Assessment of Outdoor Thermal Comfort in the Street Markets of South Mumbai

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Abstract: It is well known that the quality of outdoor urban spaces becomes one of the important items in the urban design process not only for ecological and economical purposes, but also it is important from the social point of view. This study is based in the street markets in South Mumbai which aims to point out the impact of urban morphology on outdoor thermal comfort in a warm and humid climate during summer. The aim of this study is to examine the influence of urban spaces on people's thermal perception. This study is based on over 120 structured interviews during summer. The relation between thermal comfort indices and personal factors (age , clothing , activity) have been assessed. Results show that markets having shading either in the form of trees or a built mass are more comfortable.

Keywords: Warm and humid climate; Outdoor thermal comfort; Street markets ; Thermal perception , Physiologically Equivalent Temperature , RayMan

Introduction

Mumbai has some of the best malls in the nation, which host outlets of the most popular Indian and international brands. Apart from all these brands, there are street shopping markets in the city which are much more popular than the malls and definitely worth a visit. The products that you can find here are affordable, unique and of excellent quality in most cases. It is common to find such shops throughout the city, but there are a few areas where they have agglomerated and this is where one heads to for shopping when coming to Mumbai. It is common to find these areas crowded with tourists as well as residents. While indoor shopping malls have become an endemic part of the Indian metropolitan cities, there are still a lot of people who prefer shopping from the vendors on the nearby streets. This research focuses on three street markets located in a warm and humid climatic zone. In this type of zone, it is critical to understand the factors that affect the perception of thermal comfort in outdoor public and commercial spaces. Weather can greatly affect a shopper's mood and behavior.

Purpose of the Study
The study's purpose is to clarify the design attributes that influence a user's perception of thermal comfort in warm and humid climates using the case study of street markets in South Mumbai. By identifying these attributes and perceptions, landscape architects, architects, planners, and urban designers can incorporate them into outdoor retail centres and urban spaces. This study investigates the landscape features and urban morphological features that

are vital to a successful outdoor public spaces in warm and humid climates to be perceived as comfortable by users.

Geographical area studied

Mumbai stakes its claim as the biggest metropolitan city in India in terms of population size and economy it generates. Located in the western coast facing the Arabian Sea (Fig. 1), the city, which serves as an important seaport and trade hub, is also the financial nerve-centre of the country. This capital city of the state of Maharashtra was once made up of seven small islands, which over the centuries got connected through natural and man-made land reclamations. Today, it is a narrow strip of island that abuts the coastal belt of Konkan.

Mumbai is located in the western seaboard of India at coordinates 18.96° North 72.82° East. A major part of Mumbai sits on the old island of Salsette which lies at the mouth of Ulhas River. Usually, Mumbai is referred to as three different geographic entities: Mumbai City, Greater Mumbai, and Mumbai Metropolitan Region (Fig. 2). Mumbai City is the core of the old port city of Mumbai during the colonial period. Since then, its territory has expanded northward to cover the suburbs and extended suburbs. The Mumbai Island City plus the Mumbai Suburban District comprise what is now called as Greater Mumbai.

Climate

Mumbai has a tropical wet and dry climate under the Köppen climate classification. The city does not experience distinct seasons, but the climate can broadly be classified into two main seasons—the humid season and the dry season. Usually, the period between October to May is relatively dry. The city gets southwest monsoon rains beginning June to end September with peak rains occurring in July. Occasionally, northeast monsoon showers occur in October and November.

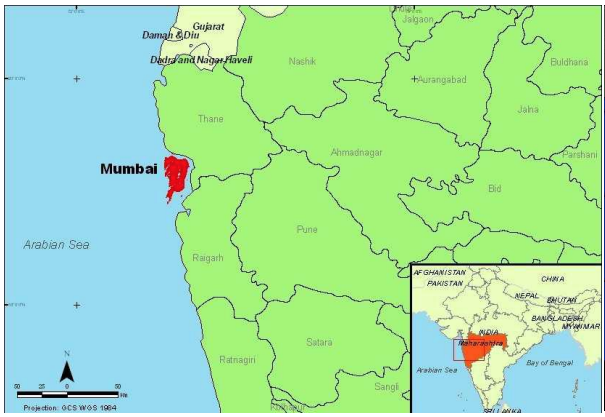


Fig 1. Greater Mumbai Location Map
Sources: Center for Disease Control and Prevention; Census Info India 2001

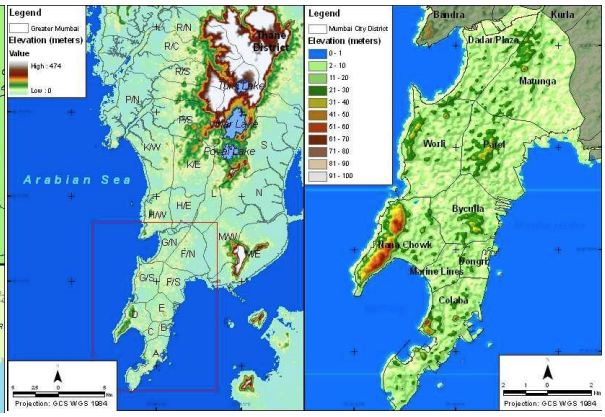


Fig 2. The Maps show the composition of Greater Mumbai namely, Mumbai Suburban District and Mumbai City (District).
Sources: ASTER GDEM, Google Earth, Praja.org, and EMI

Methodology

Outdoor thermal comfort and thermal indices

The Outdoor Thermal Comfort Evaluation is carried out following two methods in combination:

1. Micro-Meteorological Measurement:
This includes physical measurement of the microclimatic conditions at the immediate surroundings of the subjects. The four main physical parameters those characterize thermal environment and thermal comfort sensation are Air temperature, Relative humidity, Wind and Solar Radiation.

2. Guided User Questionnaire Survey:
It consists of questionnaire survey addressing the subjects' thermal comfort condition (e.g. thermal sensation and comfort) and also record of subjects' demographic background (gender and age) during the survey. The thermal comfort sensation can be recorded in any one of the thermal comfort scale as shown below in Table 2.

3. External parameters (e.g. activity level, Clo value etc.) required for the thermal comfort conditions calculation can be obtained from this questionnaire survey.

4. Activity level: The body converts a part of food into energy according to type of activity. Amount of energy produced per unit of time is called metabolic rate and it is expressed in Watt/ m2 of body surface. Table 1 presents metabolic rate for different activities.

5. Clothing: It is an interface between body and environment. Different clothing type has its own efficiency which is expressed by Clo value as shown in Table 4. Subject's thermal sensation and comfort vote are obtained by face to face interview while subject's demographic background, clothing and activities are observed and recorded by the interviewer while conducting the survey. The results of the questionnaire survey are correlated with the micro-meteorological data to analyse the general thermal comfort conditions in the outdoor spaces of that place and the comfort requirement of the local people.

Activity	Metabolic rate (W/ m²)
Sitting	1
Eating	3
Walking	2.6
Playing/exercise	4
Standing	1.2
Studying and sitting	1
Serving	1.6

Table 1: Metabolic Rate of Various Outdoor Activities
Sourc e : ASHRAE Handbook of Fundamentals, 1989

ASHRAE SCALE		BEDFORD SCALE		SEVEN POINT		NINE POINT	
Hot	3	Much Too Warm	3	Very Cold	1	Very Cold	1
Warm	2	Too Warm	2	Quite Cold	2	Cold	2
Slightly Warm	1	Comfortably Warm	1	Cold	3	Cool	3
Neutral	0	Comfortable	0	Comfort	4	Slightly Cool	4
Slightly Cool	-1	Comfortably Cool	-1	Hot	5	Neutral	5
Cool	-2	Too Cool	-2	Quite Hot	6	Slightly Warm	6
Cold	-3	Much Too Cool	-3	Very Hot	7	Warm	7
						Hot	8
						Very Hot	9

Source: Nasir et al.,2012

Table 2: Thermal Comfort Scale
Source : Nasir et al.,2012

Selection of the urban zones studied.
The study was carried out in open street markets since the street markets in South Mumbai are the most common public space; they are the main place where people can stroll and pass

by for different reasons such as going to work and shopping as well as for recreational purposes. Three case studies have been chosen in South Mumbai (fig 3,4,5)

Fig 3. Sheikh Memon Street


Fig 4. Fashion Street

Fig 5. Colaba Causeway

The analysis part also includes a comparison between these three markets regarding the type of use, location , setting of the site , number of floors, maximum height, aspect ratio , orientation of street , building materials , etc (Table 3).
Drawings as architectural plans, sections, and perspective model were made with Auto CAD and Sketch up respectively in order to show the spaces around buildings, building heights, and H/W ratios.

Parameters	Colaba Causeway	Fashion Street	Sheikh Memon Street (Crawford market)
Location	Colaba causeway joins Fort to the Defence land at the southern tip of Mumbai	M G Road , Fort Mumbai	Near CST
Setting of the site	Branded clothing shops , spas, Multiplex and restaurants are located on both sides of the street. The Colaba causeway street market is located on the pavement abutting these stores. All these branded stores have glass facades . The bylanes in the market lead to the Arabian sea (Gateway of India)	Located between Azad maidan and Cross maidan.	This is an extremely crowded and busy area. Goods are brought in shops by manually pulling wooden trolleys as vehicular movement is not possible on this street. Kalbadevi & Bhuleshwar are adjoining street markets . This street is also busy for the fact this this is the only route that leads straightaway to the Juma masjid
Type of street	This colonnaded and shaded market is on both sides of the road.	Located on only one side of the road. The pavement and the street are very wide	Both sides of the street
Orientation of Street :	NE-SW	NW-SE	NW-SE

Height/width ratio :	0.8	0.125	1.5
Road material	Concrete	Concrete	Paver blocks
Paving material	Paver blocks	Paver blocks	Paver blocks
Structure of the shops/ stalls	Stalls are placed under a colonnaded pathway . Hence it is shaded all the time.	The stalls are temporary structures . There are abundant evergreen shady trees on this street .	Shops are inside permanent cement concrete structures on both sides of the street . But the street vendors on the pavement neither have a temporary roof nor any shady tree. There are no stalls or temporary structures for street vendors
Type of goods sold	Antique items , western clothes	Garments	Wholesale market of clothes for all age groups , utensils, bags , soft toys
Population Density	High	Medium	Highly crowded all the time. Highest density of population is seen on Fridays due to presence of Juma masjid in the heart of the market.

Table 3: Comparative Analysis of the three case studies

Field measurements

In order to find out the characteristics of urban microclimate and thermal comfort in the 3 study areas , both field measurements and a questionnaire survey were conducted from 13th to 15th March 2018. The combination of the methods (measurements and structured interviews) allowed to assess different thermal environments and to simultaneously determine the user's thermal perception through investigating different thermal indices.

Selection of measurement locations and time period

Measurements were taken at one selected point in each case study from 12 noon to 8pm . The measurement equipment was placed at the points where people could be expected to sit or walk either under the sun or in shade. Air temperature (Ta), relative humidity (RH), wind speed (W) and wind direction (Wd) were measured.

Outdoor thermal comfort and thermal indices

A great number of indices, which try to predict the state of thermal comfort, mainly for indoor applications but also for outdoors, have been developed. The Predicted Mean Vote (PMV), the Standard Effective Temperature (SET*) and the New Effective Temperature (ET*) were all developed for indoor conditions (McIntyre, 1980). In addition, many indices have been primarily designed for outdoor applications, e.g., the Perceived Temperature (PT), which is based on the comfort equation of Fanger (Jendritzky et al., 2000), OUT_SET*,

which is an adaptation of SET* for outdoor use (Pickup and de Dear, 2000), and the Physiological Equivalent Temperature (PET) (Höppe, 1999).

In this study, PET, SET and PMV have been used to assess and evaluate the outdoor thermal comfort in the street markets of South Mumbai . The RayMan PC application (Matzarakis, 2010) was used to calculate PET, SET and PMV indices. (table 5)

Types	Clo Values of various clothes					
Under Garments & Inners	0.05	Briefs				
	0.15	Vest (light)		0.29	Vest (heavy)	
Clothing above waist	0.14	Shirt short sleeve		0.22	Shirt long sleeve	
	0.25	T-Shirt short sleeve		0.29	T-Shirt long sleeve	
Clothing below waist	0.15	Shorts/Half pant				
	0.2	Capris				
	0.3	Jeans				
	0.26	Trouser light material		0.32	Trouser heavy material	
Winter Wears	0.3	Inner above waist		0.3	Inner below waist	
	0.2	Sweater light		0.37	Sweater heavy	
	0.22	Jacket light		0.49	Jacket heavy	
	1.5	Overcoat				
Others	0.5	Hat/Cap				
	0.1	Scarf/shawl				
	0.05	Tie				
	0.1	Socks till knee		0.5	Socks till ankle	
	0.04	Shoes	0.02	Sandal / Slippers	0.08	Boots

Table 4 : Clo Value Chart for Male
Source : ASHRAE Handbook of Fundamentals, 1989 and ANSI/ASHRAE Standard 55-2010

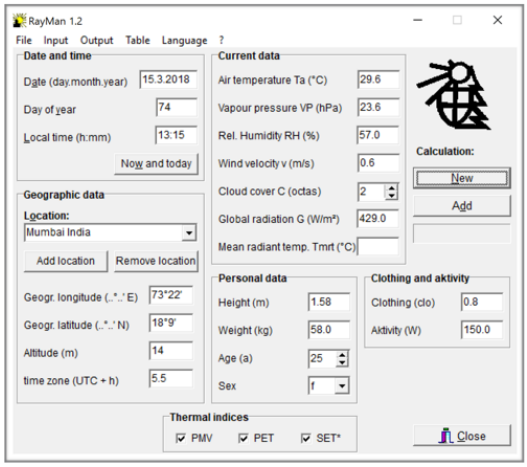


Table 5 : Input parameters in Rayman

Structured interviews

A structured interview survey was performed simultaneously with the measurements in each location in order to estimate actual thermal perception and to compare with the calculated PMV, PET and SET indices derived from microclimatic measurements (Table 3.9 a, 3.9 b). The survey study covered a random sample in all measurement locations. People were interviewed by the author between 13th to 15th March at the three study areas . 40 people were interviewed in market . These 40 people consisted of 10 shopkeepers and 30 customers .

Assessment of transition and neutral temperatures

To determine transition temperatures between different thermal sensation zones, i.e. the index temperatures at which the thermal sensation changes from one zone to another – e.g. from comfortable to slightly warm – as well as the neutral temperature, which is defined as the temperature at which people feel thermally neutral (neither cool nor warm) and which corresponds to the value zero in the thermal sensation scale, probit technique (Ballantyne et al., 1977) was used.

Results and discussion

1. Measured surface temperatures and thermal comfort in summer

Influence of H/W ratio and orientation on surface temperatures and PET

The surface temperatures of concrete roads and pavements in all three studied zones between 12 noon and 8:00 pm are shown in fig. 5a, 5b respectively . As can be seen in the table, the highest surface temperatures are at Sheikh Memon street where temperatures reach as high as 52°C. The temperature difference between the pavements is very small in Colaba Causeway and Fashion Street . For these zones – which consist attached traditional buildings in South Mumbai – the influence of street orientation on surface temperatures is not decisive. Sheikh

Memon street has significantly high surface temperatures as compared to other two case studies. Fashion Street and Sheikh Memon street are N-S oriented and they do not have any permanent shading structure . Fashion Street is shaded due to the presence of a large number of Rain trees with a wide spread. The shopkeeper at Sheikh Memon street use umbrellas as a temporary shading device . Furthermore, for Colaba Causeway and Fashion Street with H/W equal to 0.8 and 0.25 respectively, the maximum PET reaches the value of 39.1°C and 40.6°C respectively (fig. 5c) . On the other hand, at Sheikh Memon street with a higher H/W ratio equal to 1.5, the maximum PET value reaches as high as 46.9 °C (Fig. 5c)

The results show that the H/W ratio has a large impact on outdoor thermal comfort and that the PET tends to decrease with increasing H/W. The small difference in PET values between the Colaba Causeway and Fashion Street is explained by the small difference in the aspect ratio as discussed for the surface temperatures above.
The main reason for the lower PET in the Colaba Causeway is the reduction of radiation fluxes due to increased shading which results in a lower mean radiant temperature. The results agree well with other studies in hot dry climates which found that outdoor thermal comfort is affected by H/W ratio variation (Ali-Toudert and Mayer, 2006; Johansson, 2006a).

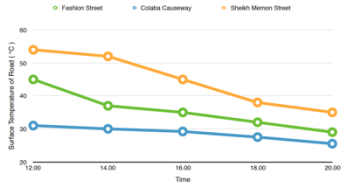


Fig 5a. Surface temperature of Road vs Time

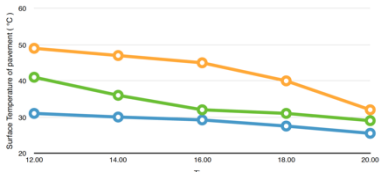


Fig 5b. Surface temperature of pavement vs Time

Fig 5c. Influence of street trees on PET values at Fashion Street (with trees) and Sheikh Memon Street (without trees)

Other studies for urban canyons (Ali-Toudert and Mayer, 2006; Johansson, 2006b) have shown that in general N–S streets tend to be more comfortable than E–W streets. This is because a N–S street is exposed to solar radiation during a shorter period than an E–W street. However , Colaba Causeway which is on a NE-SW street is completely shaded as it is a market located in a arcade (similar to Connaught Place in Delhi and Old city market in Jaipur)

Influence of vegetation on PET

There are no trees at Sheikh Memon street (fig. 7) whereas Fashion street is located in between two lush green playgrounds (fig. 6a, 6c) and the shops are just below a row of dense trees (fig. 6b). The graph shows that the surface temperatures below the trees are considerably lower than for an exposed surface. Colaba Causeway has not been considered for the comparison is at it a semi outdoor market covered by a slab.

(a) Azad Maidan and Bombay Gymkhana

(b) MG Road and the fashion street market

(c) Cross Maidan

Fig 6. Vegetated spaces in the surroundings


Fig 7. Glimpses of Sheikh Memon Street without a single tree or green space in it .

2. Measured microclimate and calculated thermal comfort indices

Microclimatic variations

Readings of air temperature , surface temperature , humidity , wind direction and wind speed were taken at a 2 hourly basis from 12noon to 8 pm . In addition, microclimatic measurements allowed investigating the behaviour of different thermal comfort indices (PET, SET and PMV) in the warm and humid climate of South Mumbai. The readings were taken on 13th , 14th and 15th of March 2022 at Fashion Street , Sheikh Memon Street and Colaba Causeway respectively . On 13th and 14th of March 2022, the weather was sunny and sky cover was clear . The readings were taken in the scorching heat of Mumbai. However , on 15th March , it started raining in the middle of summers . Hence significant variation in readings is seen in case of Colaba Causeway.

Air Temperature

The ambient temperature shoots up to 37.5 °C at 14:00 hrs at Sheikh Memon Street . The highest temperatures recorded in Fashion Street and Colaba Causeway are 34.1 °C and 32.5°C respectively . Highest temperature in all three study area were recorded at 14:00 hrs . Colaba causeway has significantly low temperature. (fig. 8)

Humidity

The humidity range is quite similar at Fashion street and Sheikh Memon street . The humidity at Fashion Street ranges from 24.5 to 28.3 %. The humidity at Sheikh Memon Street ranges from 22.1 to 25.7 % . The highest humidity recorded at Colaba Causeway is 70% . Highest humidity in all three study areas was recorded at 20:00 hrs . Colaba causeway has significantly high humidity ranging from 53.5 to 70% . (fig 9)

Wind speed

A similar trend in change of wind speed was observed in all three markets . Sheikh Memon street had the lowest wind speed ranging from 0.1 to 0.7m/s . Fashion street had the highest wind speed ranging from 0.3 to 0.9m/s . Colaba Causeway has wind speed recordings ranging from 0.1 to 0.6 m/s. The highest wind speed of 0.9 m/s was recorded at 14:00 at Fashion Street. (fig. 10)

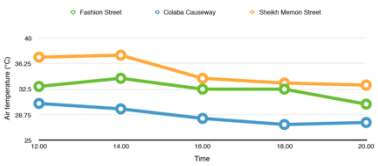


Fig 8. Comparison of air temperatures in the 3 study areas.

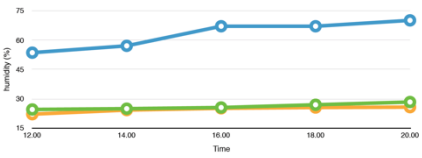


Fig 9. Comparison of humidity in the 3 study areas .

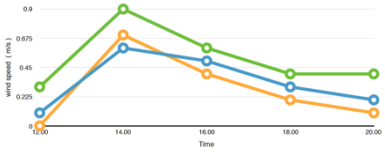


Fig 10. Comparison of wind speed in the 3 study areas .

3. Subjective thermal perception

A total of 120 people were interviewed in the markets (40no.s in each of the 3 markets). Their thermal perception and statistical data has been analysed below :

Air temperature: 55% people in Colaba Causeway and Fashion Street felt that the air temperature is neutral . Not a single person at Sheikh Memon Street felt that the air temperature is neutral . 52.5% people at Sheikh Memon Street felt that air temperature is high and the rest of them felt that air temperature is very high. (fig. 11)

Humidity: 45% people in Colaba Causeway and 35% people in Fashion Street felt that the humidity is neutral. 35% people at Sheikh Memon Street felt that the humidity is very high. (fig. 12)

Wind: 57% people in Colaba Causeway and 52% people at Fashion Street felt that the wind is neutral. 60% people at Sheikh Memon Street felt that the wind movement is low . (fig. 13)

Radiation: 67% people in Colaba Causeway felt that the radiation is neutral as it is a permanently shaded market in a deep canyon. 47% people at Sheikh Memon Street felt that the radiation is ‘very high’ as it has no shading at all. 65% people in Fashion Street felt that the radiation is high as it is partially shaded by trees. (fig. 14)

Most unpleasant weather parameter: 47% people at Sheikh Memon Street felt that Temperature is the Most unpleasant weather parameter.15% people at Colaba Causeway said that none of the weather parameters are making them feel uncomfortable .13% people in Fashion Street felt that the humidity is the most unpleasant weather parameter. (fig. 15)

Overall comfort: 75% people at Colaba Causeway felt comfortable. 47% people at Fashion Street felt comfortable . Not a single person at felt comfortable at Sheikh Memon Street. 60% people at Sheikh Memon Street felt that its very hot. (fig. 16)

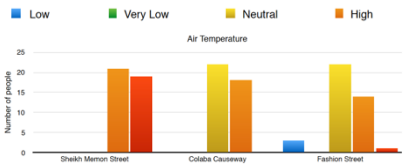


Fig 11. Perception of air temperature in the 3 study areas

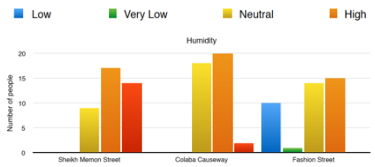


Fig 12. Perception of humidity in the 3 study areas

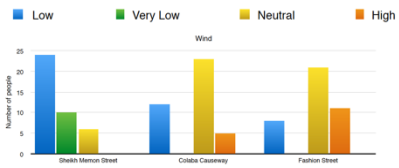
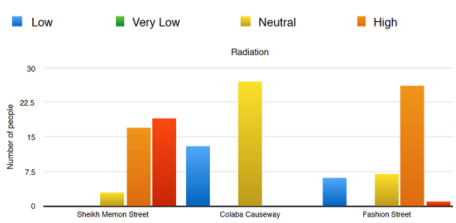
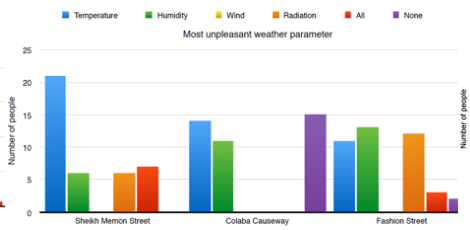


Fig 13. Perception of wind in the 3 study areas .





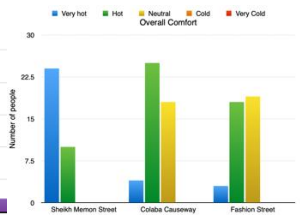


Fig 14. Perception of radiation in the 3 study areas .

Fig 15. Perception of unpleasant weather parameter in the 3 study areas .

Fig 16. Perception of overall comfort in the 3 study areas .

4. Relationship between thermal sensation votes and thermal indices

When looking at the relationship between Actual Sensation Votes (ASV) and the calculated indices, it was found that the original thermal sensation scales of these indices (PET, SET and PMV) often do not correspond to people's actual thermal perception in South Mumbai. Figure 17, 18, 19 show the relationship between ASV and the index temperatures for PET. At all index temperatures there is a wide spread of votes. This reflects the variations in people's thermal perception, which supposedly is due to differences in activity, clothing, thermal history, emotional state, etc as well as individual thermal preferences. The distribution of people's answers reflects the real situation in summer regarding the calculated thermal comfort and people's perception. In this case, the R2 for all studied indices varied between 0.03 and 0.5

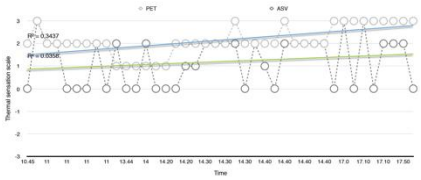


Fig. 17 Fashion Street : Relationship between the actual sensation vote and calculated PET

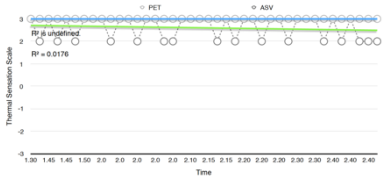


Fig. 18 Sheikh Memon Street : Relationship between the actual sensation vote (ASV) and calculated PET

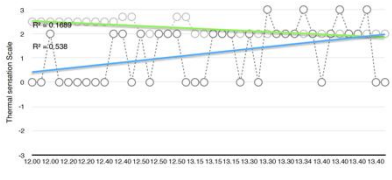


Fig. 19 Colaba Causeway : Relationship between the actual sensation vote (ASV) and calculated PET

Similar patterns of the widespread have been found by Thorson et. al. (2004) and Rossi (2011). The large individual differences in thermal perceptions between the subjects may have many reasons. For PET, one reason is the clothing and activity factors that this index does not take into account . Other reasons are believed to be related to different thermal preferences, differences in thermal history and emotional state as well as the influence of aesthetic qualities of the place that affect thermal perception (Knez and Thorsson, 2006)

5. Clothing and thermal comfort

Investigating the relationship between clothing and thermal comfort indices PET and SET shows that in the summer season, the distribution of clothing values varied between 0.65 and 0.81. These clothing values are represented by the values far from the regression lines in fig. 20, 21 and 22. Thus in the summer, some people adjust their clothing according to the weather, whereas others use heavy clothing although it is fairly warm. As expected, this study found that the insulation value of people's clothing tend to decrease with increasing temperatures. This study has shown that in the case of Mumbai, the choice of clothing is to some extent also linked to cultural aspects. As can be seen in fig. 21 there is also a tendency at high PET values in summer that some users have heavier clothing (clo about 0.8) than the rest (clo 0.6- 0.7). Thus, the dress code of some of the people of Mumbai seems to depend on cultural traditions rather than climate whereas most people choose their clothing according to the weather conditions when they feel thermally uncomfortable.

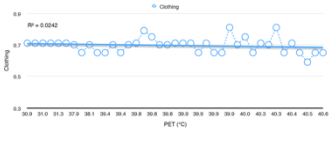


Fig. 20 Fashion Street : Relationship between the clothing and PET index

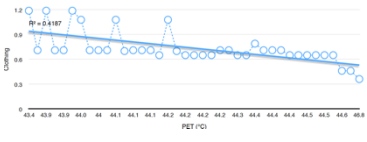


Fig. 21 Sheikh Memon Street : Relationship between the clothing and PET index

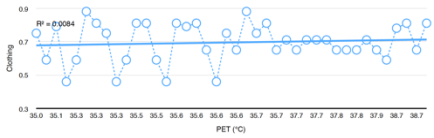


Fig. 22 Colaba Causeway : Relationship between the clothing and PET index

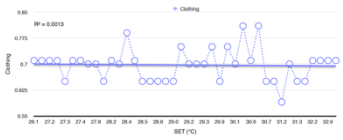


Fig. 23 Fashion Street : Relationship between the clothing and SET index

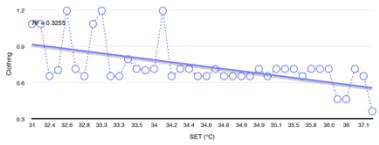


Fig. 24 Sheikh Memon Street : Relationship between the clothing and SET index

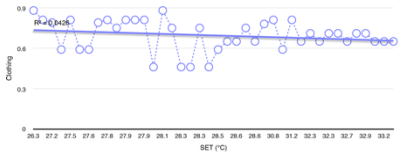


Fig. 25 Colaba Causeway : Relationship between the clothing and SET index

6.Shadow analysis- Actual Sensation Vote

Interviews were conducted at Sheikh Memon Street between 12noon to 2:40pm. All the people interviewed were standing in the sun as there is no shade at Sheikh Memon Street in form of a permanent structure or trees (fig. 26). The street vendors use umbrellas for temporary shading. Colaba Causeway is a market inside semicovered arcade. That is why it is permanently shaded. 30 persons interviewed at Colaba causeway were in shade. The rest of them were in sun as they were standing at the bus stop . Fashion Street is majorly shaded due to the large amount of Rain Trees with a wide spread . Temporary awnings have been put up outside the shops as a shading device .

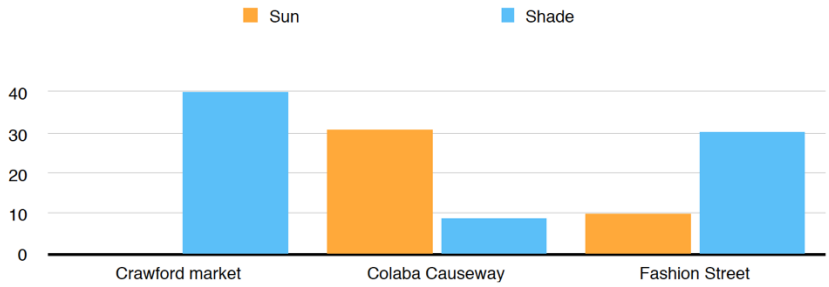


Fig. 26 Actual Sensation vote : Exposure in the street markets

Conclusion

This study assesses the microclimate of the outdoor urban environment and investigates the relationship between different thermal comfort indices and people's actual thermal sensation in the street markets of the warm and humid city of Mumbai. It is concluded that the thermal conditions of different outdoor environments vary considerably, mainly as a function of solar access. In general, areas that provide shade – either by buildings, such as Colaba Causeway, or vegetation – are more comfortable in summer.

The study also shows the influence of culture and traditions on clothing. While most people choose the clothing according to the climate, some people in Mumbai are influenced by their cultural traditions when they choose how to dress (such as the women from Muslim community dressed in 3 layers of clothes at Sheikh Memon Street). In summer time, which is the most problematic season, the study finds that the majority of interviewees felt hot. This can be improved by adding trees or shading devices in order to provide shade for people who pass by and linger on these places.

The results highlight the importance of a climate-conscious urban design and design flexibility. It is important to consider microclimate and thermal comfort in the urban design process. This can be done by providing a basic knowledge for architects, designers, and planners about the importance of microclimate and thermal comfort and how to create better urban spaces in harmony with climate. Based on this knowledge, summer comfort zones and acceptability limits for Mumbai can be understood and promoted as a goal to design better street markets.

Future studies

Further studies in the field of microclimate and thermal comfort are needed since this and other studies have shown that the actual thermal perception is not only affected by microclimatic parameters (air temperature, solar radiation, relative humidity, and wind speed) but also by personal parameters such as people's activity and clothing. Thus, more studies about the relationship between the actual thermal perception and other parameters – such as gender, age, thermal history, and people's emotional states – are needed. For all climates, the thermal comfort range and acceptability limits are needed to be defined. Such limits are absolutely important to develop the urban spaces in the city in harmony with microclimate. Additionally, it would be important to develop the urban planning regulations in every city according to the climatic requirements.

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