Climatic Regimes Based on Temperature and Rainfall in Nepal

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Abstract

Nepal, a small mountainous country extending from less than 100 m in the south to 8,848 m in the north, exhibits remarkable climatic diversity due to its rugged topography and east–west orientation. This study classifies climatic regimes based on mean monthly rainfall, and mean monthly maximum and minimum temperatures from 168 meteorological stations covering the period 1956–1975. Using the TAXON program (CSIRO) and a hierarchical, agglomerative, polythetic clustering method (MULCLAS), 35 standardized climatic attributes were analyzed to produce a DENDOGRAM identifying 30 distinct rainfall and temperature regimes. These were further consolidated into six major homo-climatic groups. The results reveal a strong altitudinal control on temperature regimes, with a mean lapse rate of approximately 6°C per kilometer, while rainfall patterns display greater spatial complexity, particularly in the central and western hill regions. The six major groups correspond broadly to three macroclimatic zones: subtropical (Terai and Inner Terai), warm temperate (Hill region), and cool temperate (Mountain region below 4,000 m). These zones reflect distinct thermal and moisture conditions that directly influence vegetation distribution, crop suitability, and agricultural potential. The classification provides a practical framework for crop breeding, agricultural planning, irrigation management, and the transfer of high-yielding varieties to climatically similar regions. Although based on mean climatic data, the study establishes a valuable baseline for understanding Nepal's climatic diversity. The findings remain relevant for future climatic assessments using updated datasets and for broader applications in ecological and medicinal plant research.

Keywords: DENDOGRAM, monothetic, polythetic, classification, station

Introduction

Nepal is a small mountainous country. The altitude ranges from less than 100m in the south to 8848m in the north. It spreads from east to west. Due to rugged topography with low to high relief and its locational features, the country has experienced diverse weather and climatic conditions. Nepal experiences subtropical, mesothermal, microthermal, taiga, and tundra climates (Nayava, 1975). This paper discusses climatic regimes based on mean monthly values of rainfall and mean monthly maximum and mean monthly minimum temperatures for 168 meteorological stations in the country (Table 1 in Appendix in Appendix) (Nayava, 1982). The classification of rainfall and temperature regimes, which has 30 groups in DENDOGRAM has been considered to evaluate sunshine hours in 168 places as well as many other related parameters, to examine the relationship between crop and weather (Fitzpatrick and Nix, 1970), and in particular to exploit the full potentialities of the climate for food production within Nepal.

Figure 1

Meteorological Stations of Nepal
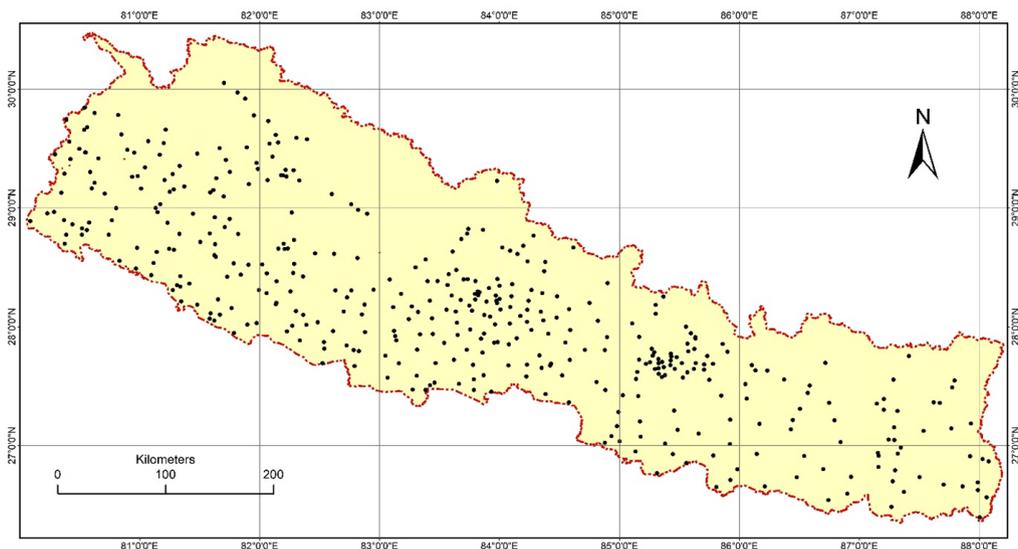
Based on observed mean monthly maximum temperature and mean monthly minimum temperature data of 35 meteorological stations and generated data of 133 locations, were converted to weekly values of the light, thermal, moisture, and growth indices, which were calculated for each of the "subtropical", "warm temperate", and "cool temperate" plant groups at all 168 stations in Nepal. It is interesting to note that separate thermal

responses are also adopted to suit Nepalese crops and plants. Out of 168 stations, 57 stations are below 500m; 25 stations lie between 501-1000m; 36 stations lie between 1001-1500m; 28 stations lie between 1501-2000m; 10 lie between 2001-2500m; 6 lie between 2501-3000m; and 6 lie above 3000m. The meteorological stations of Nepal are shown in Figure 1. This has been achieved through statistical classification procedures, in which individual data sets have been reduced to a manageable number of groups.

These classification procedures are frequently used in a wide range of research fields, such as the technological transfer of crop varieties developed in one region, and transfer may be to similar climate and homo climate regions to save the trial and error of experimental cost. Other direct implications are in the Meteorological Station network. One should not have many more meteorological stations in one homo-climate than necessary to save the over expenditure of meteorological and climatological stations. This type of study may be used to minimize the cost of expenditure and the uncontrollable expansion of the Meteorological Station Network in Nepal and elsewhere. Similarly, this type of study is further used for transferring herbal and medicinal plants from one homo-climatic zones to similar homo-climates.

Methods and Materials

Data

Rainfall–its amount, seasonal distribution, intensity, frequency of occurrence, variability, and areal rainfall variation are necessary for agricultural development. According to the World Meteorological Organization, a climate data period of 30 years is called normal. Therefore, considering the availability of data in the study area during my research in the late 1970's, 1956-75 inclusive, was chosen to investigate the mean monthly and annual rainfall in Nepal The 168 stations for mean monthly rainfall standardized to 1956-75, as shown in Table 1 in Appendix and Figure 1, were developed as described in Rainfall in Nepal (Nayava, 1980). Similarly, temperature is a significant factor limiting plant growth. Knowledge of the characteristics of the seasonal distributions of temperature and extreme occurrences of high and low temperatures are both important factor for agricultural planning. Therefore, the mean monthly maximum and minimum temperature values for 168 locations in Nepal have also been considered, and the development of those data by multiple regression was described in the estimation of temperature over Nepal by Nayava (1982). The monthly rainfall data, and mean monthly maximum and mean monthly data are obtained from "Climatological Records of Nepal" published in different years, as 1968, 1971, 1972, 1973, and 1977 by the Department of Hydrology and Meteorology and the Department of Irrigation, Hydrology and Meteorology.

Method of Analysis

A large number of individual data sets are reduced to a meaningful and manageable number of groups by statistical classification procedures. These classification procedures are frequently used in a wide range of research and fields. The program adopted here, TAXON, was developed by the CSIRO and has been applied by various scientists, especially in the studies of agricultural patterns when confronted with problems similar to the present case. Detailed information, discussion, and selection of attributes for the program are described by Lance and Williams 1968; Williams and Lance (1968a, 1968b); Dale *et al*. 1970, and 1971; Williams, 1976; and Dale *et al*. 1978). Examples of the application of the programs in climatic studies have been seen in publications by Russel and Moore (1976), and Austin and Nix, (1978).

A wide range of statistical classification methods is available from the "TAXON" library of computer programs. A brief introduction to the TAXON program, various methods, such as data, choice of strategy, and results, have been discussed in the TAXON user manual (Dale *et al*., 1978). The program user has several choices of appropriate options at various levels. Firstly, a distinction is made between hierarchical and non-hierarchical strategies. The hierarchical optimization involves progressive steps in a division, and the non-hierarchical optimization optimizes intra-group homogeneity. A second level of choice is between an agglomerative and divisive strategy. The former begins with individuals and forms groups of increasing size, and the latter splits the population into smaller and smaller groups. The third level of choice is between monothetic, and polythetic methods. The monothetic consists of sub-groups at each stage according to a selected attribute, and polythetic is based on a measure of similarity or dissimilarity applied over all attributes. The method chosen for the analysis is a hierarchical, agglomerative, and polythetic technique; or in simple terms, similarity measures, which are used to indicate the relationships between individuals to be analyzed. Detailed discussions of these methods are seen in Williams (1976); and Sneath and Sokal (1973).

The specific program used in the Climatic regimes based on rainfall and temperature in Nepal was MULCLAS. The basic requirements and general steps of this program are as follows:

Data Matrix

There are three attributes: monthly rainfall, monthly maximum temperature, and monthly minimum temperature for 168 locations. To equalize the influence of rainfall and temperature in one place and 9 each from maximum and minimum temperature, thus a data matrix has been prepared containing 35 attributes at each of the 168 stations i.e., 5880 (35×168) pieces of information (Supplementary Table 2).

Table 2

Thirty-five Climatic Attributes Used in the Analysis

Type	Attribute no.	Derived measurements
Rainfall (mm)	1	(a) mean annual rainfall
	2	(b) Highest mean monthly rainfall
	3	(C) Lowest mean monthly rainfall
	4	(d)The difference of the highest and lowest mean monthly rainfall
	5	(e) The ratio of (d) to (a)
	6	January, mean monthly rainfall
	7	February, mean monthly rainfall
	8	March, Mean monthly rainfall
	9	April, mean monthly rainfall
	10	May, mean monthly rainfall
	11	June, mean monthly rainfall
	12	July, mean monthly rainfall
	13	August, mean monthly rainfall
	14	September, mean monthly rainfall
	15	October, mean monthly rainfall
	16	November, mean monthly rainfall
	17	December, mean monthly rainfall
Maximum Temp. °C	18	(f) mean annual maximum temperature
	19	(g) Highest mean monthly maximum temperature
	20	(h) lowest mean monthly maximum temperature
	21	(i) The difference of the highest and the lowest mean monthly maximum temperature
	22	(j) The ratio of (i) to (f)
	23	Mean seasonal (Dec, Jan, Feb) maximum temperature
	24	Mean seasonal (Mar, Apr, May) maximum temperature
	25	Mean seasonal (June, July, Aug) maximum temperature
	26	Mean seasonal (Sep, Oct, Nov) maximum temperature
Minimum temp. °C	27	(k) mean annual minimum temperature
	28	(l) Highest mean monthly minimum temperature
	29	(m) lowest mean monthly minimum temperature

Table 2: Thirty-five climatic attributes used in the analysis cont...

	30	(n) The difference of the highest and the lowest mean monthly minimum temperature
	31	(o) The ratio of (n) to (k)
	32	Mean seasonal (Dec, Jan, Feb) minimum temperature
	33	Mean seasonal (Mar, Apr, May) minimum temperature
	34	Mean seasonal (June, July, Aug) minimum temperature
	35	Mean seasonal (Sep, Oct, Nov) minimum temperature

Standardization of Attributes

The rainfall and temperature values are in different units, which have to be eliminated by standardizing the data matrix. During this process, the contribution of any single attribute to the overall distance is selected between 0 and 1. This technique makes it much easier to classify the attributes. The next step is to calculate some similarity measures between all pairs of individuals.

Grouping of the Stations

The stations were then grouped using the flexible sorting method of Lance and Williams (1967), with the coefficient value adjusted to influence the subsequent choice of fusion strategy; in this case, the clustering intensity coefficient, beta, was set to 0.25. This strategy creates space-diluting, i.e., clustering is intensified, thereby resisting the formation of a single large group and forcing the formation of more evenly sized groups (William, 1977; Booth, 1978).

Finally, the main theme of MULCLAS Classification is to identify the most similar points in a group, which allows a final output DENDOGRAM to show the relative degree of similarity between individual points and groups of individual points. In this study, the program user has chosen a 30-group final output DENDOGRAM

Results

The rainfall and temperature regimes obtained are shown in the DENDOGRAM (Figure 2). The number of stations in each regime is shown in Table 3. The highest meteorological station was the Tengboche, 3857m, and there is limited discussion above that elevation. To show a general pattern of rainfall and temperature regimes in Nepal, the characteristics of rainfall, maximum and minimum temperature for 30 groups, and their mean elevation are computed as shown in Tables 4a, 4b, and 4c. Broadly, these thirty groups were divided into six major groups, which have been shown within bold lines in Tables 4a, 4b, and 4c.

The order of fusion of the 168 meteorological grid network obtained from the MULCLAS classification is shown in the DENDOGRAM (Figure 2). Next, to show the general pattern of rainfall and temperature regimes in Nepal, the characteristics of rainfall, maximum temperature, and minimum temperature for 30 groups and the mean elevations are shown in Table 3. These thirty groups may be again divided into two, three, four, six, or more as shown in DENDOGRAM. The DENDOGRAM shows horizontal lines cutting the hierarchy at increasing values of the similarity coefficients and there by defining a decreasing number of groups.

When the first two large groups are considered, the groupings are generally separated by being stations between land below 1000m and above. Elevation is specifically noted here because the weather and climate in Nepal are mostly dominated by topography. Similarly, the three groups, generally show low land- the Terai, Hill, and Mountain Regions. When six groups are considered, low land is further divided into two groups, widely separated areas. For example, thirty groups are substantially reduced.

Table 3

Classification of Rainfall and Temperature Regimes of 168 Stations in Nepal

Group no.	No. of stations	Station number in groups
1	7	55, 72, 89, 152, 153, 165, 168
2	16	56, 58, 60, 78, 82, 83, 85, 121, 151, 154, 155, 156,157, 158, 166, 167
3	19	5, 6, 14, 16, 31, 32, 34, 35, 40, 53, 75, 79, 80, 84, 86, 87, 124, 139, 140
4	9	44,57,59,62,63,65,66,123,125
5	7	102, 104, 115, 122, 136, 147, 150
6	7	48, 73,74, 76, 91, 145, 146
7	5	7, 41, 42, 43, 45
8	7	1, 12, 18, 33, 39, 51, 90
9	1	30
10	4	13, 15, 27, 29
11	15	64,81, 92, 97, 99, 101, 103, 105, 109, 118, 120, 132, 138, 161, 164
12	5	95, 96, 112, 113, 114
13	3	134, 135, 163
14	9	98, 107, 108, 119, 126, 133, 137, 148, 149
15	6	3, 10, 38, 49, 67, 111
16	4	25, 26, 28, 54
17	4	8, 9, 11, 20
18	7	19, 21, 24, 37, 52, 68, 81
19	4	2, 4, 23, 50
20	2	36, 162
21	1	144
22	6	68, 69, 70, 71, 106, 127
23	6	94, 110, 116, 117, 130, 131
24	1	93
25	1	100
26	1	77
27	4	129,143,159,160
28	3	22, 46, 47
29	3	128, 141, 142
30	1	17

In this study, six major groups form patterns from which meaningful deductions or hypotheses are generated. A larger group is suitable to study the homo climates, and the selection of these groups may depend upon the application in mind. In this study, six major groups of rainfall and temperature regimes are for further discussion. The mean elevation of the first major group is 236m, which lies in the Terai. The Hill Regions are divided into three groups, and the Mountain Region is in one group. It seems reasonable to describe the general climatic pattern in Nepal. In this way, several conclusions are reached from the analysis.

Figure 2

Dendogram of 30 Groups of MUCLAS Classification of 168 Meteorological Station Network
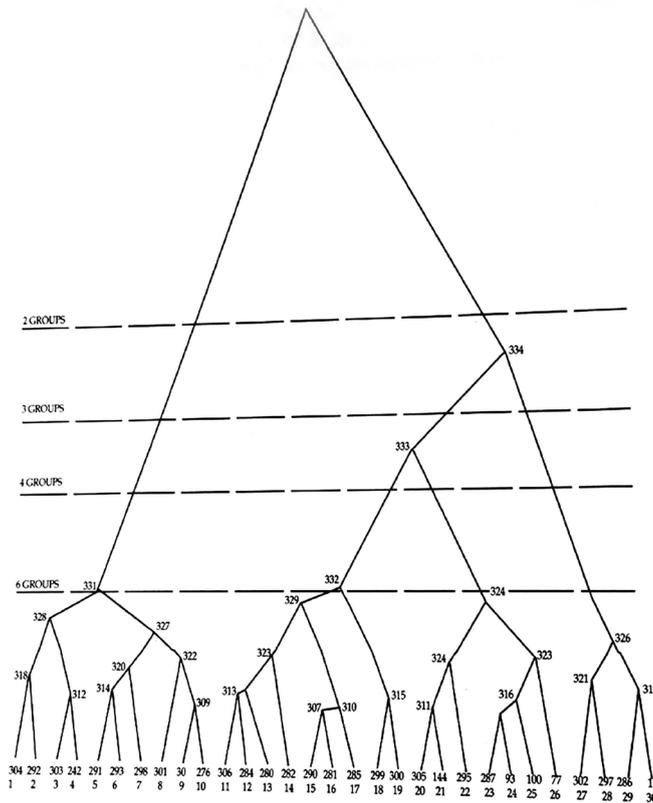

For simplicity, the station number and group number (in italics) are presented in Figure 3, and the major groups are shown in shaded lines in Figure 3. This makes it much easier to identify similar rainfall and temperature regimes in the Terai and the Inner Terai of

Nepal, where the mean total amount of annual rainfall and the highest mean monthly rainfall are 1804mm and 534mm, respectively. Similarly, the mean monthly maximum and minimum temperatures show 22.3°C to 35.2°C and 9.1°C to 24.7°C, respectively (Tables 2 to 4).

Figure 3

Major Rainfall and Temperature Regime
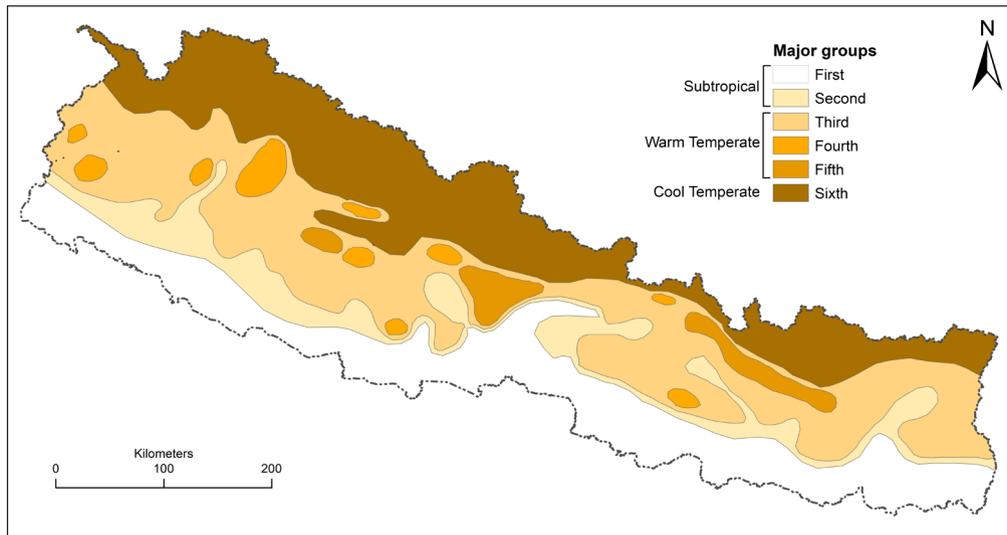
The second major group falls at about 711m over the Hills of the Churia Range and the river valleys of the Hill Region, where the mean annual total rainfall and the highest mean monthly rainfall are 21 percent lower than those of the first major group. At the same time, the maximum and the minimum temperatures of the second major group are 2°C lower than those of the first. Similarly, the mean monthly maximum and the minimum temperatures show 19.5°C to 34.2°C and 7.4°C to 22.4°C, respectively (Tables 2 to 4).

Thus, the first and second major groups are named as the Subtropical Climate as shown in Figure 3., where crops like paddy, maize, sugarcane, mustard, and tobacco can be grown.

The third major group (1450m) lies over the valley and ridges of the Hill Region, where the mean total amount of annual rainfall and the highest mean monthly rainfall are about 11 percent higher than those of the second major group. The mean monthly temperature is about 4°C lower than that of the second major group. Similarly, the mean monthly maximum and minimum temperatures range from 15.7°C to 28.1 °C and from 4.3°C to 18.6°C, respectively (Tables 2 to 4).

Table 4a

Attributes of 30 Major Classes

Group	Mean elevation (m)	Mean month	High month	Low month	High month-low month	High month-low month/mean month
			Precipitation (mm)			
1	376	216.3	719.4	4.6	714.8	3.3
2	237	170.7	578.6	0.6	578.0	3.4
3	206	126.1	425.6	2.3	423.3	3.4
4	125	113.8	412.6	0.0	412.6	3.6
Mean	**236**	**156.7**	**534.1**	**1.9**	**532.2**	**3.4**
5	578	98.0	314.8	1.2	313.6	3.2
6	1004	142.3	439.2	0.9	438.3	3.1
7	940	117.1	442.3	0.0	442.3	3.8
8	766	102.0	302.1	5.7	296.4	2.9
9	720	183.6	605.9	0.0	605.9	3.3
10	255	158.9	493.8	0.0	493.8	3.1
Mean	**710.5**	**133.7**	**433.0**	**1.3**	**431.7**	**3.2**
11	1472	162.2	518.3	3.0	515.3	3.2
12	1774	154.0	550.9	0.0	550.9	3.6
13	1731	125.3	337.1	12.9	324.2	2.6
14	1366	94.7	286.2	3.0	283.2	3.0
15	1301	114.1	342.5	9.3	333.2	2.9
16	1163	144.8	457.0	0.7	456.3	3.2
17	1340	157.3	473.7	6.1	467.6	3.0
Mean	**1449.6**	**136.1**	**423.7**	**5.0**	**418.7**	**3.1**
18	2009	81.2	240.7	5.2	235.5	2.9
19	1940	90.8	252.5	16.9	235.6	2.9
Mean	**1974.5**	**86.0**	**246.6**	**11.05**	**235.55**	**2.9**
20	1472	220.5	655.6	13.8	641.8	2.9
21	1497	260.1	686.3	0.0	686.3	2.6
22	921	266.0	840.0	0.0	840.0	3.2
23	2047	183.5	601.0	2.1	598.9	3.3
24	2000	266.9	833.4	0.0	833.4	3.1
25	2625	244.3	943.1	0.0	943.1	3.9
26	1642	431.7	1425.7	0.0	1425.7	3.3
Mean	**1743.4**	**267.6**	**855.0**	**2.3**	**852.7**	**3.2**
27	2832	147.8	364.1	7.4	356.7	2.4
28	2786	35.3	105.8	3.7	102.1	2.9
29	3669	87.3	258.8	1.8	257.0	2.9
30	3803	72.7	169.6	6.6	163.0	2.2
Mean	**3272.5**	**85.8**	**224.6**	**4.9**	**219.7**	**2.6**

Table 4b

Attributes of 30 Major Classes

Group	Mean elevation (m)	Maximum temperature in centigrade				
		Mean month	High month	Low month	High month-low month	High month-low month/mean month
1	376	28.9	33.5	21.9	11.6	0.4
2	237	29.8	34.5	22.6	11.9	0.4
3	206	30.2	36.5	22.1	14.4	0.5
4	125	30.3	36.1	22.4	13.7	0.5
Mean	**236**	**29.8**	**35.2**	**22.3**	**12.9**	**0.5**
5	578	28.2	32.8	20.7	12.1	0.4
6	1004	25.9	30.1	18.8	11.3	0.4
7	940	26.4	33.3	18.2	15.1	0.6
8	766	27.7	34.6	19.4	15.2	0.5
9	720	27.8	35.8	18.7	17.1	0.6
10	255	30.3	38.3	21.2	17.1	0.6
Mean	**710.5**	**27.7**	**34.2**	**19.5**	**14.7**	**0.5**
11	1472	22.3	26.2	15.4	10.8	0.5
12	1774	21.4	25.6	14.7	10.9	0.5
13	1731	20.3	23.9	13.4	10.5	0.5
14	1366	23.8	27.6	16.9	10.7	0.4
15	1301	24.3	30.5	16.5	14.0	0.6
16	1163	24.7	31.0	17.1	13.9	0.6
17	1340	24.3	31.7	15.8	15.9	0.7
Mean	**1449.57**	**23.0**	**28.1**	**15.7**	**12.4**	**0.5**
18	2009	20.5	26.4	12.8	13.6	0.7
19	1940	20.9	27.5	12.9	14.6	0.7
Mean	**1974.5**	**20.7**	**26.95**	**12.85**	**14.1**	**0.7**
20	1472	23.2	27.7	16.5	11.2	0.5
21	1497	21.7	25.7	15.4	10.3	0.5
22	921	25.4	29.5	18.5	11.0	0.4
23	2047	19.2	22.7	12.9	9.8	0.5
24	2000	19.2	22.8	12.9	11.9	0.6
25	2625	16.1	19.3	10.1	9.2	0.6
26	1642	19.1	22.6	12.4	10.2	0.5
Mean	**1743.4**	**20.6**	**24.3**	**14.1**	**10.5**	**0.5**
27	2832	14.7	18.7	8.5	10.2	0.7
28	2786	16.5	22.3	9.1	13.2	0.8
29	3669	10.7	15.0	4.7	10.3	1.0
30	3803	10.6	17.3	2.9	14.4	1.4
Mean	**3272.5**	**13.1**	**18.3**	**6.3**	**12.0**	**1.0**

Table 4c

Attributes of 30 Major Classes

| Group | Mean elevation (m) | Minimum temperature in centigrade | | | | |
		Mean month	High month	Low month	High month-low month	High month-low month/mean month
1	376	18.4	24.1	10.2	13.9	0.8
2	237	18.3	24.7	9.5	15.2	0.8
3	206	18.0	24.9	8.6	16.3	0.9
4	125	18.1	25.1	8.1	17.0	0.9
Mean	**236**	**18.2**	**24.7**	**9.1**	**15.6**	**0.9**
5	578	16.8	22.9	8.6	14.3	0.9
6	1004	15.0	20.6	7.5	13.1	0.9
7	940	14.8	21.0	6.4	14.6	1.0
8	766	16.1	22.1	8.3	13.8	0.9
9	720	14.5	22.8	3.4	19.4	1.3
10	255	18.5	24.7	10.1	14.6	0.8
Mean	**710.5**	**16.05**	**22.4**	**7.4**	**15..0**	**1.0**
11	1472	11.7	18.0	3.5	14.3	1.2
12	1774	10.5	16.7	2.9	13.8	1.3
13	1731	11.6	17.5	4.1	13.4	1.2
14	1366	12.2	19.4	3.3	16.1	1.3
15	1301	13.1	19.3	5.4	13.9	1.1
16	1163	13.8	20.2	5.3	14.9	1.1
17	1340	13.1	19.1	5.8	13.3	1.0
Mean	**1449.57**	**12.3**	**18.6**	**4.3**	**14.2**	**1.2**
18	2009	9.4	15.6	1.9	13.7	1.5
19	1940	9.7	16.0	2.1	13.9	1.4
Mean	**1974.5**	**9.55**	**15.8**	**2.0**	**13.8**	**1.5**
20	1472	12.3	18.0	4.8	13.2	1.1
21	1497	12.6	18.1	5.4	12.7	1.0
22	921	14.7	20.9	6.8	14.1	1.0
23	2047	8.6	12.9	0.4	12.5	1.5
24	2000	9.3	15.3	1.9	13.4	1.4
25	2625	5.6	12.0	-1.9	13.9	2.5
26	1642	12.1	17.2	4.9	12.3	1.0
Mean	**1743.4**	**10.7**	**16.3**	**3.2**	**13.2**	**1.4**
27	2832	5.0	11.1	-2.1	13.2	2.6
28	2786	5.4	11.7	-1.5	13.2	2.4
29	3669	-0.8	6.2	-8.6	14.8	-18.5
30	3803	0.4	6.4	-5.4	11.8	29.5
Mean	**3272.5**	**2.5**	**8.9**	**-4.4**	**13.3**	**4.0**

The fourth major group (1975m) lies over the Hills of Far Western Nepal, where the total amount of annual rainfall is forty percent lower than that of the third major group. The mean monthly temperature is about 2°C lower than that of the third major group. Similarly, the mean monthly maximum and minimum temperatures range from 15.2°C to 29.0°C and from 2.0°C to 15.8°C, respectively (Tables 2 to 4).

There is a difference of three percent in the amount of rainfall between the fourth and the fifth major group (1743m). The heavy rainfall in the fifth group is mostly scattered in the Hill Region, in the Central and Western parts of Nepal. Despite these differences in rainfall, the mean monthly maximum and minimum temperatures range from 14.1°C to 24.3°C and from 3.2°C to 16.3°C, respectively (Tables 2 to 4). Thus, the third, fourth, and fifth groups lie in the Warm Temperate Climate, as shown in Figure 3, where crops, like wheat, barley, potato, bean, pea, apple, and peach can be grown.

Finally, the last group (3273m) lies mainly in the Mountain Region. As expected, the rainfall is more or less similar to the fourth group, and the temperature is about 7°C lower than the fifth major group. Similarly, the mean monthly maximum and the mean monthly minimum temperatures range from 6.3°C to 18.3°C and from -4.4°C to 8.9°C, respectively (Tables 2 to 4). Thus, the sixth group lies in the Cool Temperate Climate, where rye, conifers, evergreen forest can be grown.

Broadly, the major groups of maximum and minimum temperature are related to altitude, but the major groups of rainfall show more complex patterns with altitude. However, in general, the rainfall regimes follow the rainfall model discussed by Hagen (1961), and the lapse rate of mean air temperature shows 6°C per Kilometer

Discussion

Classification of climate regimes is still important for finding the homo-climates that can be used in plant geography, i.e.,

i. Many scholars have classified the world into different climatic zones using various climatic elements. Among them, the classifications of Köppen (Arnfield,2020) and Thornthwaite (1931, 1948) are widely accepted. Both systems are broadly based on average temperature and precipitation; however, Köppen's classification does not adequately address the complexities of mountain climates.

Since Nepal is predominantly a Mountainous Country, Thornthwaite's classification has been adopted to delimit its climatic zones. The present analysis of rainfall and temperature regimes is based on statistical methods and reveals distinct climatic

patterns across Nepal, where elevation plays a dominant role in shaping climatic zones at different altitudes.

Climate regimes classification remains important for identifying homo-climates, which can be applied in plant geography. As noted by Russel and Moore (1970, 1976), similar relief, soil conditions, temperature, and rainfall patterns tend to produce similar vegetation in widely separated regions. In Nepal, the classification of temperature and rainfall regimes into distinct groups helps to identify such homo-climates. These can be useful in several ways, including studying climate–vegetation interactions and transferring new high-yielding crop varieties to areas with similar rainfall and temperature regimes.

The present use of mean climatic data, however, overlooks the role of variability within data sets in shaping similar environments. Despite this limitation, mean data provide a useful starting point for homo-climate analysis.

ii. The analysis of rainfall and temperature regimes indicates that the first two homo-climates lie in the Terai and Inner Terai; the third, fourth, and fifth groups lie in the Hill Regions, and the last lies in the Mountain regions. This hypothesis simplifies understanding by suggesting three broad areas of macroclimatic rainfall and temperature regimes in Nepal. When these regimes are compared with the author's published paper, Climates of Nepal (1975), broadly, the first two regimes lie in their "Subtropical Climate", the next three lie in their "Mesothermal climate", and the last lies in their "Microthermal climate". The highest altitude of climatic station considered in this present analysis is 3857m, Tengboche. So, naturally, other climatic types dominate above this altitude. Since the snowline is subject to local variations ranging from 4500m to 6000m (Hagen, 1961), the altitude above Tengboche and below the snowline can be called the Taiga, and above the snowline can be called the Alpine Climate. However, Taiga and Alpine Climate have not been shown in Figure 3. Besides those important analysis, one of the main objectives of this study is to use thirty regimes of rainfall and temperature to estimate the global solar radiation in the same regimes (Nayava,1982).

iii. Breeding of new crop varieties should be undertaken in accordance with climatic suitability and planting conditions. For example, paddy cultivated in the Terai, Hill, and Mountain regions requires different varieties adapted to their respective climatic environments. The length of the growing season generally increases with altitude due to cooler thermal conditions at higher elevations. Therefore, optimum production of subtropical, warm temperate, and cool temperate species under

both the rainfed and irrigated conditions must be determined based on the specific microclimatic environment.

Similarly, depending on water availability, single, double, or even triple cropping systems can be planned and implemented within the same field across the Mountain, Hill, and Terai regions. With adequate irrigation facilities, a wide range of cropping strategies can be successfully adopted. The implications for plant growth the suitability of each region has been mapped and analyzed (Nayava, 1982).

This paper is derived from my doctoral thesis (Nayava, 1982) and has not previously been submitted to or published in any Journal. Recognizing the continued relevance of the findings, I prepared this manuscript to make the results accessible to a wider research community. I believe that publishing this work will provide a valuable baseline for researchers to re-examine and expand the analysis using updated datasets. The findings may support further applications not only in cropping system research, but also in herbal and medicinal plant studies in Nepal.

Conclusions

Analysis of temperature and precipitation data recorded between 1956 and 1975 from 168 meteorological stations across Nepal identified Sub-tropical, Warm Temperate, and Cool Temperate Climatic Zones below 4,000 m. It is recommended that a similar assessment should be carried out using precipitation and temperature data up to the present day to improve understanding of recent climatic changes. The present study demonstrates that the statistical classification of rainfall and temperature regimes provides a meaningful framework for understanding Nepal's climatic diversity. Based on temperature and precipitation records from 168 meteorological stations (1956–1975), thirty climatic regimes were identified and subsequently grouped into six major homo-climatic units. These units correspond broadly to altitudinal belts and can be simplified into three macroclimatic zones: Subtropical (Terai and Inner Terai), Warm Temperate (Hill region), and Cool Temperate (Mountain region).

The results confirm that temperature regimes are closely related to altitude, with a mean lapse rate of approximately 6°C per kilometer, while rainfall patterns show greater spatial complexity, particularly in the Hill regions of Central and Western Nepal. The classification highlights that similar combinations of temperature and precipitation produce comparable vegetation types and agricultural potential, thereby validating the concept of homo-climates in plant geography.

The identified climatic zones provide a practical basis for agricultural planning, crop breeding, and the transfer of high-yielding varieties to areas with comparable environmental conditions. They also offer important guidance for irrigation planning and the design of multiple cropping systems under different microclimatic settings.

Although the study relies on mean climatic data and does not fully incorporate variability within datasets, it establishes a valuable baseline for future climatic assessments. Given ongoing climatic changes, similar analyses using updated data are strongly recommended. The findings remain relevant not only for cropping system research but also for broader applications, including ecological and medicinal plant studies in Nepal.

Acknowledgements

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Appendix

Table 1

168 Meteorological Stations in Nepal

1	101	Kakerpakha	842	42	508	Tulsipur	725
2	102	Baitadi	1635	43	509	Ghorahi (Masina)	725
3	103	Patan (west)	1256	44	510	Koilabas	320
4	104	Dadeldhura	1837	45	511	sallyan Bazar	1457
5	105	Mahendra Nagar	176	46	601	Jomosom	2744
6	106	Belauri Shantipur	159	47	604	Thakmarpha	2566
7	107	Darchula	1097	48	605	Baglung	984
8	201	Pipalkot	1456	49	606	TatoPani (Mustang)	1243
9	202	Chainpur (west)	1304	50	607	Lete	2384
10	203	Silgagadhi Doti	1360	51	609	Beni Bazar	835
11	205	Katai	1388	52	611	Dunai	2058
12	206	Asra Ghat	650	53	701	Ridi Bazar	442
13	208	Sandepani 1	95	54	702	Tansen	1067
14	209	Dhan Gadhi	167	55	703	Butwal	205
15	210	Banga Camp (Benighat)	340	56	704	Beluwa (Girwari)	150
16	212	Sitapur	152	57	705	Bhairawa (Airport)	110
17	301	Mugu	3803	58	706	Dumkauli	154
18	302	Thirpu	1006	59	707	Bhairawa Agriculture)	120
19	303	Jumla	2300	60	710	Dumkibas	164
20	305	Sheri Ghat	1212	61	715	Khanchikot	1708
21	306	Gum Shree Nagar	2133	62	716	Taulihawa	94
22	307	Rara	3048	63	721	Birpur	120
23	308	Nagma	1905	64	722	Musikot	1280
24	309	Bijapur (Raskot)	1814	65	723	Bhagwanpur	80
25	401	Pusma Camp	950	66	724	Paklihawa	100
26	402	Dailekh	1402	67	801	Jagat (Setibas)	1334
27	403	Jamu (tikuwa Kuna)	260	68	802	Khudi Bazar	823
28	404	Jajarkot	1231	69	803	Pokhara (Hospital)	918
29	405	Chisapani Karnali	225	70	804	Pokhara (Airport)	854
30	406	Surkhet	720	71	805	Syangja	860
31	408	Gulariya	215	72	807	Kuncha	855
32	409	Khajura (Nepalganj)	190	73	808	Bandipur	965
33	410	Bale Budha	610	74	809	Gorkha	1097
34	412	Naubasta	135	75	810	Chapkot	400
35	413	shyano Shree	302	76	812	Kushma	891
36	501	Rukumkot	1560	77	814	Lumle	1642
37	502	Shera gaun	2152	78	815	Kharini Tar	500
38	504	Libang gaun	1270	79	902	Rampur	256
39	505	Bijuwar Tar	823	80	903	Jhawani	270
40	506	Kusum	235	81	904	Chisapani Gadhi	1706
41	507	Naya Basti (Dang)	698	82	906	Hetauda	466

Table1: 168 Meteorological Stations in Nepal cont…

83	907	Amlekhganj	359	127	1116	Hariharpur Gadhi	880
84	909	Simra (Airport)	137 1	128	1201	Namche Bazar	3450
85	910	Nij Gadhi	244	129	1202	Chaurikharka	2619
86	911	Parwanipur	115	130	1203	Pakarnas	1982
87	912	RamauliBairiya	152	131	1204	Aiselukharka	2143
88	1001	Timure	1900	132	1206	Okhaldhunga	1810
89	1002	Aru Ghat Bazar	518	133	1207	Mane Bhajyang	1576
90	1003	Trishuli	595	134	1208	Dwarpa	1829
91	1004	Nuwakot	1003	135	1209	Bhojpur	1595
92	1005	Dhading	1420	136	1210	Kurle Ghat	497
93	1006	Gumthang	2002	137	1211	Khotang Bazar	1295
94	1007	Kakani	2064	138	1213	Udaipur Gadhi	1175
95	1008	Nawalpur	1592	139	1215	Lahan	138
96	1009	Chautara	1660	140	1216	Siraha	102
97	1013	Sundarijal (water Res.)	1576	141	1218	Tengboche	3857
98	1014	Kathmandu (I.E)	1324	142	1225	Syagboche	3700
99	1015	Thankot	1630	143	1220	Chialsa	2770
100	1016	Sarmathang	2625	144	1301	Num	1497
101	1017	Dubachaur	1550	145	1302	Dumuhan	762
102	1018	Baunepati	845	146	1303	Chainpur (East)	1329
103	1022	Godavari	1539	147	1305	Leguwa Ghat	412
104	1023	Dolal Ghat	710	148	1306	Munga	1317
105	1024	Dhulikhel	1552	149	1307	Dhankuta	1160
106	1027	Bahrabishe	1220	150	1308	MulGhat	365
107	1029	Khumaltar	1350	151	1309	Tribeni	143
108	1030	Tribhuwan Intl. Air.	1336	152	1310	Barakshetra	146
109	1035	Saankhu	1463	153	1311	Dharan Bazar	444
110	1043	Nagarkot	2150	152	1310	Barakshetra	146
111	1052	Bhaktapur	1330	153	1311	Dharan Bazar	444
112	1054	Thamachit	1847	154	1312	Haraiche	152
113	1055	Dhunche	1982	155	1313	Biratnagar	67
114	1056	Tokha	1790	156	1316	Chatara	183
115	1036	Paachkhal	865	157	1320	Tarahara	200
116	1102	Charikot	1940	158	1322	Machuaghat	158
117	1103	Jiri	2003	159	1401	Olanchunggola	3119
118	1104	Melung	1536	160	1402	Pangthang Doma	2818
119	1106	Ramechap	1395	161	1403	Lungthung	1780
120	1107	Sindhuli Gadhi	1463	162	1404	Taplethok	1383
121	1109	Pattharkot	275	163	1405	Taplejung	1768
122	1110	Tulsi	457	164	1407	Ilam	1300
123	1111	Janakpur Airport	90	165	1408	Damak	163
124	1112	Chisapani Bazar	165	166	1409	Anarmani Birta	122
125	1114	Hardinath	93	167	1412	Chandra Gadhi	120
126	1115	Nepalthok	1098	168	1415	Sanischare	168