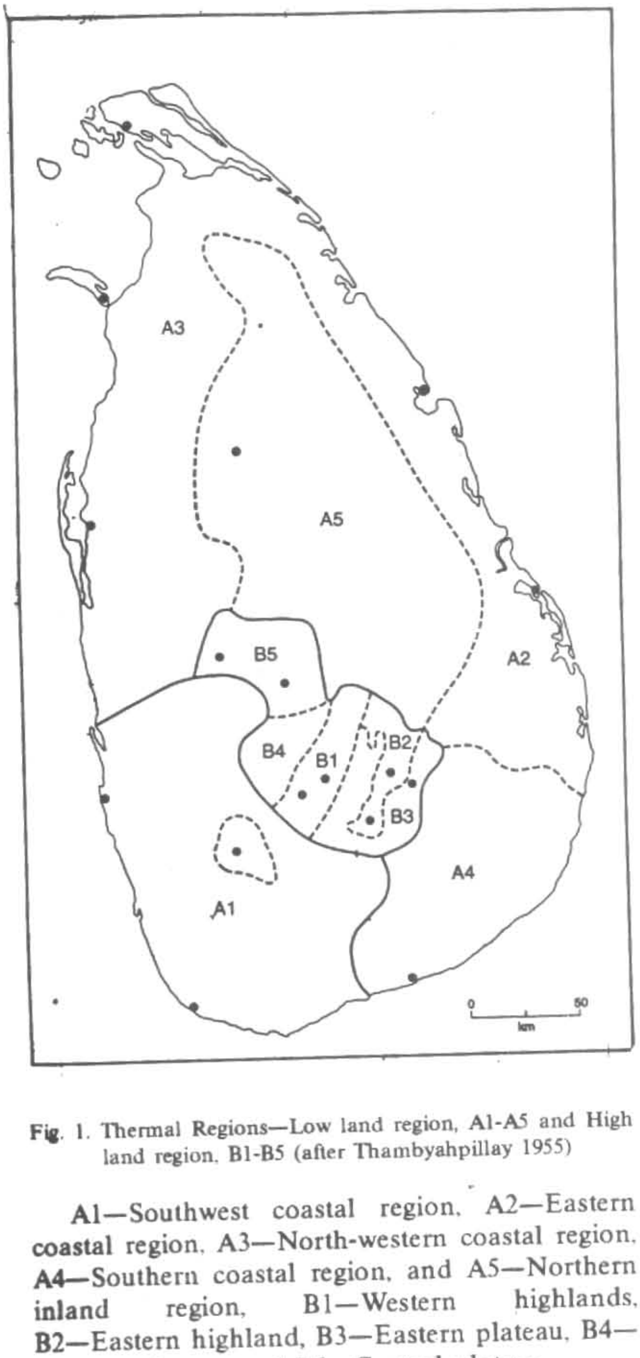

Fig. 1. Thermal Regions—Low land region, A1-A5 and High land region, B1-B5 (after Thambyahpillay 1955)

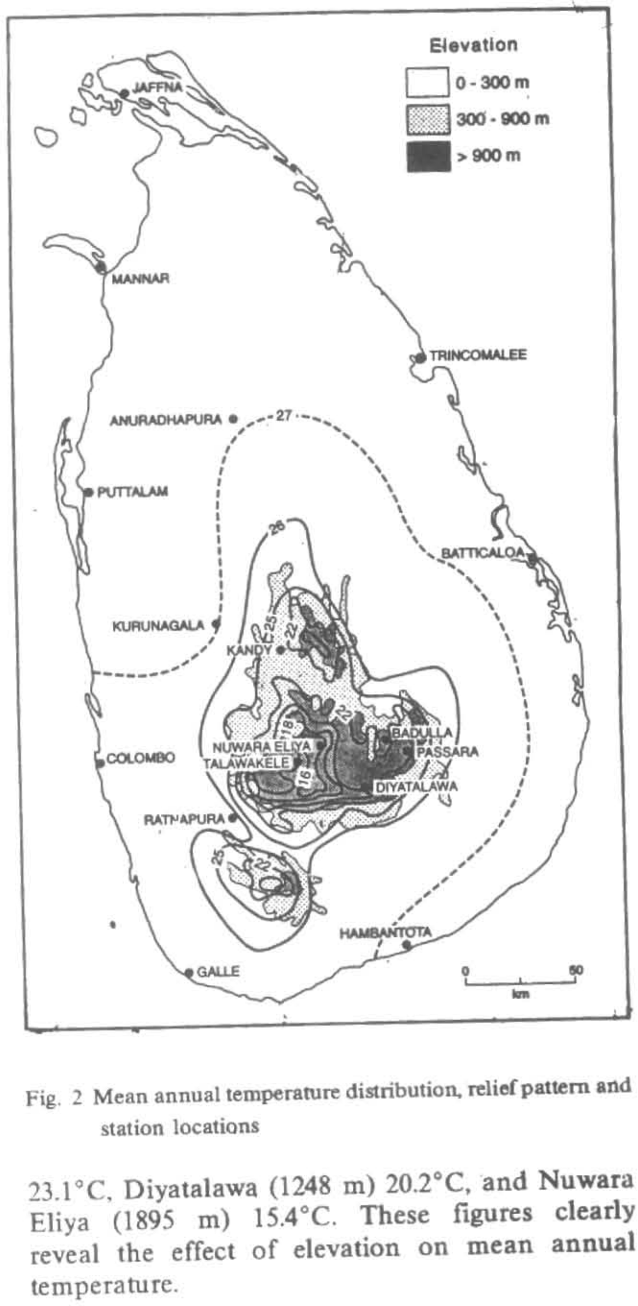

Fig. 2 Mean annual temperature distribution, relief pattern and station locations

A1—Southwest coastal region, A2—Eastern coastal region, A3—North-western coastal region, A4—Southern coastal region, and A5—Northern inland region, B1—Western highlands, B2—Eastern highland, B3—Eastern plateau, B4—Western plateau and B5—Central plateau

1.1. *Pattern of temperature in Sri Lanka*

1.1.1. *Mean temperatures and vertical variation*

The mean annual temperature is over 26.5°C throughout the lowlands of Sri Lanka. It varies between 26.5° and 28°C in the lowlands up to an altitude of 100 m to 150 m, *e.g.*, Jaffna (27.6°C), Trincomalee (27.8°C), Hambantota (27.1°C), Galle (26.6°C) and Anuradhapura (27.3°C) (Fig. 2 and Table 3). In contrast, mean annual temperatures in the Central Highlands decrease rapidly due to altitude, *e.g.*, Kandy (477 m) 24.4°C, Badulla (670 m) 23.1°C, Diyatalawa (1248 m) 20.2°C, and Nuwara Eliya (1895 m) 15.4°C. These figures clearly reveal the effect of elevation on mean annual temperature.

Thambyahpillay (1955) pointed out that the mean thermal gradient is 3.5°F per 1000 feet (0.64°C per 100 m) which is very close to the average environmental lapse rate (Barry 1990). In view of the thermal differences between the western (wet highlands) and eastern (dry highlands) slopes of the Central Highlands and the different air masses affecting them, it is likely that the temperature gradient will also vary. This fact was not considered by Thambyahpillay (1955) in quoting a mean figure for Sri Lanka. Domros (1974) was the first to highlight the differences in lapse rate between the dry and wet zone slopes. According to him, "a vertical temperature gradient or normal lapse rate of temperature on the western slopes amounts to about 0.65°C per 100 m and on the eastern slopes to about 0.5°C per 100 m"

However, the lapse rates derived by Puvaneswaran (1992) using six highland stations, representing sites from both the dry and wet highland slopes with Colombo as a base station for the wet zone slopes and Batticaloa for the dry zone slopes, differ from the previous suggestions. The derived lapse rate figures revealed that variations in lapse rate prevail only upto a height of about 1000 m, *e.g.*, the lapse rate to Kandy (477 m) is 0.52°C per 100 m, whereas to Badulla (670 m) it is 0.65°C per 100 m. This result would be expected in view of the higher moisture content of the western slopes of the highlands. However, a greater consistency in lapse rate (0.58°C to 0.61°C per 100 m) has been found above the 1000 m elevation, despite the moisture variation that might be expected between the wet and dry highlands. The lapse rates derived for the wet zone slopes were 0.60°C per 100 m (Nuwara Eliya 1895 m) and 0.62°C per 100 m (Talawakele 1375 m), while for the dry zone slopes, 0.58°C (Diyatalawa 1248 m) and 0.62°C (Passara 1007 m) were obtained respectively. Previous work by Puvaneswaran and Smithson (1991) has shown that above 600 m, precipitation levels no longer increase and by 1500 m, precipitation differences between the two slopes are not great. Hence lapse rates are less likely to differ.

The lapse rate value for the dry zone differs from that suggested by Domros (1974). The single lapse rate figure (0.64°C) given by Thambyahpillay (1955) seems an over-estimate if applied to all areas. In the light of the above findings it could be concluded that to predict temperature at a given altitude one of three lapse rate figures needs to be used depending upon location. For elevations above 1000 m the lapse rate of 0.60°C per 100 m is most appropriate for mean annual temperature irrespective of location. Below this height, the lapse rate of 0.52°C per 100 m for wet zone slopes and 0.64°C per 100 m for the dry zone slopes should be used. These figures clearly reflect the thermal and moisture properties of the airflows that prevail on the wet and dry zone slopes, and support the value given by Tabony (1985) of 0.5°C per 100 m for the lowlands in the humid tropics.

1.1.2. *Annual and diurnal temperature ranges*

The annual temperature range is of limited significance in Sri Lanka. It varies from 1.5°C (at Talawakele in the Highlands) and 1.8°C (at Galle on the south coast) to 4.2°C (at Trincomalee and Batticaloa on the east coast) with a clear tendency of increasing temperature range in a southwest to northeast direction as shown in Fig. 3. The diurnal temperature is far more significant than the annual course of temperature. It is even the most noticeable thermal feature in the equatorial climate. In order to explain the thermal climate of Sri Lanka in a meaningful manner, Troll (1943) introduced a term 'thermic diurnal climate'. This term was later used by Domros (1974) to analyse in detail the temperature for two representative stations: Colombo for the lowlands and Nuwara Eliya for the highlands. The term indicates that, "the differences in temperature involve exclusively or predominantly the diurnal and not the annual course". Fig. 4 illustrates

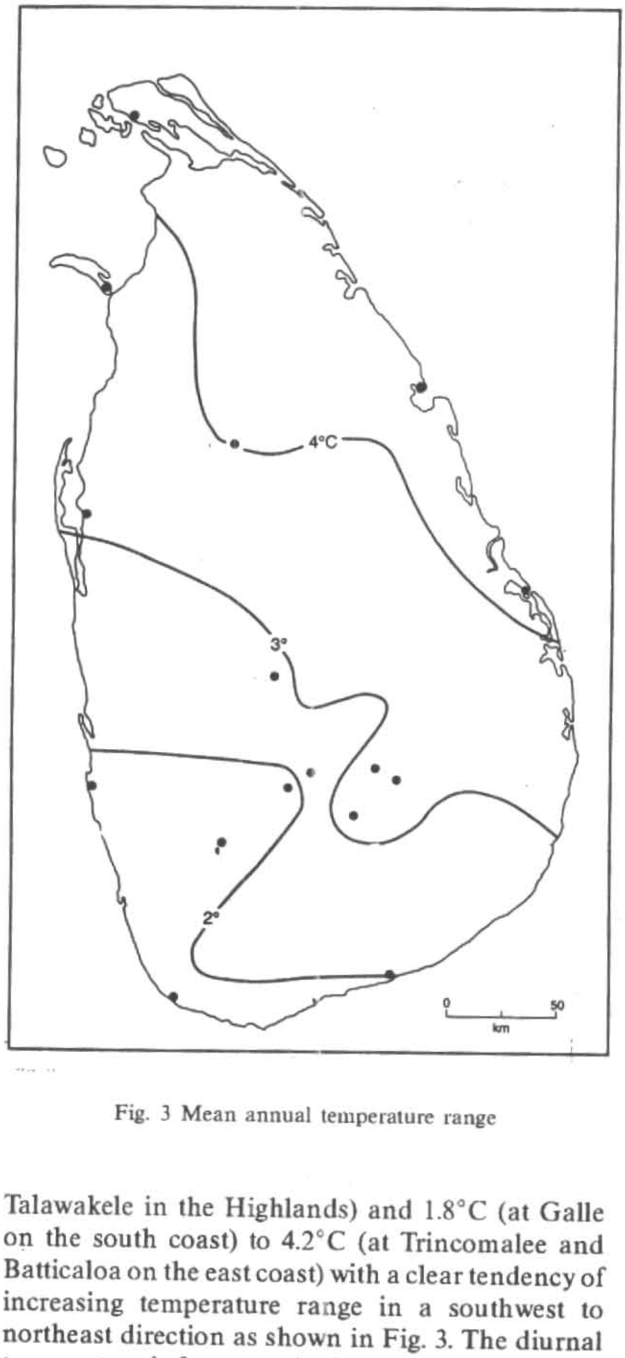

Fig. 3 Mean annual temperature range

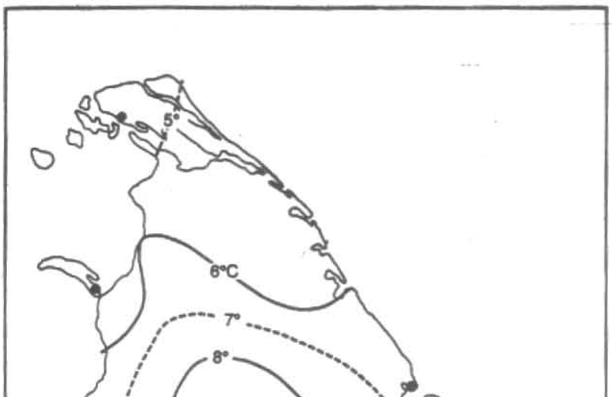

Fig. 4 Pattern of mean diurnal temperature range

the considerable spatial variation of diurnal temperature range increasing towards the Central Highlands. The extreme northern (Jaffna) and southern (Galle) locations have the smallest amplitude (4.8°C and 4.7°C) whilst the highest is recorded in the Central Highlands, *i.e.,* Badulla, 9.8°C and Nuwara Eliya, 9.4°C. When considering the seasonal diurnal temperature range, it is higher during the inter-monsoon seasons, (March and April, October and November) than during the NE and SW monsoon seasons.

2. Data and methods

Seventeen sites were selected on the basis of the availability of homogeneous data and their spatial representation (Fig. 2). Fifteen of the sites were official meteorological stations; the other two stations were Talawakele, a tea research institute site and its sub-station in Passara. Although the lowlands are adequately represented, the highlands with their topographical and climatic complexity are more of a problem. On the western slopes, at least one station represents the lower, intermediate and top hill country respectively. (These divisions were made subjectively using the mean annual isotherms of less than 22°C and less than 18°C that approximately correspond to the heights of 800 m and 1600 m respectively). However, on the eastern slopes, while the lower and intermediate highlands of the Uva basin were represented by three stations, no data were available for the highest areas. At each site, except Passara (which commenced in 1932), mean monthly temperatures were available for the period 1931-60 with no missing values.

A correlation matrix was computed from a 37×37 data matrix of the orginal variables (see Table 1). It reveals exceptionally high coefficients for each pair of variables in all observations.

Factor analysis was initially performed to reduce the original 37 variables (Table 1) to three appropriate orthogonal factors. The factors that have eigenvalues greater than one have been chosen as significant.

Table 1 shows the derived correlations for each variable in four classes. In addition, r^2 values are also included as they are the direct proportion of the variance "accounted for" by one variable with another. Accordingly monthly mean minimum and maximum temperatures have shown high levels of inter-correlations and this accounted for 64% of the total variance, while monthly and annual ranges have less than 5 correlations above 0.75. At this stage it was evident that factor analysis would be an effective technique for reducing the complex matrix to a smaller number of "composite variables" extracted from the original data matrix.

The correlation matrix was then subjected to factor analysis and the resultant factor loading matrix was rotated, applying the varimax procedure. The unrotated factor solution reduced the 37×37 matrix to three factors with eigenvalues greater than 1. This criterion has been widely used in previous studies (McBoyle 1971, Atwoki 1976, Barring 1986, Puvaneswaran 1992, Puvaneswaran and Smithson 1993). For the factor extraction from the covariance matrix, principal component analysis was adopted. The unrotated factor solution reduced the original

TABLE 1

Number of correlations in various ranges

X_i Variables (37)	$r < 0.25$ $r^2 = 0.0625$	0.25–0.50 0.0625–0.25	0.50–0.75 0.25–0.56	0.75> 0.56>
Min temp.				
X1 Jan	3	1	9	23
X2 Feb	2	3	7	24
X3 Mar	3	2	7	24
X4 Apr	3	2	7	24
X5 May	1	4	7	24
X6 Jun	1	4	7	23
X7 Jul	0	5	8	23
X8 Aug	1	4	7	24
X9 Sep	1	4	8	23
X10 Oct	1	4	8	23
X11 Nov	3	2	8	23
X12 Dec	4	1	8	23
Max temp.				
X13 Jan	5	7	1	23
X14 Feb	6	7	2	21
X15 Mar	10	3	0	23
X16 Apr	4	9	0	23
X17 May	4	3	6	23
X18 Jun	4	3	7	22
X19 Jul	6	1	9	20
X20 Aug	6	3	7	20
X21 Sep	6	4	4	22
X22 Oct	4	9	0	23
X23 Nov	6	7	0	23
X24 Dec	4	8	4	20
Diu range				
X25 Jan	10	6	1	4
X26 Feb	8	4	19	5
X27 Mar	6	7	18	5
X28 Apr	2	13	13	8
X29 May	6	9	16	5
X30 Jun	20	11	1	4
X31 Jul	20	11	1	4
X32 Aug	14	17	0	5
X33 Sep	12	18	1	5
X34 Oct	4	11	17	4
X35 Nov	5	9	17	5
X36 Dec	8	5	18	4
X37 Anu Tem Range	20	14	2	0

Min—Minimum, Max—Maximum,
Diu—Diurnal, Tem—Temperature,
Anu—Annual

data matrix to three components that accounted for 97.4% of the original total variance. The percentage explained by each of the three components was 70.1%, 15.3%, and 12.0% respectively. Three factors accounting for over 97% of the variance implies relatively little variation of the temperature pattern in Sri Lanka. The results obtained by the factor analysis at this stage do not give an optimum solution. In order to maximise the variance of the loading of each factor and improve the interpretation of the results, variance rotation was performed. Three factors were derived from the rotation of the component scores and they are referred to as follows :

Factor 1 — Monthly mean minimum and maximum temperature factor.

Factor 2 — Mean annual and monthly mean diurnal temperature range during northern winter months (November to April).

Factor 3 — Monthly mean diurnal temperature range of summer half year (May to October).

Factor scores of the rotated solution of the three factors, the eigenvalues and percentage explanation of the total variance for each of the three major factors are given in Table 2.

The three components and higher loadings associated with them in the rotated factor scores reveal that all the variables considered are significantly contributing towards the extracted factors and any reduction in selection of the variables would not give meaningful results in the present context. However, having factor one with the highest loading (mean monthly mimimum and maximum) reveals that instead of monthly minimum and maximum temperatures, mean monthly values can be used.

Finally, the initial correlation matrix was transposed to group the observations as components. The outcome was not surprising; a one factor solution was produced which means factor analysis fails to detect any group among the 17 observations for the type of data presented. The exceptionally high inter-correlation coefficients had demonstrated this earlier. Therefore, in order to achieve the objective of the aim of this study, cluster analysis using Ward's method (Ward 1963) and discriminant analysis were employed for the three factor scores derived using the SPSS (version 4) computer program.

TABLE 2

Matrix of rotated factor loading

Factor No			I	II	III
Eigen value			25.946	5.665	4.432
Percentages of total variance or communality			70.1	15.3	12.0
S. No.	Variable	Percentage communality over three factors	Sorted variable loading on components		
1.	Min Tem Jan	0.984	0.854	0.854	−0.209
2.	Min Tem Feb	0.983	0.848	0.848	−0.217
3.	Min Tem Mar	0.986	0.858	−0.401	−0.236
4.	Min Tem Apr	0.994	0.862	0.425	−0.262
5.	Min Tem May	0.996	0.849	0.416	−0.317
6.	Min Tem Jun	0.986	0.841	0.406	−0.336
7.	Min Tem Jul	0.992	0.866	0.400	−0.287
8.	Min Tem Aug	0.993	0.847	0.383	−0.258
9.	Min Tem Sep	0.992	0.852	0.389	−0.339
10.	Min Tem Oct	0.998	0.863	0.411	−0.290
11.	Min Tem Nov	0.997	0.872	0.419	−0.249
12.	Min Tem Dec	0.992	0.866	0.438	−0.220
13.	Max Tem Jan	0.983	0.995	−0.067	−0.323
14.	Max Tem Feb	0.995	0.959	−0.111	−0.252
15.	Max Tem Mar	0.980	0.977	−0.043	−0.153
16.	Max Tem Apr	0.984	0.979	0.140	−0.073
17.	Max Tem May	0.992	0.934	−0.339	0.063
18.	Max Tem Jun	0.996	0.865	0.474	0.146
19.	Max Tem Jul	0.994	0.861	0.467	0.190
20.	Max Tem Aug	0.996	0.887	0.418	0.185
21.	Max Tem Sep	0.992	0.907	0.376	0.168
22.	Max Tem Oct	0.995	0.964	0.255	0.026
23.	Max Tem Nov	0.988	0.985	0.067	−0.115
24.	Max Tem Dec	0.981	0.947	−0.007	−0.289
25.	Diu Ran Jan	0.983	−0.217	−0.963	−0.089
26.	Diu Ran Feb	0.983	−0.244	−0.948	0.046
27.	Diu Ran Mar	0.961	−0.330	−0.877	0.234
28.	Diu Ran Apr	0.932	0.399	−0.746	0.493
29.	Diu Ran May	0.958	−0.396	−0.389	−0.818
30.	Diu Ran Jun	0.977	0.087	0.073	0.967
31.	Diu Ran Jul	0.948	0.088	0.100	0.974
32.	Diu Ran Aug	0.967	−0.128	−0.009	0.984
33.	Diu Ran Sep	0.985	−0.178	−0.178	0.966
34.	Diu Ran Oct	0.993	−0.303	−0.546	0.774
35.	Diu Ran Nov	0.989	−0.251	−0.909	0.313
36.	Diu Ran Dec	0.988	−0.272	−0.951	−0.016
37.	Anu Tem Ran	0.979	0.128	0.613	0.463

N. B. — Min-Minimum, Max-Maximum, Diu-Diurnal, Anu-Annual, Tem-Temperature, Ran-Rainfall.

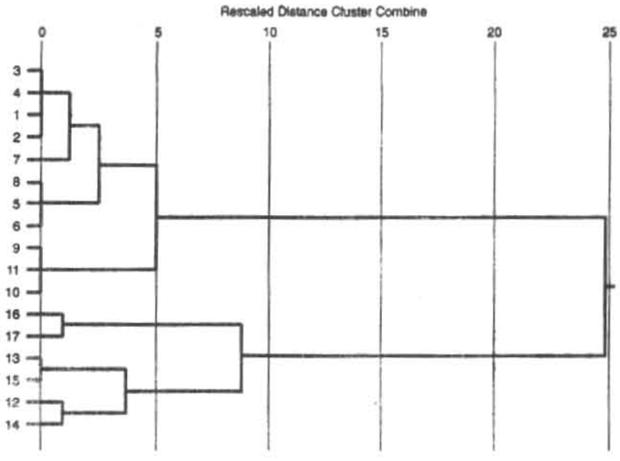

Fig. 5. Dendrogram produced by cluster analysis

The computer program for Ward's method of cluster analysis produced two to ten cluster groups. Each cluster group will have a spatial variation in terms of space in ascending order. However, for the purpose of the present study, three, five and eight cluster groups have been arbitrarily selected as they explain sufficiently the pattern of the cluster decomposition and also represent the low, middle and higher order of cluster groups considered: maps have been drawn accordingly. The distance grouping procedure and its resultant cluster grouping with a linkage tree constructed by computer is given in Fig. 5.

There is no agreement on rules or formulae for the selection of these cluster groups. One could select any number of cluster groups within the given possibilities computed from this method. Since the sole purpose of this study is to focus on the thermal regions, all the above mentioned cluster groups have been considered to illustrate the spatial variations. Further, when taking relatively few cluster groups into consideration, it is easier to visualise the cluster decomposition in a spatial context. Thus, on a spatial map, it is clear how the homogeneous thermal regions are formed according to various cluster groups [Figs. 6(a-c)].

Subsequently, discriminant analysis was also carried out in order to test the validity of the previously derived cluster groups. For this purpose, "eight cluster coding" has been taken as an input variable or 'actual probability groups' in order to derive their 'highest probability groups' and the probability levels of each case being to that 'given actual group'. Since the results of the discriminant analysis confirm the 'cluster grouping' with very high probability levels (< 0.001), it is not necessary to change the groups. Thus cluster groupings are taken as valid in probability terms.

An explanation of the mathematical part of these techniques is not provided here as abundant literature is available in text books (Romesburg 1984, Bock 1975) and advanced computational facilities are available in the SPSS-X (4th edition, 1990) package program to apply these techniques as used in the present study.

3. Results

3.1. *Thermal regions in Sri Lanka*

From the distance grouping technique, thermal regions have been identified. For this purpose three, five and eight cluster groups have been arbitrarily chosen and mapped. Fig. 6(a) illustrates two distinctive thermal regions that could be referred to as :

(1) lowlands thermal region.

(2) highlands thermal region.

These two basic patterns are clearly shown in the linkage tree diagram. When the demarcation line between these two macro regions was drawn, physiographic features were also considered: ignoring this information would only produce an unrealistic boundary especially when the number of temperature measuring stations is inadequate to represent the complex physiography of the Central Highlands. This boundary runs approximately along the 200 m contour or 26°C isotherm. The thermal variations between these two regions are distinctive in character as explained earlier.

Fig. 6(b) illustrates a marked division in the lowlands thermal region that could be termed as coastal lowland region and inland lowlands region. The inland lowlands region lies between the highlands and coastal lowlands. Having examined the linkage tree it was decided to choose the eight cluster numeric grouping for further description. The spatial map constructed with eight cluster groups was sufficient to provide adequate explanation of the pattern of thermal regions in Sri Lanka. Fig. 6(c) also clearly reveals three areas that, from

Figs. 6(a-c). Spatial patterns of thermal regions of Sri Lanka

their size, could be termed as meso-scale regions and are as follows :

(1) coastal lowlands region.

(2) inland lowlands region.

(3) highland region.

The five and eight cluster groups [Figs. 6 (b & c)] show a distinction between the coastal and inland low country thermal regions except in the southern plain where the absence of this region is a noticeable feature. A possible explanation for this pattern would be the relatively shorter distance between the coast and central highland in the south. This pattern was also seen in the classification of Thambyahpillay (1955) (Fig. 1).

Fig. 6(c) also gives further details of the subdivision of the meso scale thermal regions. These sub-divisions could be referred to as micro-thermal regions. It is noteworthy that, at the eight cluster groups, the coastal lowland regions are divided into two homogeneous regions.

I (a)-the south, west, and northern coastal lowlands region.

I (b)-eastern coastal lowlands region.

II-The low-inland region has emerged with no groups at the eight cluster level. However, when considering the tenth cluster iteration (not shown) this unique region is divided into two, having one region in the north around Anuradhapura and the other being represented by Kurunagala and Ratnapura.

The highlands region was divided into five micro-thermal regions which are referred to as :

III (a)—northern plateau region.

III (b)—eastern plateau region.

III (c)—southern mid-highland region.

III (d)—western mid-highland region, and

III (e)—highland region.

Brief details of the thermal characteristics are given in Table 3 for the representative stations chosen for each of the thermal regions.

It is desirable to compare the above thermal regions with those subjectively determined by

TABLE 3

Thermal characteristics of the eight cluster regions

Cluster region	Thermal region	Station	Altitude (m)	Mean annual temp.	Mean annual range	Highest mean monthly temp.	Lowest mean monthly temp.	Mean annual diurnal range
I (a)	S. W & N coast	Hambantota	16	27.1	2.0	28.0	26.0	6.2
		Galle	13	26.6	1.8	27.6	25.8	4.7
		Colombo	7	26.9	1.8	27.9	26.1	6.1
		Puttalam	2	27.2	3.1	28.7	25.5	6.7
		Mannar	4	27.8	3.5	29.5	26.0	5.2
		Jaffna	4	27.6	4.0	29.4	25.4	4.8
I (b)	E Coastal lowlands	Trincomalee	3	27.8	4.3	29.9	25.6	6.4
		Batticaloa	3	27.4	4.1	29.5	25.3	6.3
II	W. N & E Inland lowlands	Ratnapura	34	27.1	1.5	28.1	26.6	8.7
		Kurunagal	116	27.0	2.6	28.3	25.7	8.2
		Anuradhapura	93	27.3	4.0	28.7	24.7	8.8
III (a)	Northern and western plateau	Kandy	477	24.4	2.9	26.0	23.1	8.8
III (b)	Eastern plateau	Badulla	670	23.1	3.2	24.7	21.2	9.8
III (c)	Southern mid-highland	Diyatalawa	1248	20.2	3.2	21.4	18.2	8.8
		Passara	1007	21.3	3.5	22.7	19.2	7.4
III (d)	Western mid-highland	Talawakele	1375	18.6	1.5	19.7	18.2	8.9
III (e)	Central highlands	Nuwara Eliya	1895	15.4	2.4	16.7	14.3	9.4

Thambyahpillay (1955). As pointed out earlier, he derived these regions using annual and diurnal temperatures. Although there are similarities in the coastal and low-inland regions, particularly in the west, north, east and south-eastern parts, the south-western part has little relationship to the present classification. Furthermore, even when considered into 10 cluster groups, Colombo will be grouped with Puttalam to make one homogeneous group, while Galle will be grouped with Hambantota. However, Galle, Colombo and Ratnapura are grouped into a wider region in his classification (Fig. 1). This pattern of demarcation suggests that the author must have attempted his classification taking into account the conventional climatic regions, *i.e.*, the wet and dry zones. The south-western part demarcated as A1 or the SW coastal region, resembles the conventional rainfall based classification of the wet zone lowlands, an area that receives more than 75 inches of rainfall during the SW monsoon season.

The highland regions suggested by Thambyahpillay (1955) are not in any way comparable with the present classification: grouping Kurunagala (116 m) with Kandy (447 m) is unrealistic. In the present case Kurunagala is linked with Ratnapura (34 m) and Anuradhapura whilst Kandy represents a wider plateau region. Moreover, the 'hypothetical' region shown in Fig. 1 is not a desirable group as it has no station to represent it and it is unclear how this region was demarcated.

4. Conclusion

The thermal climate of Sri Lanka has been re-exmined briefly and a review of previous classifications of thermal regions has been made. The determination of the thermal regions of Sri Lanka has been attempted by means of factor. cluster and discriminant analysis. Factor analysis reduced the 37×37 data matrix into three principal components. However, a factor solution for the flipped variables (17×17) was not successful for a factor-based classification as the solution detected only one significant component. At this point it was decided to use the cluster and discriminant analysis for the classification of thermal regions. Four and eight cluster groups have been chosen for spatial mapping. The derived thermal region (eight cluster group) was compared with previous work. Brief details of thermal characteristic are given in Table 3 for the representative stations chosen for each of the thermal regions.

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