



Seasonal and regional differences in neutral temperatures in Nepalese traditional vernacular houses

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ABSTRACT

Two surveys of the thermal environment and thermal sensations were conducted in the indoor and the semi-open spaces of traditional houses, during both summer and winter, in five districts of Nepal: Banke, Bhaktapur, Dhading, Kaski and Solukhumbu. The surveys were carried out for 40 days, gathering a total of 7116 thermal sensations from 103 subjects. The results show that residents are highly satisfied with the thermal condition of their houses, since they adjust well to the thermal conditions. The residents have higher neutral temperatures in semi-open spaces such as verandas than in indoor spaces. The findings reveal that people in the regions studied adapt well to the natural environment, as a result of which neutral temperatures are different in different climates. They are lowest in the cool climate, medium in the temperate climate and highest in the sub-tropical climate.

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1. Introduction

Nepal has a small land area of 147,181 km². Its climate varies from sub-tropical to frigid due to large differences in altitude, typically 60–8848 m. Traditional houses are adapted to the climate; similar types of house are found in locations of similar climate and culture. Houses and lifestyles vary, and various adaptive actions are used that produce comfortable thermal conditions where possible [1–3]. For example, 1) there is the custom of wearing traditional clothing designed to protect both from extreme heat and extreme cold, 2) houses have cooler and warmer spaces and residents move between them, and residents sleep in the semi-open spaces or front yards to stay cool, 3) firewood is burnt to provide heat in winter, 4) people drink large quantities of cold water and take more cold showers to keep cool in summer, and drink large quantities of butter tea to keep warm in winter.

The Nepalese can face extremes of heat and cold in everyday life, the results of which range from discomfort to illness and death. They also need to consume a great amount of energy. There are many problems to solve. For instance, 1) the prevalence of

infectious diseases in summer and the high mortality rate among aged people from cold in winter¹, 2) thermal discomfort from going barefoot on very cold earthen floors in winter, 3) excessive heat and smoke from burning firewood in open hearths, 4) scarcity of firewood because of excessive consumption [4].

Many field investigations to establish neutral or comfortable temperatures in houses have been conducted in Japan [5–8], Bangladesh [9], India [10], Pakistan [11,12], Iran [13], Zambia [14], UK [15,16] etc. However, the climate and living conditions of Nepal are different, and in order to evaluate and improve the thermal environment of the houses in Nepal, a thermal comfort study was needed. Nepal is in the process of modernization, and in order to establish a standard for indoor air temperature, first of all it was necessary to

¹ In summer, large numbers of mosquitoes and flies invade the houses, and as a result infectious diseases are prevalent in several parts of country. The mortality rate of aged people is high in winter, and the aged hope that if they survive the winter, they can survive another year. There is no official death record in Nepal, so a time of death must be established from their families. The death rate in the winter (December to February) was 59% (n = 22) in Bhaktapur, 43% (n = 58) in Dhading, 36% (n = 105) Kaski and 48% (n = 23) in Solukhumbu, all of which are high values. This may be related to the small indoor and outdoor temperature differences in the houses during winter. However, a death rate couldn't be established in Banke because of inaccurate information.

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clarify the neutral temperatures experienced by the Nepalese in current conditions of traditional living. Moreover, knowledge of the neutral temperature experienced by the Nepalese, who live in natural environments, may yield suggestions for building designers considering a sustainable life style well adapted to the local climate. If the neutral temperature is found to be different according to region or season, it is possible to use this information to improve thermal comfort while lowering energy consumption and consequently, reducing the impact on the environment.

This survey of the thermal environment and thermal sensations was conducted in real life situations in summer and winter in five areas of Nepal in both indoor and semi-open spaces [17,18]. Since no research had previously been conducted on indoor thermal comfort in Nepal, the objectives of this research were: 1) to investigate the residents' methods of thermal adjustment, 2) to evaluate the thermal comfort of the houses, and 3) to estimate the neutral temperature of the residents in indoor and semi-open spaces in the different climatic zones.

2. The study area

The study areas were chosen having regard to the altitude, climate, topography, ethnicity, fuel resources, and housing types (Table 1, [19]). The areas are located in a sub-tropical climate (Banke), temperate (Bhaktapur, Dhading and Kaski) and cold climate (Solukhumbu) (Fig. 1, [20]). In Nepal, summer is in May and winter is in January. Because of the landlocked nature of the country, the climate is in general dry and hot in summer. However, in the sub-tropical region, relative humidity is around 53% in May and it can feel cool in the shade. It is warm in winter during the daytime because Nepal lies in low latitudes (26–30° N) and insolation is high. Bhaktapur is an urban area and the other areas are rural. In the rural areas, agriculture is the main occupation and firewood is used for cooking and heating.

3. Investigation method

Two kinds of surveys (1) thermal comfort and 2) the thermal environment) were conducted. From survey 1), the methods of thermal adjustment and the thermal suitability of houses were clarified and from the relation of the two surveys, the neutral temperature of residents was estimated. Semi-open spaces have been included because they form an important part of the living and working spaces.

3.1. Survey of thermal adjustments

The factors thought to be influential for thermal adjustments, such as clothing changes, controlling apertures, burning firewood, sunbathing, taking cold showers, etc. were placed in the categories of “1. highly influential”, “2. slightly influential” and “3. not

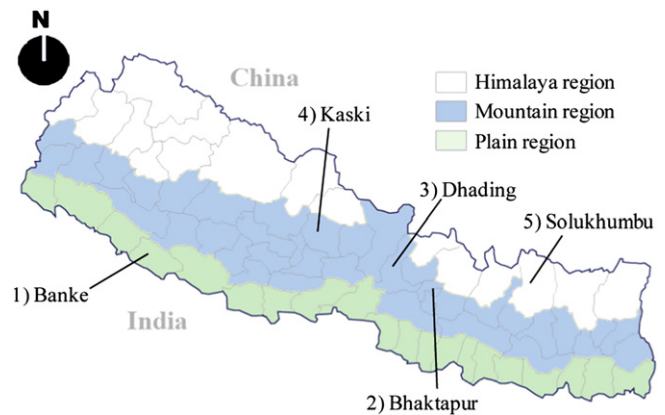


Fig. 1. The investigated districts of Nepal.

influential”. These questions were asked individually of the people who took part in the thermal comfort survey.

3.2. Thermal comfort survey

3.2.1. Thermal comfort words of Nepalese

The English and Nepalese questionnaires of the thermal comfort survey are shown in Appendix 1. In Nepalese language, there are many words relating to thermal comfort. For example, “Chiso” and “Sital” for cool and “Tato” and “Nyano” for warm. These words also have the meaning of discomfort for “Chiso” and “Tato” and comfortable for “Sital” and “Nyano”. Generally, Nepalese people do not say “Sital” in winter or “Nyano” in summer. For these reasons, we used “Chiso” and “Tato” in the thermal sensation questionnaire and “Sital” and “Nyano” in the thermal preference questionnaire.

3.2.2. Thermal sensation scale

To evaluate the wide range of thermal environments in which the Nepalese live, a 9-point thermal sensation scale was used. The questionnaires were translated into Nepali, the official language of Nepal, so that people could be interviewed. Some of the female subjects of the Tharu, Newar and Sherpa race could not speak Nepali very well and the questionnaire was translated for them by local people fluent in Nepali. The meaning, relationships and evaluation methods of the questionnaires were explained in advance to all the subjects either individually or in groups to improve the accuracy of their responses.

3.2.3. The people

The average age, height, body surface area and clothing insulation are shown in Table 2. In the table, these values are presented separately for indoor and semi-open spaces, and for summer and winter. The total number of people was 103 and 44 people took part in both the summer and winter surveys. The people were generally local, healthy, and between the ages of 17 and 60. The average age

Table 1
Outline of investigated areas.

Survey area	Altitude (m) ^a	Topography	Climate	T_{out} (°C) ^b	H_{out} (%) ^b	Area	Race	Energy
1) Banke	150	Plain	Sub-tropical	31.4/15.2	53/80	Village	Tharu	Firewood
2) Bhaktapur	1350	Valley	Temperate	22.2/10.6	64/82	City	Newar	Electricity
3) Dhading	1500	Mountain	Temperate	25.4/13.3	70/76	Village	Chhetri	Firewood
4) Kaski	1700	Mountain	Temperate	18.8/8.9	75/80	Village	Chhetri	Firewood
5) Solukhumbu	2600	Himalaya	Cool	13.1/4.0	76/80	Village	Sherpa	Firewood

T_{out} & H_{out} : monthly mean outdoor air temp. & relative humidity (May/January).

^a Approximate value.

^b Mean value of 1987–1996 (meteorological observatory: Banke; Nepaljung (reg. off.), Bhaktapur; Kathmandu airport, Dhading; Dhunibesi, Kaski; Lumle, Solukhumbu; Chialsa).

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