# CLIMATIC ANALOGUES FOR THE ADMINISTRATIVE DISTRICTS OF NEPAL

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## ABSTRACT

**This paper deals with climatic analogues of all the administrative districts of Nepal within and outside the country. On the basis of the moisture index (Im) calculated as per the scheme of thornthwaite (1948), 8 districts of Nepal have perhumid climate, 28 districts have humid climate, 23 districts have moist sub-humid climate, 15 districts have dry sub-humid climate, and one district (Mustang) has semi-arid climate. On the basis of potential evapotranspiration (PE) value, 50 districts have megathermal climate, 24 districts have mesothermal climate, and one district (Solukhumbu) has microthermal climate.**

## INTRODUCTION

In view of the present day food shortage as well as other vegetal resources in the world, reclamation of degraded lands, arid and semi-arid regions is being seriously contemplated by the introduction and successful culture of different plant communities and agricultural crops. Agroclimatic analogues may be defined as areas that are sufficiently alike with respect to the major weather characteristics affecting crop production to offer a chance for success for plants transported from one area to its climatic counterpart. Depending upon their ecological amplitude, plants can adapt themselves to physical conditions that are different slightly or even up to quite some extent from the environment of their original area but in order to assure the survival of the transported species, knowledge of degree of similarity between the donor region and receiving region is essential. For aiding such introduction programmes, Howe (1960) published homoclimatic data for about 1,500 stations in the British Commonwealth according to the water balance scheme of Thornthwaite (1940). Subrahmanyam and Sastri (1969), and Subrahmanyam and Karuna Kumar (1977) have reported climatic analogues for the dry and humid regions of India, respectively. In this report also the concept of water balance of Thornthwaite has been followed for determining the climatic analogues for the administrative districts of Nepal.

## MATERIAL AND METHODS

For computing water balance, meteorological data (mean monthly temperature and precipitation) of each administrative district was obtained from the book 'Mechidekhi Mahakali, Parts 1 to 4" (HMG/ Nepal, 1975a, 1975b, 1975c, 1975d). Meteorological data of the nearest district was used for computation of water balance in case of districts for which no such data was available in the book. Details of the elements of Thornthwaite's scheme for

computation of water balance is already reported earlier (Jha, 1997) and hence is omitted here.

In Thornthwaite's classification the climate of any region can be represented by four letters __ two standing for the moisture regime and the other two for the thermal regime. The capital letters in the two sets indicate the main moisture or thermal type while the smaller letters indicate the seasonal variation of moisture affectivity or thermal efficiency.

Moisture index (Im) of each district was calculated as:

$Im = \frac{100\ s - 60\ d}{PE} \times 100$, where s was annual water surplus, d – annual water deficiency, and PE, the potential evapotranspiration (i.e., water need). The climatic type categorization of the districts was done as follows:

| Im | Climatic type | Im | Climatic type |
|---|---|---|---|
| 100 and above | A (Perhumid) | 39 to 21 | $B_1$ (Humid) |
| 99 to 80 | $B_4$ (Humid) | 20 to 0 | $C_2$ (Moist sub-humid) |
| 79 to 60 | $B_3$ (Humid) | -1 to –20 | $C_1$ (Dry sub-himid) |
| 59 to 40 | $B_2$ (Humid) | -21 to –40 | D (Semi-arid) |

Seasonal variation of effective moisture (SVEM) within each climatic type was formulated as per the following scheme:

| Moist climates (A, B4 to B1, C2) | Dry climates (C1, D, E) |
|---|---|
| Little or no moisture deficiency throughout the year…r | Little or no moisture surplus throughout the year …d |
| Moderate summer water deficiency … S | Moderate winter water surplus … s |
| Moderate winter water deficiency … w | Moderate summer water surplus … w |
| Large summer water deficiency … $s_2$ | Large winter water surplus … $s_2$ |
| Large winter water deficiency … $w_2$ | Large summer water surplus … $w_2$ |

The climatic division based on thermal efficiency (PE value) was represented by the following notations:

| PE (mm) | climatic type | PE (mm) | Climatic type |
|---|---|---|---|
| 427 | $C'_1$ Microthermal | 1425 | $A'_2$ Megathermal |
| 570 | $C'_2$ Microthermal | 1567 | $A'_3$ Megathermal |

| | | | |
|---|---|---|---|
| 712 | $B'_1$ Mesothermal | 17010 | $A'_4$ Megathermal |
| 855 | $B'_2$ Mesothermal | 1852 | $A'_5$ Megathermal |
| 997 | $B'_3$ Mesothermal | 1995 | $A'_6$ Megathermal |
| 1140 | $B'_4$ Mesothermal | 2148 | $A'_7$ Megathermal |
| 1282 | $A'_1$ Megathermal | 2290 | $A'_8$ Megathermal |

Summer concentration of thermal efficiency (SCTE) of each district was derived as follows:

$$SCTE = \frac{\text{Total of maximum PE for three successive months}}{\text{Total PE for the year}} \times 100$$

On the basis of SCTE value the climatic sub-types of the districts were recognised as follows:

| SCTE | Climatic sub-type | SCTE | Climatic sub-type |
|---|---|---|---|
| 61.6 | $b'_1$ | 38.8 | $a'_3$ |
| 56.3 | $b'_2$ | 36.3 | $a'_4$ |
| 51.9 | $b'_3$ | 34.0 | $a'_5$ |
| 48.0 | $b'_4$ | 31.9 | $a'_6$ |
| 44.6 | $a'_1$ | 29.9 | $a'_7$ |
| 41.6 | $a'_2$ | 28.0 | $a'_8$ |

## RESULTS AND DISCUSSION

Eight districts of Nepal (four of High Mountain ranges_Bajhang, Dolkha, Lamzung, Sindhupalchok; two of Middle Mountain ranges_Kaski, Paanchthar; one of Siwalik ranges_Sindhuli; and one of Terai region_Jhapa) have perhumid climate. Out of these eight districts, six have little or no water deficiency throughout the year, Jhapa has moderate water deficiency during summer while Kaski has moderate water deficiency during winter (Table 1).

Number of districts with humid climate is 28 out of which 9 districts (one of High Himal ranges_Darchula; two of High Mountain ranges_Solukhumbu, Kalikot; 5 of Middle Moutain ranges_Okhaldunga, Ramechhap, Baitadi, Kabhrepalanchok, Kathmandu; and one of Siwalik ragesa) (Udaypur) have little or no water deficiency throughout the year. Jhapa has moderate water deficiency during summer while Kaski has moderate water deficiency during winter (Table-1).

**Number of Table 1.-** Climatic analogues for the administrative districts of Nepal

| **Megathermal A'** | **Mesothermal B'** | **Microthermal C'** |
|---|---|---|
| **1. Perhumid climates (A)** | | |
| **(i) Little or no water deficiency at any time of the year (Ar)** | | |
| Lamzung (Nepal) $A'_2{}^{a'}_6$ | Bahjang (Nepal) $B'_1{}^{a'}_2$ | |
| Dibrugarh (India) $A'_1{}^{a'}_3$ | Dolkha (Nepal) $B'_3{}^{a'}_4$ | |

Paanchthar (Nepal) $B'_4{}^{a'}_5$

Sindhuli (Nepal) $B'_4{}^{a'}_5$

Sindhupalchok (Nepal) $B'_4{}^{a'}_5$

Simla (India) $B'_1{}^{a'}_2$

Darjeeling (India) $B'_1{}^{a'}_3$

Gangtok (India) $B'_1{}^{a'}_4$

Kalimpong (India) $B'_3{}^{a'}_4$

Shillong (India) $B'_2{}^{a'}_4$

Mussooree (India) $B'_2{}^{a'}_2$

Chirapunji (India) $B'_2{}^{a'}_5$

Jalpaiguri (India) $A'_1{}^{a'}_4$

Silchar (India) $A'_2{}^{a'}_4$

Noakhali (Bangladesh) $A'_3{}^{a'}_5$

Cox's Bazaar (Bangladesh) $A'_3{}^{a'}_6$

Ratnapura (Sri Lanka) $A'_5{}^{a'}_9$

Pingtung (Taiwan) $A'_2{}^{a'}_5$

Bogor (Indonesia) $A'_2{}^{a'}_{10}$

Innisfail (Australia) $A'_6{}^{a'}_6$

Victoria (Nigeria) $A'_3{}^{a'}_8$

Ootacamund (India) $B'_1{}^{a'}_7$

Koidaikanal (India) $B'_1{}^{a'}_7$

Karioi (New Zealand) $B'_1{}^{a'}_7$

**(ii) Moderate water deficit during summer (As)**

Jhapa (Nepal) $A'_3{}^{a'}_6$

**(iii) Moderate winter water deficit (Aw)**

Kaski (Nepal) $A'_2{}^{a'}_6$

**1. Humid climates ($B_4$-type)**

**(i) Little or no water deficit at any time of the year ($B_4r$)**

Okhalduhunga (Nepal) $B'_4{}^{a'}_5$

Ramechhap (Nepal) $B'_4{}^{a'}_5$

Coonoor (India) $B'_2{}^{a'}_7$

Mukteshwar (India) $B'_1{}^{a'}_3$

Kapsabet (Kenya) $B'_2{}^{a'}_9$

Port Macpuire (Australia) $B'_3{}^{a'}_4$

Diyatalawa (Sri Lanka) $B'_3{}^{a'}_8$

Shawnigan (British Columbia) $B'_1{}^{b'}_4$

**(ii) Moderate winter water deficiency ($B_4w$)**

Tanahu (Nepal) $A'_1{}^{a'}_6$

Calicut (India) $A'_4{}^{a'}_8$

Chittagong (Bangladesh) $A'_3{}^{a'}_5$

**1. Humid climates ($B_3$-type)**

**(i) Moderate summer water deficiency ($B_3s$)**

Baglung (Nepal) $A'_2{}^{a'}_6$

Nawalparasee (Nepal) $A'_4{}^{a'}_6$

**1. Humid climates ($B_2$-type)**

**(i) Little or no water deficiency at any time of the year ($B_2r$)**

Baitadi (Nepal) $B'_2{}^{a'}{}_2$
Darchula (Nepal) $B'_2{}^{a'}{}_3$
Udaypur (Nepal) $B'_4{}^{a'}{}_5$
Ottawa (Canada) $B'_1{}^{b'}{}_1$
Lake Louise (Alberta) $C'_2{}^{c'}{}_2$
Entebbe (Uganda) $B'_4{}^{a'}{}_6$
Solukhumbu (Nepal) $C'_1{}^{a'}{}_5$
Manouram (Quebec) $C'_2{}^{b'}{}_1$
Albanel (Quebec) $C'_2{}^{c'}{}_2$
Dumfires (Scotland) $B'_1{}^{b'}{}_4$
Jos (Nigeria) $B'_4{}^{a'}{}_6$

**(ii) Moderate summer water deficiency ($B_2s$)**

Dailekh (Nepal) $A'_1{}^{a'}{}_5$
Alibagh (India) $A'_4{}^{a'}{}_7$
Palpa (Nepal) $A'_1{}^{a'}{}_6$

**(iii) Large summer water deficiency ($B_2S_2$)**

Jajarkot (Nepal) $A'_1{}^{a'}{}_5$
Sunari (Nepal) $A'_3{}^{a'}{}_6$

**(iv) Moderate winter water deficiency ($B_2w$)**

Parwat (Nepal) $A'_2{}^{a'}{}_6$
Taplejung (Nepal) $A'_1{}^{a'}{}_6$
Rangoon (Myanmar) $A'_5{}^{a'}{}_8$

**1. Humid climates ($B_1$-type)**

**(i) Little or no water deficiency at any time of the year ($B_1r$)**

Kathmandu (Nepal) $A'_1{}^{a'}{}_5$
Ranchi (India) $A'_2{}^{a'}{}_3$
Gauhati (India) $A'_2{}^{a'}{}_3$
Veracruz (Mexico) $A'_2{}^{a'}{}_5$
Wate (Pemqa Isle) $a'_4{}^{a'}{}_8$
Axim (Ghana) $A'_3{}^{a'}{}_9$
Kuala Lumpur (Malaysia) $A'_5{}^{a'}{}_1$
Kabhrepalanchok $B'_4{}^{a'}{}_5$
Kalikot (Nepal) $B'_1{}^{a'}{}_3$
Queentown (New Zealand) $B'_1{}^{a'}{}_2$
Hastings (New Zealand) $B'_1{}^{a'}{}_3$
Sydney (Australia) $B'_2{}^{a'}{}_9$
Kabale (Uganda) $B'_2{}^{a'}{}_9$

**(ii) Moderate summer water deficiency ($B_1s$)**

Dhading (Nepal) $A'_4{}^{a'}{}_6$
Gulmee (Nepal) $A'_1{}^{a'}{}_6$
Bombay (India) $A'_4{}^{a'}{}_7$
Khotang (Nepal) $B'_4{}^{a'}{}_6$
Perth (Australia) $B'_3{}^{a'}{}_3$
Sao Hill (Tanzania) $B'_2{}^{a'}{}_7$

(iii) **Large summer water deficiency ($B_1s$)**

Bara (Nepal) $A'_4{}^{a'}{}_6$

Parsa (Nepal) $a'_4{}^{a'}{}_6$

Rukum (Nepal) $A'_1{}^{a'}{}_6$

Saptari (Nepal) $A'_3{}^{a'}{}_6$

**(iv) Moderate winter water deficiency ($B_1w$)**

Gorkha (Nepal) $A'_1{}^{a'}{}_6$

Surkhet (Nepal) $A'_2{}^{a'}{}_5$

Tehrathum (Nepal) $A'_1{}^{a'}{}_6$

Capetown (Australia) $A'_4{}^{a'}{}_6$

Cooktown (Australia) $A'_4{}^{a'}{}_6$

**1. Moist sub-humid climates ($C_2$)**

**(i) Little or no water deficiency at any time of the year ($C_2r$)**

Lalitpur (Nepal) $A'_1a'_4$

Purnea (India) $A'_2a'_4$

Calcutta (India) $A'_3a'_5$

Khulna (Bangladesh) $A'_3a'_5$

Port of Spain (Trinidad) $A'_2a'_9$

Kumari (Ghana) $A'_3a'_8$

Bajura (Nepal) $B'_1a'_2$

Bhojpur (Nepal) $B'_4a'_6$

Dolpa (Nepal) $B'_2a'_3$

Christchurch (New Zealand) $B'_1a'_3$

Brisbane (Australia) $B'_4a'_4$

Port Elizabeth (South Africa) $B'_2a'_5$

Burban (S. Africa) $B'_3a'_5$

**(ii) Moderate summer water deficiency ($C_2s$)**

Achham (Nepal) $A'_1a'_5$

Chitwan (Nepal) $A'_3a'_5$

Dadeldhura (Nepal) $A'_1a'_4$

Makwanpur (Nepal) $A'_1a'_5$

Morang (Nepal) $A'_3a'_6$

Myagdee (Nepal) $A'_2a'_6$

Nuwakot (Nepal) $A'_2a'_6$

Pyuthan (Nepal) $A'_1a'_6$

Hazaribagh (India) $A'_2a'_3$

Bhaktapur (Nepal) $B'_4a'_4$

South Perth (Australia) $B'_3a'_4$

Kitui (Kenya) $B'_3a'_8$

Asansol (India) $A'_3a'_4$

Sambalpur (India) $A'_3a'_4$

Cuttack (India) $A'_4a'_5$

Bhopal (India) $A'_2a'_3$

Batticalva (Sri Lanka) $A'_5a'_8$

Trincomalee (Sri Lanka) $A'_5a'_8$

**(iii) Large summer water deficiency ($C_2S_2$)**

Dhanusha (Nepal) $A'_4a'_6$

Kapilvastu (Nepal) $A'_4a'_5$

Mahotari (Nepal) $A'_4a'_6$

Rauthat (Nepal) $A'_4a'_5$

Rupendehi (Nepal) $A'_4a'_5$

Sarlahi (Nepal) $A'_4a'_6$

Synagza (Nepal) $A'_2a'_6$

**(iii) Moderate winter water deficiency ($C_2w$)**

Kailali (Nepal) $A'_4a'_5$

Humla (Nepal) $B'_1a'_3$

Mugu (Nepal) $B'_1a'_3$

**1. Dry sub-humid climates ($C_1$)**

**(i) No adequacy of moisture at any time of the year ($C_1d$)**

Arghakhanchee (Nepal) $A'_1a'_5$

Dang (Nepal) $A'_4a'_6$

Doti (Nepal) $A'_1a'_5$

Ilam (Nepal) $A'_3a'_6$

Rolpa (Nepal) $A'_1a'_5$

Salyan (Nepal) $A'_1a'_6$

Sankhuwasabha (Nepal) $A'_2a'_6$

Banglore (India) $A'_1a'_5$

Satna (India) $A'_2a'_5$

Banaras (India) $A'_3a'_3$

Lucknow (India) $A'_3a'_3$

Gorakhpur (India) $A'_3a'_3$

Patna (India) $A'_3a'_3$

Dhankuta (Nepal) $B'_4a'_5$

Jumla (Nepal) $B'_1a'_3$

Manang (Nepal) $B'_2a'_2$

Rasua (Nepal) $B'_4a'_5$

Sringagar (India) $B'_2b'_3$

Gaya (India) $A'_3a'_3$

Darbhanga (India) $A'_3a'_4$

Jamshedpur (India) $A'_3a'_4$

Puri (India) $A'_4a'_6$

**(ii) Moderate summer water surplus ($C_1w$)**

Banke (Nepal) $A'_3a'_5$

Siraha (Nepal) $A'_3a'_6$

Raipur (India) $A'_3a'_4$

Saugar (India) $A'_2a'_3$

**(iii) Large summer water surplus ($C_1W_2$)**

Bardiya (Nepal) $A'_4a'_6$

Kanchanpur (Nepal) $A'_4a'_6$

Seoni (India) A'4a'3

**1. Semi-arid climates (D)**

**(i) No adequacy of moisture at any time of the year (Dd)**

Mustang (Nepal) $B'_2a'_3$

Leon (Mexico) $B'_3a'_5$

Charleville (Australia) $B'_4b'_4$

districts with moderate summer water deficiency is 7 (six of Middle Mountain rages_Baglung, Dailekh, Palpa, Dhading, Gulmee, Khotang; one of Siwalik ranges_Nawalparasee); and number of districts with large summer water deficit is 6 (two of High Mountain ranges_Jajarkot, Rukum; four of Terai region_Sunsari, Bara, Parsa, Saptari). Number of districts with moderate winter water deficiency is 6 (one of High Mountain rages_Taplejung; 4 of Middle Mountain rages_Tanahu, Parwat, Gorkha. Tehrathum; one of Siwalik rages_Surkhet).

Number of districts with moist sub-humid climate is 23, out of which 4 (one of High Himal ranges_Dolpa; one of High Mountain rages_Bajura; two of Middle Mountain ranges_Lalitpur, Bhojpur) have little or no water deficiency throughout the year. Nine districts have moderate summer water deficit (one of High Mountain rages_Myagdee; five of Middle Mountain ranges_Achham, Dadeldhura, Nuwakot, Pyuthan, Bhaktapur; two of Siwalik ranges_Chitwan, Makwanpur; one of Terai region_Morang); and seven districts (one of Middle Mountain ranges_Syngza; six of Terai region_Dhanusha, Kaplivastu, Mahotari, Rauthat, Rupendehi, Sarlahi) have large summer water deficits. Districts with moderate winter water deficit are Humla and Mugu of the High Himal ranges, and Kailai of the Terai region.

Among 15 districts with dry sub-humid climate, eleven (three of High Himal rages_Jumla, Manang, Rasua; one of High Mountain rages_Sankhuwasabha; six of Middle Mountain ranges_Arghakhanchee, Doti, Ilam, Rolpa, Salyan, Dhankuta; one of Siwalik ranges_Dang) have no adequacy of moisture at any time of the year; two Terai districts (Banke, Siraha) have moderate summer water surplus while the other two Terai districts (Bardiya, Kanchanpur) have large summer water surplus.

Only one district of Nepal_Mustang (situated in the High Himal ranges) has semi-arid climate with no adequacy of water at any time of the year.

Based on earlier reports (Howe, 1960; Subrahmanyam and Sastri, 1969; Subrahmanyam and Karuna Kumar, 1977) the climatic counterparts outside the country of the administrative districts of Nepal are given in Table 1.

In a comprehensive regional planning it is necessary that information on soil and other conditions should be available but for the preliminary selection of sites for the introduction of different species of forest and agricultural vegetation, the climatic analysis reported herein should be of immense value. This is because the Thornthwaite system on which the present analytical investigation is based assigns quantitative estimates to water surplus and water deficit and is thus eminently suited to the study of vegetation zonation in response to climatic controls.

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