ASPECTS OF THERMAL PREFERENCES IN HUMID TROPICAL CLIMATES

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ABSTRACT This paper presents the findings of two recent studies on the thermal preferences of householders in upland and coastal tropical environments. The aim of the studies was to investigate those behavioural factors that influence a householder's appreciation of an indoor environment. The studies involved 159 households in Kampala, Uganda, and 104 households in Surabaya, Indonesia.

The studies indicated that householders made choices regarding their indoor environments based not on comfort sensation alone, but on "real-world factors". Of particular interest in both studies was the low priority given to comfort sensation as a factor influencing the choice of indoor environments. Real-world factors, which are context specific, were found to be of greater importance and had a significant bearing on the responses made by householders. The paper concludes with a brief discussion of the implications of these results and makes suggestions for the presentation of such information to designers for the design of thermally appropriate housing.

1 Introduction

A building is usually expected to do more than just provide shelter to its occupants. Among the many ends it has to achieve is that of thermal comfort. In attempts to achieve this aim, numerous studies have been conducted to determine the conditions in which house occupants are comfortable. These studies have largely concentrated on thermal sensation, the physiological aspects of human thermal comfort, taking human comfort as the primary design criterion. This approach, in its obligation to derive and present near universal models and indices of thermal response, has tended to sacrifice the context specific nature of satisfaction with a thermal environment (Olweny and Williamson, 1995). By limiting design data to descriptions of thermal conditions, particularly temperature and humidity levels that house occupants find comfortable or uncomfortable, these studies fail to account for the important belief systems and the underlying factors that lead to the choice of these thermal conditions in the first place. These 'thermal preferences', defined by Williamson et al. (1991) as being,"... the choice of physical factors influencing thermal sensation (air temperature, humidity, air movement, radiation, clothing and activity) which house occupants would make when constrained by climate and existing social and cultural influences... ." Knowledge of these thermal preferences convey to designers important information about the way people interact with their environment and acknowledge the fact that within certain parameters, people are able to, and do react to situations that impact on their well-being and comfort.

2 The present studies

This paper presents findings from two studies carried out to investigate and outline the thermal preferences of householders in two cities in tropical settings, Kampala, Uganda (Olweny, 1996) and Surabaya, Indonesia (Sufianto, 1995). Kampala, the capital of Uganda, is located about the latitude 0°20'N and longitude 32°30'E at an altitude of about 1310m. Kampala is the largest urban centre in Uganda and has a population of about one million people (est. 1996). Being an inland city, Kampala has a modified climate, with a mean maximum temperature of 27°C, a mean minimum of 17°C, and an average humidity of 75%. Average rainfall is about 1174mm per annum falling in two distinct wet seasons, April to May & October to December. Surabaya is the Capital of the East Java province of Indonesia and is located about latitude 7°16'S and longitude 112°45'E. Surabaya has a population of well over two million people, and is the second largest city in Indonesia (after the capital Jakarta). This coastal city has a mean maximum temperature of 33°C and a mean minimum of 19°C, with an average humidity of 68%. Rainfall averages about 1570 mm a year, much of it during the monsoon season.

Both studies used a questionnaire-based interview approach as the primary data-gathering instrument. The underlying principles for the design of the questionnaires were essentially the same for both studies. However, the questionnaires were presented differently to account for the cultural differences between the two study groups. Questions were classified into five general areas; background, lifestyle, attitudes to climate, attitudes to housing and housing use patterns. Most questions were open-ended, allowing participants some latitude in answering questions. Only householders over the age of 15 were invited to answer questions. A participant had to have been acclimatised to the specific climate as early research by Yagloglou & Drinker (1928) has suggested that acclimatisation, or lack of it, does have a significant effect on perception of a thermal environment. Householders were regarded as being acclimatised if they had been resident in the location for more than 24 months. One hundred and seventy nine acclimatised householders were interviewed in Kampala and one hundred and nineteen in Surabaya. The use of a similar methodology was essential to reveal any differences in thermal preferences.

3 Results

3.1 Attitudes to housing

Householders were asked a series of questions directed at discovering their attitudes to housing. As an example, they were asked what suggestions they would make to a friend, who was looking to build, buy or rent a house:

> *"Suppose you have a friend who is looking to build, buy, or rent a house in the area, what suggestions would you give to her or him?"*

A second question sought details on what householders would look for if they were to build, buy or rent a house for themselves:

> *"Suppose you are to build, buy, or rent a house for your own family, what important features would you look for?"*

Tables 1 and 2 present the most common responses to these two multiple response questions.

Table 1 "What features would you suggest to a friend?"

KAMPALA		SURABAYA	
Response	**% of Cases**	**Response**	**% of Cases**
Accessibility[1]	18.0	Area does not flood[2]	40.0
Close to Services	16.3	Good Location	24.0
Large Yard	14.0	Good Ventilation	17.0
Good Security	13.4	With Services (Water & Electricity)	17.0
Close to Amenities	9.3	Suit Finances	16.0

Table 2 "What features would you look for in your ideal house?"

KAMPALA		SURABAYA	
Response	**% of Cases**	**Response**	**% of Cases**
Close to Services	23.6	Good Ventilation	28.6
Good Security	20.1	Have a Yard / Garden	24.0
Large Yard	19.0	Area does not flood[2]	24.0
Accessibility[1]	16.1	Clean Environment	23.0
Close to Amenities	16.1	With Services (Water & Electricity)	18.9

The results indicate differences in the housing preferences of the two study groups. The issues of importance to householders are intrinsically linked to the conditions in the areas in which they live. Householders in Kampala were more concerned about the general environment around the dwelling and the social aspects of housing such as the need for proper access, availability of amenities, and the need for a large yard in which to grow fruit and vegetables, rear chickens, and in some cases goats. In Surabaya the primary concern was in regard to environmental aspects, such as the need for protection from flooding and the need for good ventilation. In Kampala and Surabaya, the availability of essential services such as electricity and water were found to be paramount.

It is particularly intriguing to note that thermal factors were not a high priority for householders in Kampala, with the most direct thermal factor being "elevated site - for breeze". This factor was considered important enough to suggest to a friend in 2.3% of cases, and in relation to an ideal house for respondents, 6.9% of cases. In contrast, in Surabaya, ventilation was considered of major importance in 17% of cases and 28.6 % of cases respectively. An explanation for this can be found in householders' responses to the climate of the respective cities.

3.2 Attitudes to climate

People's attitudes to the climate of the study location were sought. Householders were asked: *"What is your opinion about the climate and weather?"* In Kampala, 29.3% of the householders stated that the climate of Kampala was 'hot', while 20.7% stated that it 'varied'. In Surabaya, the same question revealed that 46% of householders saw the climate as being hot or very hot. Further questions investigated the times when householders felt comfortable or uncomfortable. These were regarded as being the design times of the householders, defined as "... those times considered to be significant to optimise the performance of a building" (Williamson et al, 1989). These results are presented in Table 3. The significance of design times is based on the understanding that households have different thermal expectations depending on their house-use patterns that are affected by their experience of the thermal environment. Householders in Surabaya indicated that they were uncomfortable primarily during the hot season, and to a lesser extent during the wet seasons. Thus, the most important design time for householders in Surabaya would be the hot season. Householders in Kampala found the nights the most uncomfortable followed by the dry season.

Table 3 "When do you feel Uncomfortable inside your house?"

KAMPALA		SURABAYA	
Response	**% of Cases**	**Response**	**% of Cases**
At Night	26.1%	The Hot Season	67.0%
The Dry Season	22.4%	The Wet Season	28.9%
The Afternoon	12.4%	Both Wet and Hot Seasons	7.2%
During the Day	14.9%	Daytime In Hot Season	5.2%

[1] Accessibility - There is poor access to many residential areas of Kampala due mainly to inadequate planning. Some access roads are barely wide enough for a car to get through and are virtually impassable after a heavy rainstorm.

[2] Area does not flood - Surabaya is susceptible to flooding during the monsoon season (November - March).

A subsequent investigation of the results received from householders in Kampala revealed that much of the nighttime discomfort was due to households closing windows at night. Windows are tightly shut at about 6pm and not opened till 7am the following morning. Two reasons were given for this behaviour, firstly, to prevent the mosquitoes from entering their dwellings at night, important as less than 50% of all dwellings included in the study had mosquito screens installed. Secondly, the issue of security, a legacy of the long civil war in Uganda, meant that open windows were an invitation for potential intruders to visit. Householders were thus willing to sacrifice comfort during the night in order to protect themselves from thieves and malaria carrying mosquitoes. It was also found that the majority of householders included in the Kampala study slept with over 80% bed covering (all but their head beneath the blanket), another contributing factor to night-time discomfort. In contrast, in Surabaya, over 90% of households had mosquito screens installed on all windows and doors. Interesting though is the fact that despite having mosquito screens, householders in Surabaya typically closed their windows and doors between the hours of 6pm and 7am as well, to keep out mosquitoes. In many cases householders had adjustable mosquito screens that were closed in the evenings when mosquitoes are prolific, and opened in the mornings to let in the cool morning breezes. Past experiences in housing without mosquito screens or with damaged mosquito screens could account for some of this behaviour.

3.3 Response to warm and cool conditions

Householder's responses to warm and cool conditions were also the subject of investigation in both Kampala and Surabaya. They were asked what their responses would be in warm conditions:

> *"If you feel warm, slightly warm or hot inside your house, what would be your response to that situation?"*

Responses in relation to warm conditions are presented in Table 4.

It was found that the use of coolers was more prolific in Surabaya than in Kampala. This is a reflection of the higher penetration of cooling devices in Surabaya, where 85% of households mentioned they had a cooler (in most cases a portable fan), compared with only 24% of households in Kampala. In both Kampala and Surabaya, cooling devices were used predominantly in the living room or main bedroom of the dwelling.

Table 4 Response to warm conditions

KAMPALA		SURABAYA	
Response	**% of Cases**	**Response**	**% of Cases**
Put on Lighter Clothing	38.1	Go Outside	43.3
Have a Cool Bath/Shower	26.7	Turn On Coolers	37.5
Go Outside	22.7	Put on Lighter Clothing	34.6
Open Windows/Doors	22.2	Fan Self Manually	19.2
Go Into Shade	14.8	Go Into Shade	10.6
Turn On Coolers	14.8	Sleep On Floor	10.6

In addition, householders in Kampala were asked what their response would be in cool conditions:

> *"If you feel cool, slightly cool or cold inside your house, what would be your response to that situation?"*

This question revealed that there was an overwhelming response towards personal aspects, with 77% of responses related to an increase in clothing levels, and 20% taking a hot drink. A novel way reported of keeping warm was to smoke a cigarette.

4 Discussion

This study has shown that there are contextual differences in the thermal preferences of householders in Kampala compared with those in Surabaya. Differences were found in householders' attitudes to housing, responses to warm conditions and design times. Householders in Kampala were more concerned for the general surrounds of the house, and for things such as access and security. Householders in Surabaya, which again showed concern for the surrounding conditions and amenities, also indicted that providing for good ventilation was also an issue. These real-world factors have a bearing on the choice of thermal conditions and give an indication of the priorities and preoccupations of householders in the two cities. Use of such data in the overall assessment of a thermal environment is recognition of a householder's actual physical, social and psychological needs in addition to those physiological requirements identified in thermal comfort studies.

Design decisions based solely on a thermal comfort model aimed at satisfying a temperature sensation are likely to produce results that are not in accordance with people's thermal preferences. This was illustrated in relation to night discomfort in Kampala, where simply opening windows would appear to overcome much of the problem. However, when we include real- world issues such as the threat to personal security and health, the picture changes. The findings highlight the need for a contextual and location-specific approach to the thermal design of buildings. It is thus imperative that theories of human thermal comfort address those contextual real-world influences, together with the social, environmental, psychological, physical, and economic issues that are relevant to design decisions for a particular area.

5 Conclusion

These findings indicate a need for a change in the way we assess the appropriateness of indoor thermal environments. Restricting assessment to an instrumental approach has the potential to give a limited understanding of the problem. The problem itself has to be defined correctly if it is to be addressed adequately. The basis for user actions in relation to the thermal environment may not necessarily be connected directly to thermal factors, as these two studies have shown, but may be related to the social and cultural background of the people. As such, the inter-related nature of satisfaction with an environment has to be recognised in the approach taken to evaluate the thermal environment. Thus the problem is not only a search for a comfortable thermal environment in terms of thermal sensation, but a search for a comfortable environment that satisfies the thermal preferences of the householder taking into account contextual real life factors. Thermal preference analysis is a move towards achieving this purpose. It is expected that design strategies utilising thermal preference data should produce more appropriate design responses.

The form of presentation of this data, however, plays a major part in the usefulness of this information in the design process. A number of different approaches could be used in presenting this data depending on the context within which one is working. One aspect that was explored with the data gathered from Kampala was the relationship of the cost and use of energy per household to the thermal performance of the buildings. This information is presented as a series of design scenarios that look at the effect of applying a particular housing preference to a base case scenario (Appendix I). A similar approach was used to present the data from Surabaya, but in this case thermal sensation was used as a criteria as it was a major concern for householders. It is expected that such design data presentations, based on thermal preferences, should produce more relevant design responses.

6 Acknowledgements

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7 References

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APPENDIX I (EXAMPLE DESIGN DATA SHEET FOR KAMPALA)

DESIGN SCENARIO H202-1


Trees


Roof


Windows

- Extra trees for shade
- Corrugated steel roof
- Windows closed at night

Sleeping Zone

Mean internal temperature:	28.1°C
Maximum temperature:	31.5°C
% of time temperature is >30°C:	
07:00 to 18:00	8.5%
19:00 to 06:00	3.3%
Thermal discomfort Index (T_{dis}):	**27.4**

T_{dis} = - the sum of the difference between the T_n and the temperature values above T_n for a 24 hour period

Thermal benefit Index (TBI):	
07:00 to 18:00	**+2.2**
19:00 to 06:00	**+4.5**

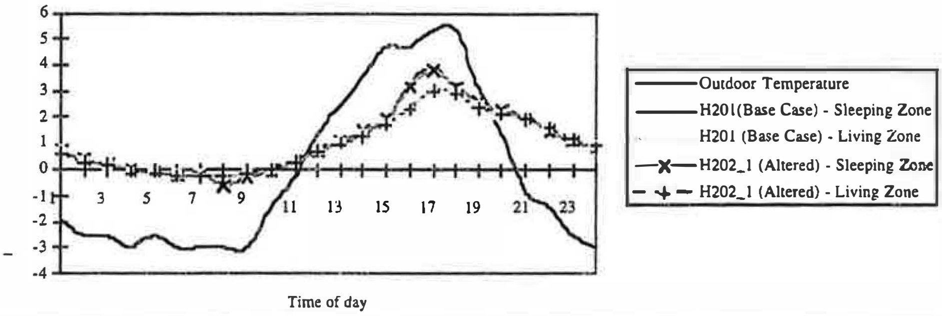
Living Zone

Mean internal temperature:	28.2°C
Maximum temperature:	31.0°C
% of time temperature is >30°C:	
07:00 to 18:00	8.4%
19:00 to 06:00	3.9%
Thermal discomfort Index (T_{dis}):	**24.4**

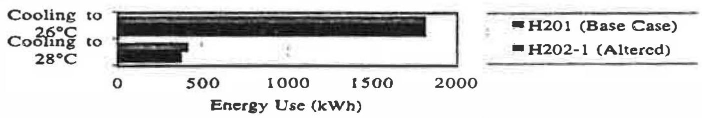
T_{dis} = - the sum of the difference between the T_n and the temperature values above T_n for a 24 hour period

Thermal benefit Index (TBI):	
07:00 to 18:00	**+0.6**
19:00 to 06:00	**+0.1**

Temperature Differential



Energy Use and Energy Cost



		Difference in Energy Use
Cost of energy to achieve 26°C:	USh 172,100 (USh 14,342 per week)	+0.3%
Cost of energy to achieve 28°C:	USh 27,900 (USh 2,325 per week)	-12.8%