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## Exploratory Study on the relation between Urban Landscapes and Urban Corridors for Outdoor Thermal Comfort

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### Abstract

Urban Heat Island (UHI) is an increasing phenomenon experienced by most of the growing cities in India. Many researchers have proved that there is a substantial increase in surface temperature between urban and rural areas. The climatic conditions in the man-made urban environment is greatly influenced by roads, buildings and many other factors where the micro-climate of indoor environment can be controlled through various mechanisms whereas the thermal comfort of outdoor environment has very limited control. On the other hand the fundamental role of roads is to move people or goods from one place to another, thereby contributing to the economic development of any city. Roads are inevitable for city planning and are no longer perceived as mere transportation corridor; they can be seen as windows of surroundings and are places that offer high degree of social interaction between people. In the recent years owing to the growth of cities there is tremendous increase in road surface leading to increased UHI effect. This paper through a series of literature study tries to explore the possible relation between urban landscapes and roads towards comfortable outdoor environment. Landscaping is considered to be one of the effective means of passive cooling.

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## 1. Introduction

Increased urbanization and the resultant urban heating is an increasing phenomenon experienced in most of the developing and developed cities around the world. This problem decreases our quality of life and has received tremendous attention by urban planners, landscape architects and designers in the recent years. The factors that contribute to urban climate are buildings, roads, hardscapes, proportion of vegetation, open spaces etc., however recent researches has proven that there is significant amount of contribution by the roads towards UHI effect. In the interest to accommodate the growing population, cities are fast expanding resulting in substantial increases of road surface. Recent research on analysis of various types of corridor structures has shown that the contribution of the road corridor towards UHI is comparatively more than the vegetative or water corridor [1]. The contributing factors are the road surfaces were mostly covered by the material of pitch, concrete and so on. All of which have great thermal capacity.

## 2. Outdoor thermal comfort

Understanding and evaluating thermal comfort conditions in urban spaces is necessary, as this can have major implications for the development of cities because urban areas accommodate daily pedestrian traffic and various outdoor activities and contribute greatly to urban liveability and vitality. Encouraging more people on the streets and in outdoor spaces will benefit cities from various perspectives, including physical, environmental, economical, and social aspects [2,3,4,5]. Human comforts are generally stated as a subjective area. It is that state of mind that expresses satisfaction with the thermal environment [6]. The feeling of comfort is the expression of an individual's wellbeing in his environment.

## 3. Parameters for outdoor thermal comfort

The parameters required to asses outdoor thermal comfort is based on both objective and subjective evaluation methods. The objective method of evaluating outdoor comfort is done by comparing the recorded climatic parameters (air temperature, air speed, radiation and relative humidity) and two physical parameters (activity and clothing) [7,8]. Researches on thermal comfort has enabled extensive studies on the above parameters and led to establish several indices based on energy balance of the human body which were applied to assess outdoor thermal comfort. For e.g., Predicted mean vote (PMV), Effective temperature (ET\*), Standard effective temperature (SET\*) and Physiologically equivalent temperature (PET). The PMT, ET\* and SET\* indices were primarily developed for assessing indoor comfort. The climatic variable for assessing the outdoor thermal comfort is more diverse than indoors. While the indoor comfort is easily controlled by the use of air conditioning the control of outdoor comfort is very limited.

Since 2003 numerous studies on outdoor thermal comfort have attempted to develop indices for assessing outdoor comfort. The importance of adaptation in the process of comfort has been largely identified [9,10,6]. This includes the subjective method of evaluation. The term 'adaptation' can be broadly defined as the gradual decrease of the organism's response to repeated exposure to a stimulus, involving all the actions that make them better suited to survive in such an environment [6]. But the term 'adaptation' in regard to thermal comfort deals with all the processes that people go through to improve their requirements between the environments.

## 4. Types of adaptation

Adaption is broadly categorized as: physical, physiological and psychological [11].

### 4.1. Physical adaptation

Physical adaptation deals with all the changes that people take to fit themselves with the environment by altering their needs. For e.g., altering one's clothing levels, consumption of hot or cool drinks, opening a window etc., [11].

#### 4.2. Physiological adaptation

Physiological adaptation refers to the changes in the physiological conditions of people resulting from repeated exposure to stimulus, leading to a gradual decrease strain from such exposure [11]. For e.g., during hot climate body tend to cool itself through sweating. This in context to thermal environment is called physiological acclimatization, which is not touched upon in this research.

#### 4.3. Psychological adaptation

The way the people perceive environment differs from person to person and their responses to a physical stimulus is not based on the magnitude but depends on the ‘information’ that people have for a particular situation [11]. Psychological adaptation towards environmental ergonomics is necessary to encourage better perception of space and thereby better usage of outdoor space. Human response to outdoor environment is vital as it helps to determine people’s understanding level of the condition.

Psychological factors which influences the thermal perception of a place are explained as shown in the Figure 1: [11]

##### 4.3.1. Naturalness

Naturalness can be referred to an environment that is free from artificiality or if the environment is found to possess more natural things and lacks pretensions then the people are found to be more tolerant to the changes in the environmental conditions [12]. In places where there is natural climate change people are tolerant to a wider changes in the physical environment.

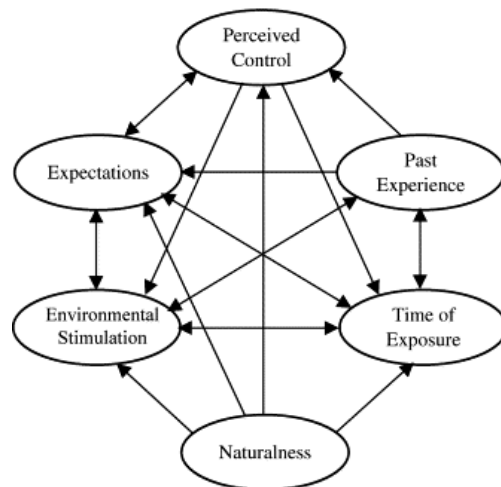


Fig. 1. Lines of influence between the different parameters of psychological Adaptation [6]

##### 4.3.2. Expectations

Expectations refer to what people want the environment to be, rather what it is. For instance people’s reply to climatic conditions such as “for this time of year I would prefer it warmer”, or “its winter it’s meant to be cold” [11]. Expectation has greater capability to influence the responses of individuals in a particular situation.

#### 4.3.3. *Experience*

Experience of a particular space has a direct impact on the expectation of people and can be differentiated into short and long-term experience. Short-term experience refers to the memory and is responsible for the changes in people's expectations, whereas long-term experience implies to the syllogistic figure that people construct in their minds under different situations. Therefore, changes in clothing, consumption of cool drinks to alter the metabolic heat, moving from sun to shade, etc., all represent well established choices of action on the issue of how to cope with the variable thermal environment. Experience like expectation is influential for the individual's responses for a particular situation.

#### 4.3.4. *Time of exposure*

The duration of exposure to discomfort may not be viewers negatively if it is short-lived depending on the individual's anticipation. When it comes to outdoor spaces, time of exposure becomes a critical factor provided they are used for recreational activities, where people modify the time they spend outside according to their needs. Time of exposure is another important parameter which influences people's decision.

#### 4.3.5. *Perceived control*

It is defined as the degree of control that people have towards the source of discomfort, in other words refers to the choice of tolerance to variations in the thermal environment. For e.g., the duration of time spent in the outdoor spends on the choice of sitting in the sun or shade [11]. The termination of their exposure to the thermal conditions depends on external factors, which causes distress, making them less tolerant to the environment. Perceived control is yet another important parameter as it gives the freedom of choice, because perceived control has more value than the actual microclimatic control which is minimal in the usage of outdoor spaces.

#### 4.3.6. *Environmental stimulation*

Comfortable conditions are defined as those conditions where people feel neither 'warm' nor 'cold' where an ambient condition is termed to be 'neutral' [11]. Environmental stimulation is of primary importance in external spaces, where the environment presents few thermal constraints, this being an important asset of such areas and one of the reasons that people use these spaces. For instance people perceive the external environment with the fresh air, the sun and the wind as invigorating stimulation for the senses, wishing to spend some time there, before returning to the more monotonous workplace.

### 5. **Urban corridors as 'Public spaces'**

Urban landscapes of hot-humid tropics regions especially experiences high intensity solar radiation with increasing heat gain and reduced evaporation in tropical outdoor environment resulting in overheating of urban areas, thus contributing to the outdoor thermal discomfort. Urban climate is greatly influence by various urban landscape factors such as the composition of urban fabrics, natural and man-made surfaces, urban geometry, street layout, architectural complexity, thermal materials and human activities. Recent researches have proved that urban the composition of urban landscape has affected the microclimatic condition of urban atmosphere [18]. Table: 1 below shows the morphological aspects in urban areas that significantly influence the thermal comfort.

While discussing on the thermal comfort conditions required for an outdoor space it is imperative to differentiate between public resting places and urban corridors used for travel purposes. This study focuses on the urban corridors as it plays a significant role in relation to energy. Urban transport is the second factor of energy consumption in cities. Moreover, it creates big problems of air pollution, noise and congestion [6]. Limiting the sources of outdoor

discomfort promotes increased use of walking, bicycling and public transport intending to develop more sustainable and ecological transport types.

The street was “the first institution of the city,” as architect Louis Kahn once wrote, they are our most fundamental shared public spaces, but they are also one of the most contested and overlooked [19]. Today primarily streets are often overlooked and are the primary zones for cars, parking, and the transporting of goods. But this has not been the case, however, throughout most of history. Across many cultures and times – since the beginning of civilization, in fact – the street has held vast social, commercial, and political significance as a powerful symbol of the public realm [19]. In the context of UHI effect urban street design plays an important role in creating urban climate, making it thermally discomfort for people to use.

Table 1. (Morphological aspects influencing urban climate [18])

<i>Morphological aspect</i>	<i>Urban Characteristics</i>	<i>Variation of temperature (°C)</i>
<i>Vegetation</i>	Dense vegetation, shading cast by tree canopies	< 33
<i>Water body</i>	Presence of dense vegetation	33 - 34
	Surrounded by sparse vegetation	34 - 35
<i>Urban architectural complex</i>	Streetscapes, street trees / planting, local park	34 - 35
	Paved / grassy surfaces, shading cast by buildings or trees, presence of little vegetation	35 - 36
	Open spaces, partially shaded by buildings / trees, paved surfaces	36 - 37
	Open spaces, no shading, bare soil, absence of vegetation	37 - 38
	Open spaces, no shading, paved surfaces, absence of vegetation	> 38

The urban corridors vary in geometry as defined by the following [13]:

- height/width ratio (H/W)
- length/width (L/W)
- orientation that is defined by its long axis

These parameters directly influence the absorption and emission of solar radiation and also urban ventilation which have a significant impact on the temperature variations within the street as well as the surrounding environment (UHI).

## 6. Effect of vegetation on urban climate

The vegetation is a modifying factor of the local climate, and it is considered an important design element in improving urban microclimate and outdoor thermal comfort in urban spaces [14,15]. The selection of vegetation should consider native and ecologically restorative rather than ornamental types, and choice of species should reflect the bioclimatic requirements. In addition, the uses of native vegetation will facilitate the adaptation to local climate [18]. Previous researches have indicated that natural tropical vegetation is capable to provide thermal benefit. Few tropical tree species like *Messua ferrea* (Ironwood tree) and *Hurra crepitans* (Indonesian Umbrella Tree) can lower

ground surface temperature by reducing amount of terrestrial radiation by 93% and 79% underneath the canopy [18]. The below table provides information on vegetal characteristics of some native species of tropical trees that can be utilised as passive cooling effects in moderating the microclimate.

Table 2. Vegetal characteristics of some tropical species that provide thermal benefits.  
(Source: adapted and modified from Shahidan *et al.* 2010 and Hidayat, 2010 [16,17])

<i>Tropical native species</i>	<i>Vegetal characteristics</i>	<i>Potential utilization in landscape design</i>
<i>Messua ferrea</i>	Dense tree canopy, branches and twig	Solar radiation modification and full shaded effect
	Leaf Area Index (LAI) – 6.1	Effective microclimate moderator
	5% transmissivity value	Thermal buffer planting
	35% shade area	
	7% average of radiant heat transfer under canopy	
<i>Hura crepitans</i>	9% solar attenuation	
	Modest tree canopy cover, branches and twig	Effective in providing shades
	Leaf Area Index (LAI) – 1.5	Street planting
	79% average heat filtration	Planting in parking and open spaces
	22% transmissivity value	
<i>Maniltoa schefferi</i>	52% shade area	
	Dense canopy (round spreading types), massive leaves and tree branches	Lowering air temperature and increasing the humidity
	Reduce the temperature by 4.8-7.4°C and increase the humidity up to 3.9% under the tree canopy	Planting in open space/park

## 7. Conclusion

The role of landscape in improving thermal comfort of outdoor spaces has been proved through many researches but still their usage in most of the urban spaces is for aesthetic and recreational purposes. The impact of urban landscape on microclimate, the human comfort and energy aspects are not taken into account during the design process because of poor interdisciplinary work between urban climatology, urban design and landscape architecture. In this paper through a series of literature review, an attempt has been made to emphasize the various parameters considered for evaluation of human comfort of outdoor spaces, need and importance of urban landscape on urban climate. Various researches reaffirms the fact that urban landscaping and greenery have many positive impacts in moderating urban climate. This further requires quantitative evaluation of the human comfort with respect to urban landscape. It also necessitates detailed study on the various factors of urban landscapes and its relative variations in temperature, humidity, wind speed and psychological comfort of the users explicitly to urban corridors. As they are no longer viewed as mere transportation corridors but they play a vital role in animating the social and economic life of communities. It's not merely a streetscape design; it is about the vibrancy of a social space. The Smart Growth, Complete Streets, and Active Transportation movements have been instrumental in moving transportation policy to better encourage multimodal street designs that safely accommodate a range of users. Together with this the role of

urban landscape would help urban corridors to truly function as public spaces by creating comfortable outdoors, encouraging people to linger, to socialize, and to experience the unique culture and character of the place.

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