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Provisional Climatic Regions of Peninsular Malaysia

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RINGKASAN

Dengan menggunakan sistem keterangan geografi berasaskan komputer mikro untuk Semenanjung Malaysia bersama-sama suatu aturcara mudah analisis kelompok, sebuah klasifikasi statistik sementara bagi zon iklim telah disediakan. Lapan zon berasingan telah dikenalpasti dan dihuraikan seperti 'kawasan rendah dan bercahaya' serta 'kawasan tinggi basah dan berawan'. Zon-zon ini dihuraikan sementara kerana beberapa sebab tertentu termasuk penghadan maklumat asas. Walau bagaimanapun prosedur-prosedur yang digunakan mempunyai potensi luas yang boleh membantu dalam bidang perancangan sekitaraan dan perancangan guna-tanah.

SUMMARY

Using a micro-computer based geographic information system for Peninsular Malaysia and a simple method of cluster analysis, a provisional statistical classification of climatic zones was produced. Eight separate zones were identified and were described in terms such as 'dry sunny lowlands' and 'wet cloudy uplands'. For a number of reasons, including limitations in the data base, these zones are described as provisional. The procedures involved however have great potential for contributing to better environmental and landuse planning.

INTRODUCTION

Land classification is a step towards sound enviromental planning. It can provide a framework for systematic data gathering and mechanism for making land related decisions which repond adequately to land constraints without being detailed beyond the comprehension or endurance of the decision-makers. Especially in circumstances where time and money are not available for very detailed data gathering and processing, land classification is the normal first stage in the simplification of land planning studies.

The approach to land classification taken most frequently has been described as the gestalt method (Hopkins, 1977). The implication of this characterisation is that all pertinent factors are brought together in one place – often into the head of one person – and by processes which cannot be rigorously defined, a set of boundaries is created on a map or on aerial photographs. When working at a broad scale (1:250,000 or smaller) the primary factors considered are climatic variables and the classification is called 'genetic'. At more detailed scales (1:250,000 and larger) variables such as soils, vegetation and land use are brought into the analysis and the resulting classification is variously called 'landscape', 'ecological' or 'terrain' classification (see Mabbut (1968), Rowe (1979) or Grant (1972)).

In dealing with the whole of Peninsular Malaysia, any classification is necessarily at a fairly broad scale – at which climatic factors tend to dominate land and land-use patterns. Nevertheless, in the author's view, a land classification of the peninsula snould include at least data on soils, drainage, and vegetation in addition to climate. These data were not included, for reasons set out below, and so the title of this paper refers only to definition of climatic regions. The techniques to be described however are applicable whatever starting data is chosen.

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The advantages of statistical methods of land (or climate) classification have been set out by Bunce *et al.*, (1974), Laut *et al.*, (1980) and Smith (1982). In broad terms they encompass such desirable traits as objectivity, repeatability, explicitness, comprehensiveness and so forth. Their clearest strengths lie in the ability of computer based classification systems to deal objectively with a greater number of data elements than is possible for the unaided mind.

MATERIALS AND METHODS

The Data Base

A complimentary first step was the establishment of a computer based Geographic Information System (GIS) on the micro-computer in the Department of Environmental Sciences, Universiti Pertanian Malaysia. The machine in question has an 8 bit, 32K RAM processor and twin floppy disk drives of 330K byte capacity. The opportunity to use this processor for GIS work arose from the Department's choice of a monitor with high resolution graphics capability. The monochrome Microangelo monitor is a raster scan device with 512 x 480 pixel resolution. Hard copy (as in Figure 1) was available through a Microline 93 dot matrix printer with 72 dots per inch (approximately 28 dot per cm) resolution.

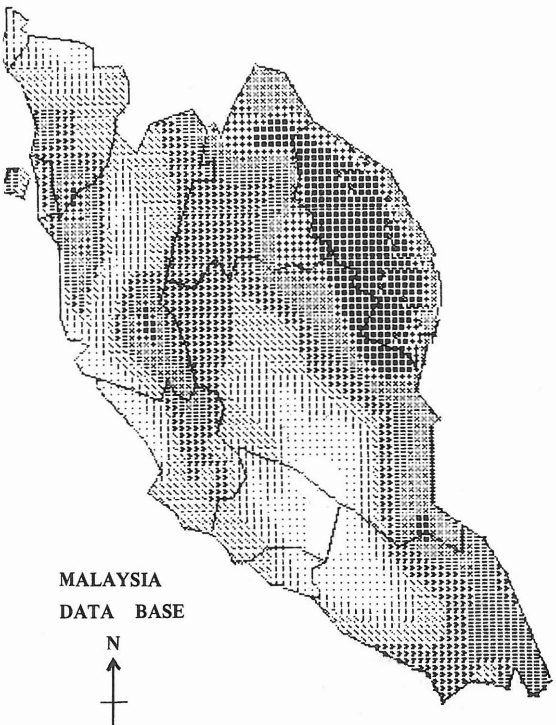

Fig. 1. Dot matrix printer output showing annual rainfall in Peninsular Malaysia.

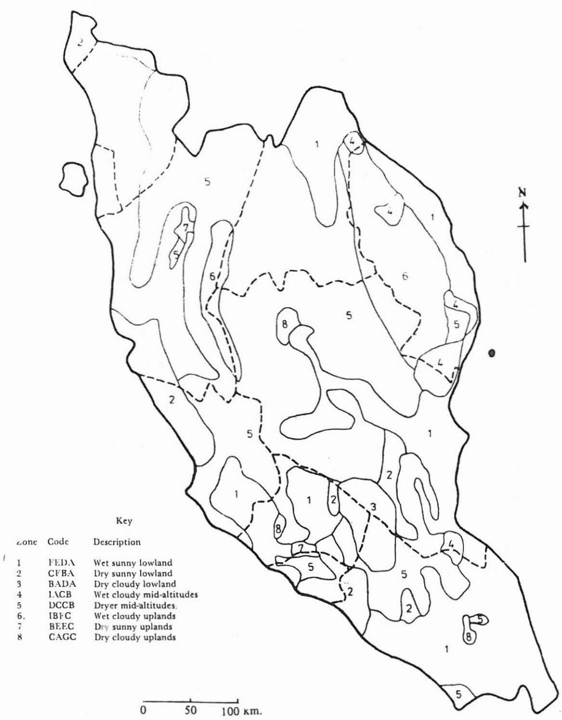

Fig. 2. The distribution of provisional climatic regions in Peninsular Malaysia.

The data base constructed was grid cell based with each cell covering an area of 37 km^2 (6.1 km x 6.1 km). The cell size was necessarily large because of the limited capacity of the processor and the diskettes.

Because time was not available to build a comprehensive data base and because the early emphasis was on software development, the selection of data to include was based on the twin criteria of simplicity and ease of map access. Consequently all the initial data was taken from the National Atlas of Malaysia produced by the Jabatanarah Pemetaan Negara (1977) and the simplest maps in terms of entry into a data base were

* annual rainfall
* annual hours of sunshine
* annual days of rain
* elevation.

The programme written for data entry was designed to allow the input of polygons as a string of (X,Y) coordinates read from the map. The computer then did the work of converting these polygons into a gridded form.Thus, each of the 37 km^2 grid cells which make up Peninsular Malaysia was assigned to one rainfall category, one hours of sunshine category and so on. These categories were represented by letter codes ranging up the alphabet from A for the lowest value (see Table 1).

As indicted in the introduction, these variables could be considered adequate for a preliminary land classification. It seemed however that the absence of such integral data elements as soils and vegetation made the classification more appropriately entitled 'climatic'.

The Classification Method

Because each of the four mapped variables included in the classification described a range of values of a single climatic determinant, the similarity between any two grid cells could be measured as a weighted distance between the cells as they would be placed in four dimensional space. Table 2 gives an example of the procedure used for calculating the distances between the points.

Some small distance was then defined as a reasonable separation within which two grid cells might be regareded as having the same climatic conditions. The computer then searched through the data base to locate those cells which could be grouped together at this level of tolerance. It should be clear that the greater the permitted separation, the more dependent the result would be on the order in which the cells were searched. The user of the computer program has the option of specifying a particular starting tolerence – thus the sensitivity of the method to changes in this variable could be explored.

TABLE 1
The breakdown of the data elements with their letter codes (the units are awkward because the source maps used inches and feet).

Code	Anual Rainfall (mm)	Annual hours of sunshine (hours)	Day of rain per annum (days)	Elevation (metres)
A	less than 1778	less than 2100	less than 150	0–76.2
B	1779–2032	2100–2199	150–159	76.3–304.8
C	2033–2286	2200–2299	160–169	304.9–914.4
D	2287–2540	2300–2399	170–179	914.5 or more
E	2541–2794	2400–2499	180–189	
F	2795–3048	2500 or more	190–199	
G	3049–3303		200 or more	
H	3303–3556			
I	3557 or more			

TABLE 2

An example of the process of calculating distances (in terms of the four variables) between grid cells.

Code for grid cell 408 = F E D A

Code for grid cell 1197= B E E C

Variable	Cell 1	Cell 2	Separation (S)	Weighting(W)	WxS^2
1	F	B	4	1	16
2	E	E	0	1	0
3	D	E	1	1	1
4	A	C	2	3	12
				Sum	29

$$\text{Distance} = \sqrt{\Sigma WxS^2} = \sqrt{29} = 5.4$$

The 'distance' between each pair of cells in Peninsular Malaysia was calculated in this way. A distance of zero would result if two cells had identical codes for all four variables while the maximum possible distance on these four variables would be:

$$\sqrt{(8x8x1 + 5x5x1 + 6x6x1 + 3x3x3)} = \sqrt{152} = 12.3$$

The user also has the opportunity to weight the different data elements to different extents, and so to imply that a difference of one letter code in one climate factor is more significant than the same difference in another. Differential weightings should certainly be included (as in Table 2) when the range of codes of the different factors is quite different. Table 3 shows the manner in which the weights used in Table 2 were derived. The first consideration was to normalise the variables so that the distance between highest value and lowest value was the same for each data element. Thus, elevation which ranges across only four categories must be weighted higher than rainfall which has nine separate codes. The other consideration was to reflect the relative importances of the four elements in the definition of climatic zones. Having little basis on which to decide this point, it seemed proper to give the variables equal importance and to use the weights generated by consideration of the ranges of the variables. The single exception to this principle was to reduce the importance of hours of sunshine. This was done after some discussion with students in the Department who had experimented with the data base and were aware of its implications, and who had greater local knowledge than the author.

TABLE 3

Determination of the weights applied in the distance calculations.

Variable	No. of Codes	Range	Normalising Factor	Importance	Weight
Rainfall	9	8	8/8 = 1.0	1	1
Sunshine	6	5	8/5 = 1.6	0.6	1
Days of Rain	7	6	8/6 - 1.3	1	1
Elevation	4	3	8/3 = 2.7	1	3

When a first set of groupings has been determined – each defined as a cluster around a particular grid cell which can reasonably be assumed to be near the centre of mass of the cluster – the tolerance is increased so that the original groups themselves begin to form larger, second generation, groups. This process can be continued until the tolerance is such that all the grid cells merge into a single comprehensive group. Such a group would presumably reflect, in its centre of mass, the broad nature of an equatorial climate.

However, before this point is reached there should be a stage at which not only does a suitably small number of groups for mapping purposes remain, but the tolerances are not so large as to make these groups meaningless or non-describeable in some useful way.

RESULTS

Definition of the Climatic Regions

As a preliminary result, a stop to the grouping was made when eight discrete land classes remained. The distribution of these is shown in Figure 2 and an attempt is made to characterize them below.

The letter codes which are applied to the land classes are those of the first cell of the group, i.e. the point to which others were attached if sufficiently close. As such, that cell is not necessarily the best example by which to characterize the classification. The system would allow for a four dimensional centre of mass to be computed for each grouping but this has not yet been done.

Thus, based on the first cell defining each group, the provisional climatic regions for Peninsular Malaysia are as follows:

1. Wet sunny lowland areas – characterized by the codes FEDA i.e. rainfall of about 2900 mm per annum, an average of 6.7 hours of sunshine a day, rain on about 175 days of the year and elevation below 75 m.

2. Dry sunny lowland – code CFBA meaning 2150 mm of rain a year, 7 or more hours of sunshine per day, and rain on only 155 days of the year. Also below 76 m elevation.

3. Dry cloudy lowland – code BADA. In this area the rainfall is low (around 1900 mm) but is spread over 175 days. Sunshine is down to below 5.8 hours per day.

4. Wet cloudy mid-altitude areas – here the identifying code is IACB which implies land between 75 and 300 m with a rainfall exceeding 3550 mm per annum and sunshine below 5.8 hours a day. Perhaps surprisingly the rain is confined to about 165 days per year.

5. Drier mid-altitude areas – code DCCB. That is, areas with a moderate rainfall (2400 mm), spread over 165 days. Also a moderate sunshine duration of 6.2 hours per day. Between 75 and 300 m in elevation.

6. Wet cloudy uplands – characterized by code IBFC. This land class includes areas above 300 m having a rainfall exceeding 3550 mm spread over nearly 200 days of the year and having only 5.9 hours of sunshine a day.

7. Dry sunny upland – code BEEC. There is very little land in this class which typically has 1900 mm of rain over 185 days a year and 6.7 hours of sunshine a day.

8. Dry cloudy upland – code CAGC. Although these few cells above 300 m have less than average rainfall (only about 2150 mm per annum) they have rain on over 200 days a year and less than 5.8 hours of sunshine a day.

Climate Zone Distribution

As Figure 2 shows, some of these zones are very widespread while others are localized to one or just a few occurrences.

Zone 1 (wet lowlands) covers most of Johore and extends all the way up the east coast spreading inland into the valleys of, especially, the Sungai Pahang and the Sungai Kelantan. On the west coast, the drier Zone 2 takes over around the Johore-Melaka boundary and agian for a long stretch of coast astride the Selangor-Perak boundary. Much of Perlis is also in Zone 2.

Zone 3 (dry cloudy lowland) occupies a large very clearly defined area to the east of the Banjaran Titiwangsa, at the head waters of the Sungai Muar. This area seems to stand out as a distinct zone more clearly than any other.

Zones 4 and 6 together define the wettest parts of Peninsular Malaysia with zone 6 taking the higher areas along Banjaran Titiwangsa and the greater part of Banjaran Timur. Zone 4 is found in the valleys of the Sungai Besut, Sungai

Terengganu and Sungai Dungun and the area around the Pahang-Trengganu border.

Easily the most extensive of the climatic zones is Zone 5 which represents dryer mid-elevation places than Zone 4. It covers all the non-coastal areas not included in the wetter Zone 4 and 6 or the in small Zones 7 and 8.

Zone 7 comprises a small area around G. Rembau in the South and another small area centred on G. Hulu Soh further north. For some reason these peaks are apparently dryer and sunnier than any others.

Zone 8 also consists of dryer uplands – in particular, G. Belumut in Johore, Bukit Galla near Seremban and Bukit Tujuh north of Kuala Lipis – which have lower sunshine than the Zone 7 hills.

CONCLUSION

The procedure described above is presented as an example of a simple appraoch to regional classification based on data stored in a Geographic Information System. The absence of data elements such as soils and vegetation from that data base made the result a climatic rather than a land classification.

In addition, there is some doubt about the reliability of the climatic data especially over the mountainous and interior regions: also, the data used takes no account of the seasonality of the rainfall or sunshine. For these reasons the regionalisation presented is described as provisional. In particular the small zones numbered 7 and 8 must be in doubt. The remaining six zones however seem to accord well with the author's observations during his stay in Malaysia.

The classification would certainly be improved by better data, by the inclusion of the other variables necessary to produce a true land classification and by the use of a data base with finer resolution than that created by the author for this project.

The difficulty that arises from the uncertainty over the appropriate weights to use in distance calculations might be removed by experimentation with a variety of weight combinations. A better solution to this dilemma would be the application of a more sophisticated statistical analysis procedure than the simple clustering applied here. For example, the reciprocal averaging ordination and indicator species analysis techniques developed by Hill and others (Hill, 1973 and Hill *et al.*, 1975) would themselves indicate the relative contributions of the variables to the definition of the land (or climatic) classes and regions.

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