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Studying The Effect Of Open Spaces In Townships On Microclimate-Case Of Pune City

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ABSTRACT

As due to the growth of the city it is causing urbanization which results in population growth increase of built-up areas. By 2030, 60% of world population will live in urban areas. As because of increasing population in urban areas which leads to rapid urbanization and raises many issues like loss of open spaces and change in microclimate. Due to this it causes global warming and rise in temperature. It is a need to increase open spaces and provide vegetation to decrease the global warming. This paper aims to study the effect of open spaces of varied scales and types on urban microclimate in different townships in Pune city through spatial-temporal analysis.

The study has explored the open spaces within townships through walkthrough audit and data collection such as photomapping of the various categories of open space. Further microclimate analysis of various categories of open spaces was studied for parameters like air temperature, humidity, mean radiant temperature and wind speed through simulation-based microclimate modelling tool Envimet.

The analysis of results obtained through simulation shows that effect of microclimate changes because of different spatial characteristics such as size of the open space, vegetation density and materials differ at various categories of open spaces. Vegetation in open space affect the microclimate it reduces air temperature while providing shade. Area under shading has a significant impact to reduce heat stress. The result of this study will be helpful for the further conception of master plan of township for the urban planners.

KEYWORDS: Open Spaces, Microclimate, Parameters, Townships

1. INTRODUCTION

The sociological phenomenon pertaining to physical expansion, causes population rise in built-up regions and high population densities is known as urbanization. Pune is the second-largest and fastest growing city in Maharashtra.Pune has become a well-known destination for industrial sectors and is now acknowledged as the nation's information technology and education powerhouse. Due to its fast expansion, the city has changed into a major administrative and educational hub as well as an active economic hub.

Between latitudes 18° 25'N and 18° 37'N and longitudes between 73° 44'E and73° 57'E lies Pune city. As per climatic classification of India Pune lies in the hot semi-arid climate zone. The hot semi-arid climate zones generally include the following relative humidity mean and temperature. Monthly maximum temperature is above 34 °C and relative humidity remains above 55%. Mean monthly minimum temperature stays above 25°C and relative humidity remains above 75% the mean maximum temperature for April month is (37.91ºC) more than that of May

month (37.21ºC) while December spectators a low temperature (20.51ºC) than that of January month. The prominent Wind is from South West for 9 months March - September while South East from October-December.

1.1. NEED OF STUDY

At present the most important issue is change in climate and unlikely the greenhouse gases which are having a warming effect primarily. Temperature plays a major role of all the climate elements. In the last thirty years Pune city has witnessed a phenomenal rise in industrialization and urbanization. Swift urbanization raises many issues like loss of open space and change in micro climate.As major urbanization is been along the townships. Hence, study of the effects of open spaces on microclimate is necessary in township

2. RESEARCH AIM

The research aims to study the effect of open spaces of varied scales and types on urban micro climate in different townships in Pune city.

2.1. RESEARCH OBJECTIVES

1.To study the open spaces and various micro climate parameters at microscale.

2.To analyze the spatiotemporal impact of open spaces on the microclimate parameters in townships.

3.To identify the outdoor thermal comfort of open spaces in townships.

3. METHDOLOGY

The Study area was carried out for three different township located in Pune,India. This study was conducted under the various categories of open spaces at micro scale.

Based on the photomapping of open spaces with different categories of open spaces the modelling of the site was simulated under microclimate parameters.

Therefore, this study was carried out for the comparison of township with UTCI which helped to analysed the effect of micro climate on open spaces.

4. LITERATURE REVIEW

4.1.INTRODUCTION

One of the important indicators regarding quality of life which is open space which helps to establish a sustainable development in urban areas. Open space in the outdoor is able to control and improve air temperatures. To understand the term open area of land that is publicly accessible, undeveloped, and devoid of any constructed structures is referred to as open space. Open space may consist of: Green space is land that is covered with grass, trees, bushes, or other types of vegetation.

Any type of urban land has greenery covering it as a green space. In addition to vegetation on both private and public property, regardless of its size or purpose, it may also contain minor water bodies like ponds, lakes, or streams.

According to Bell et al. (2007) green spaces may be divided into the following categories are parks and gardens, amenity green spaces, children's play areas, outdoor sports facilities, green corridors and natural and semi-natural places.

4.2. TYPOLOGIES OF OPEN SPACES

a) Parks and gardens: Land areas that are typically created, maintained, and managed as public parks or gardens. Depending on their location, they might be either urban or suburban parks. However, their main use is for informal activity or relaxation for social and communal reasons. They frequently contain other sorts of greenspaces, such as children's play areas and sports facilities.

b)Amenity greenspace: This kind of greenspace is controlled and maintained landscaped spaces without a specified special use by humans but providing visual amenity or separating different structures or land uses for environmental, visual or safety reasons.

c) Children's play areas: A larger green environment of amenity open space is typically present in designated and maintained places that offer safe and convenient chances for children to play.

These spaces are typically connected to housing areas. These places serve the fundamental purpose of giving kids a secure environment in which to play. The kids' play spaces are typically adjacent to homes and unofficially watched over by residences nearby.

d) Sports facilities: The flat grassy fields or artificial surfaces with distinctive designs are developed, built, managed, and maintained in this region, which is largely utilized for certain sports. For recognized outdoor sports, practice, competition, and training are the main purposes of sport facility areas.

e) Green corridors: The green corridors are defined and controlled networks that connect various pathways of places within a town or city and are utilized for walking and bicycling. The main purpose of green corridors is to enable amicable and safe mobility with urban areas.

f) Natural/ semi- natural greenspaces: These are areas of undeveloped land that receive little to no upkeep and are home to animals, plants, and wildflowers. Natural greenspaces' primary purpose is to support biodiversity and nature preservation.

4.3. HIERARCHY OF OPEN SPACES

Hierarchy of open spaces are divided into five categories of green spaces (Southampton)

a)City parks- A variety of amenities and features may be found in city parks, which serve as destinations for visitors from outside the city and may be of national significance.

b)District Parks- District parks host community activities, draw visitors from all around the city, and include a variety of amenities.

c)Local Parks - Locals utilize these parks, which have little amenities, for recreation.

d)Amenity Green Space- This green space is typically connected to or situated close to the dwellings of the

local population. It is used by the immediate neighbourhood.
e)Other Green Space- This category includes athletic fields, forests and other natural areas, school grounds, and privately owned but publicly accessible places like golf courses and greenways.

4.4. INTRODUCTION TO MICROCLIMATE

In meteorology the microclimate is defined as the climate of a very small or restricted area, especially when this differs from the climate of the vicinity. Microclimate ranges within a few meters or less, above and below the Earth's surface and canopies of vegetation (Rosenberg *et al.*, 1983).

4.5. MICROCLIMATE PARAMETERS

a) The definition of Air temperature is a measurement of how hot or cold the air is. It is measured for a frequently used meteorological parameter. The rate of evaporation is also impacted by the air temperature. Relative humidity (ii) iv) Wind velocity
b) What is wind speed? Wind speed is the rate at which air is moving around a certain spot.It is described as a maximum wind speed that may be averaged over a certain amount of time, such miles per hour.
c) Relative Humidity Definition: Relative humidity is a measurement of how near the air is to saturation. At saturation, the air is essentially filled and can no longer carry any more water vapors.
d) The term "mean radiant temperature" (MRT) refers to a measurement of the average temperature of the surfaces that surround a specific place where thermal radiation will be exchanged. Solar radiation is present if the site is exposed to the elements.

4.6. MICROCLIMATE SPATIAL SCALE

There are three spatial scale in order to understand the characteristics and variations in microclimate a)Local scale b)Meso scale c)Micro scale
a)Local scale – This scale does not contain impacts at the microscale but does include topography and the effects of climate on landscape elements. This refers to the climate of neighbourhoods in cities with comparable forms of urban development (surface cover, building size and spacing, activity) (Oke, 1984).
b)Mesoscale – This scale, which is often tens of kilometres in size, is where a city's impact on weather and climate may be seen. There are many stations that reflect this scale.The planetary boundary layer impacted by the urban area is known as the Urban Boundary Layer (UBL), which is a mesoscale phenomenon.
c)Microscale-The scale used to urban microclimates are set by the dimensions of individual elements: buildings, trees, roads, streets, courtyards, gardens, etc., extending from less than one to hundreds of metres and vertically up to roof level in what is called as urban canopy layer (UCL). The micro scale corresponds in size to city streets and small parks (Heisler, 1977).

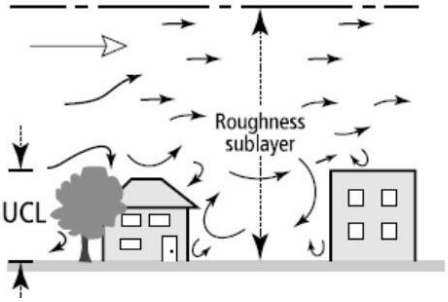


Fig.1. Classification of Spatial scale
To study the open spaces of township in detail and to study effect of microclimate parameters across Urban Canopy Layer (UCL) due to this the microscale was consider for this study.

4.7.OUTDOOR THERMAL COMFORT

The state of outdoor human thermal comfort is indicated by the Urban Thermal Climate Index (UTCI).Wind speed, air temperature, relative humidity, and solar radiation are the four microclimate factors that determine thermal comfort. Mean radiant temperature is used in the equation to represent solar radiation.

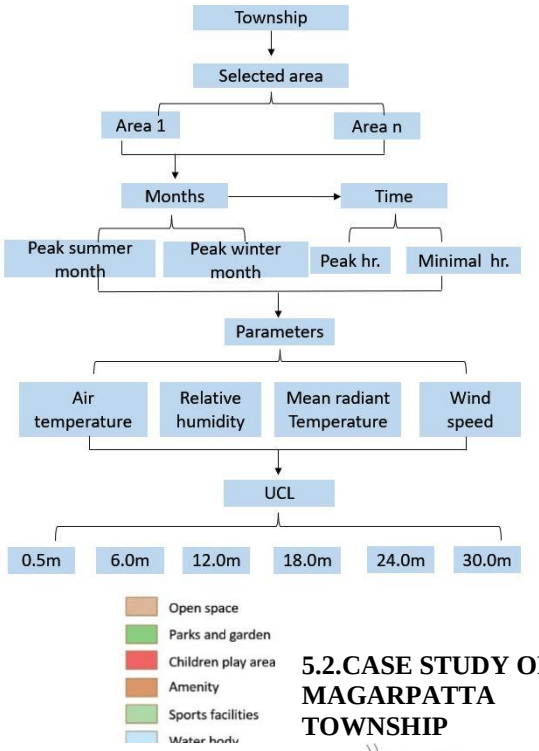
The operating method is finished by calculating the UTCI values using the inputs of air temperature (Ta), wind speed (va), mean radiant temperature (Tmrt), and relative humidity (Pa).The foundation for a wide range of applications in public and private preventive planning, such as urban and regional planning, is provided by universal thermal comfort evaluations. The outdoor thermal comfort in the townships' open areas is examined in this study using UTCI.

UTCI (°C) range	Stress Category
above +46	extreme heat stress
+38 to +46	very strong heat stress
+32 to +38	strong heat stress
+26 to +32	moderate heat stress
+9 to +26	no thermal stress
+9 to 0	slight cold stress
0 to -13	moderate cold stress
-13 to -27	strong cold stress
-27 to -40	very strong cold stress
below -40	extreme cold stress

Fig.2.UTCI category

5.DATA COLLECTION

5.1. SUB METHODOLOGY



5.2.CASE STUDY OF MAGARPATTA TOWNSHIP

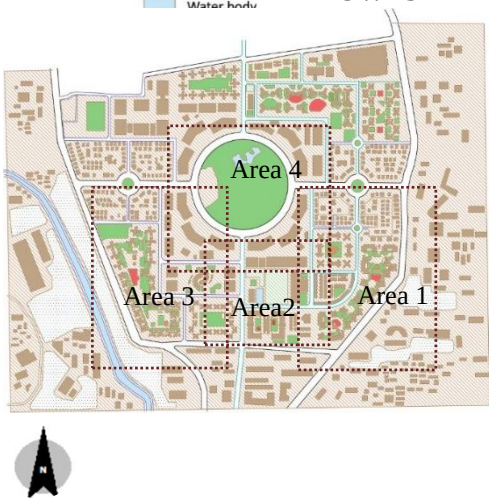


Fig.3. Magarpatta Township Plan Legend

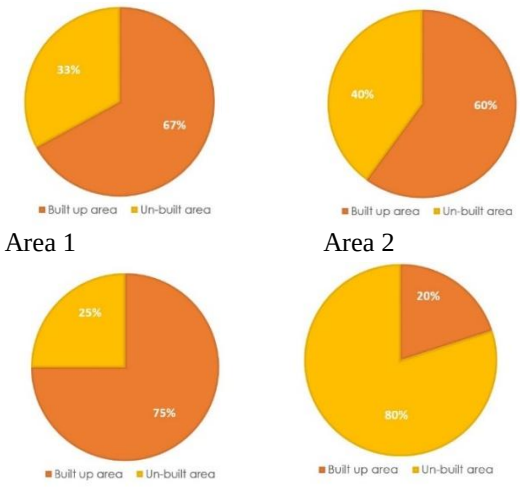
Township name: Magarpatta city
Location: Pune,India
Total area:450 acres
Status:Completed

Fig.4. Area 1

Fig.5. Area 2

Fig.6. Area 3

Fig.7. Area 4



Area 1 Area 2

Area 3 Area 4

5.2.1. INFERENCE OF AREA 1

UCL	Air temperature°C		Mean radiant temp.°C		Relative humidity %		Wind speed m/s		UTCI°C	
	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.	Peak hr.	Minimal hr	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.
0.5M	32.86	26.38	53.73	48.06	62.75	69.34	2.09	2.65	38.42	31.32
6M	32.81	26.57	53.74	48.03	63.06	67.73	3.77	3.56	36.81	30.17
12M	32.34	26.64	53.45	47.87	55.7	62.42	3.79	3.7	35.55	29.69
18M	31.73	26.63	53.08	47.62	53.71	62.18	3.35	3.67	35.13	29.64
24M	31.45	26.51	52.58	47.23	53.84	62.17	3.89	3.55	34.32	29.58
30M	31.18	26.43	50.83	17.22	54.2	62.16	2.28	2.31	35.7	23.32

Table 1.UTCI April

UCL	Air temperature°C		Mean radiant temp.°C		Relative humidity %		Wind speed m/s		UTCI°C	
	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.	Peak hr.	Minimal hr	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.
0.5M	25.14	18.18	51.1	49.63	59.23	61.46	2.62	2.85	30.16	24.45
6M	25.24	17.86	51.08	49.86	56.87	61.93	3.21	3.75	29.17	22.51
12M	24.98	17.58	50.94	49.71	56.25	62.08	3.65	3.8	28.4	22.15
18M	24.6	17.56	50.74	49.64	56.77	62.11	3.46	3.34	28.35	23.04
24M	24.4	17.5	50.46	49.56	57.06	62.15	3.27	3.03	28.47	23.61
30M	24.26	17.25	16.87	16.35	57.29	62.07	3.08	2.15	19.67	14.89

Table 2.UTCI December

The UTCI of area 1 during April month in peak hour experiences strong heat stress across UCL due to the maximum air temperature and maximum mean radiant temperature which results to strong heat stress.

In month of April during minimal hour the UTCI is moderate heat stress from 0.5m to 24m UCL due to maximum relative humidity.

During the month of December in peak hour from 0.5m to 24m UCL experiences moderate heat stress due to maximum mean radiant temperature.

5.2.2. INFERENCE OF AREA 2

UCL	Air temperature°C		Mean radiant temp.°C		Relative humidity %		Wind speed m/s		UTCI°C	
	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.	Peak hr.	Minimal hr	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.
0.5M	31.93	26.39	53.55	48.04	60.61	69.44	3.73	3.67	27.63	27.68
6M	31.96	26.56	53.51	48.01	58.04	67.96	4.63	4.77	26.32	26.16
12M	33.11	26.61	53.34	47.78	55.09	62.38	4.59	4.38	26.23	28.86
18M	31.74	26.6	53.05	47.53	54.07	62.23	4.54	4.73	26.24	28.42
24M	31.28	26.59	52.56	47.17	54.02	62.24	4.08	4.54	26.83	28.51
30M	31.19	26.58	50.82	17.2	54.21	62.18	3.67	3.02	27.41	22.68

Table 3.UTCI April

UCL	Air temperature°C		Mean radiant temp.°C		Relative humidity %		Wind speed m/s		UTCI°C	
	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.	Peak hr.	Minimal hr	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.
0.5M	22.29	18.79	44.17	48.51	52.4	60.04	3.72	2.9	24.2	24.42
6M	22.35	18.6	44.22	48.46	51.94	60.17	4.49	2.99	23.13	24.09
12M	21.78	18.29	44.05	48.42	52.9	60.57	4.65	2.98	22.37	23.89
18M	21.35	18.18	44.02	48.27	53.65	60.76	4.43	2.87	22.31	23.99
24M	21.12	18.13	44.04	48.3	53.98	60.86	4.07	2.71	22.67	24.29
30M	20.92	18.03	44.01	16.27	54.28	60.94	3.35	2.46	23.7	14.85

Table 4.UTCI December

The UTCI of area 2 during April month in peak hour experiences moderate heat stress across UCL due to the maximum mean radiant temperature and relative humidity. Due to low mean radiant temperature during minimal hour at 30m UCL which results to no thermal stress.

In the month of December the UTCI across the UCL is no thermal stress because of minimum temperature during peak hour and minimal hour.

5.2.3. INFERENCE OF AREA 3

UCL	Air temperature°C		Mean radiant temp.°C		Relative humidity %		Wind speed m/s		UTCI°C	
	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.	Peak hr.	Minimal hr	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.
0.5M	32.53	21.9	53.8	46.08	59.22	64.04	2.68	2.81	37.11	26.43
6M	32.51	21.93	53.94	46.05	57.58	63.21	3.5	3.17	36.15	25.8
12M	32.22	21.92	53.71	45.94	55.53	62.06	3.94	3.23	35.27	25.61
18M	31.72	21.91	54.57	45.77	54.02	62.04	3.64	3.21	34.87	25.59
24M	31.42	21.93	54.17	45.51	53.88	62.02	3.55	3.11	34.62	25.7
30M	31.17	21.92	51.53	16.79	54.2	61.98	2.92	2.61	35.02	18.28

Table 5.UTCI April

UCL	Air temperature°C		Mean radiant temp.°C		Relative humidity %		Wind speed m/s		UTCI°C	
	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.	Peak hr.	Minimal hr	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.
0.5M	26.51	20.7	43.88	49.6	55.88	62.89	3.16	2.77	28.87	26.49
6M	26.67	20.76	43.86	49.59	53.72	62.3	4.23	3.2	27.6	25.74
12M	26.32	20.71	43.81	49.51	52.73	62.12	4.08	3.32	27.35	25.46
18M	25.81	20.7	44.03	49.49	53.39	62.13	3.71	3.3	27.4	25.48
24M	25.49	20.64	43.93	49.51	53.8	62.12	3.34	3.2	27.59	25.62
30M	25.25	20.53	43.12	16.35	54.17	62.11	2.9	2.94	27.79	16.31

Table 6.UTCI December

The UTCI of area 3 during April month in peak hour experiences strong heat stress across UCL due to the maximum air temperature and maximum mean radiant temperature which results to strong heat stress.

In month of April during minimal hour the UTCI is moderate heat stress at 0.5m UCL due to maximum relative humidity.

During the month of December in peak hour across UCL experiences moderate heat stress due to maximum air temperature.

5.2.4. INFERENCE OF AREA 4

UCL	Air temperature°C		Mean radiant temp.°C		Relative humidity %		Wind speed m/s		UTCI°C	
	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.	Peak hr.	Minimal hr	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.
0.5M	30.52	23.75	21.95	14.83	61.64	70.46	3.4	2.72	20.6	19.93
6M	30.77	23.87	21.91	14.73	59.35	68.85	3.45	2.78	20.42	19.83
12M	31.13	24.25	22.02	14.81	57.63	64.85	3.8	3.22	24.72	19.41
18M	30.19	24.67	21.78	13.97	57.03	63.55	4.07	3.51	24.81	19.19
24M	30.82	24.93	21.76	12.78	56.56	63.1	3.89	3.34	25.01	19.34
30M	30.65	25.06	21.72	14.11	55.83	62.36	3.42	2.11	25.61	21.29

Table 7.UTCI April

UCL	Air temperature°C		Mean radiant temp.°C		Relative humidity %		Wind speed m/s		UTCI°C	
	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.	Peak hr.	Minimal hr	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.
0.5M	22.34	20.44	44.06	52.38	52.58	67.94	2.64	2.79	25.95	25.62
6M	22.39	20.16	44.45	52.07	51.63	64.78	2.75	2.86	25.89	25.76
12M	21.72	19.67	43.95	52.58	52.62	62.17	3.7	3.4	23.7	24.64
18M	21.3	19.5	44.37	52.54	53.49	61.31	3.56	3.59	23.73	24.12
24M	21.09	19.38	44.29	52.67	53.36	60.89	3.18	3.37	24.17	24.42
30M	20.9	19.1	44.22	24.5	54.27	60.76	2.87	2.85	24.59	17.61

Table 8.UTCI December

The UTCI of area 4 during April month in peak hour experiences no thermal heat stress across UCL due to low mean radiant temperature which results to no thermal stress.

In month of April during minimal hour the UTCI is no thermal stress due to low air temperature.

During the month of December in peak and minimal hour the UTCI is under no thermal stress due to low air temperature across UCL results to no thermal stress.

5.3.CASE STUDY OF AMANORA TOWNSHIP

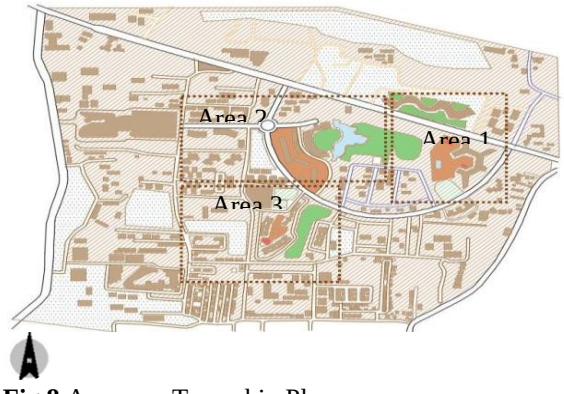


Fig.8. Amanora Township Plan

Legend

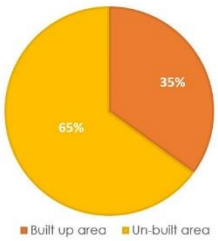
- Open space
- Parks and garden
- Children play area
- Amenity
- Sports facilities
- Natural and semi natural greenspace
- Water body

Township name: Amanora Park Town
Location: Pune,India
Total area:400 acres
Status:Completed

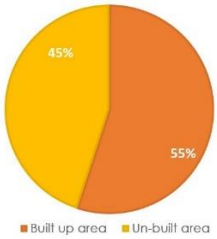
Fig.9. Area 1

Fig.10. Area 2

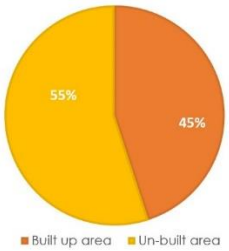
Fig.11. Area 3



Area 1



Area 2



Area 3

5.3.1. INFERENCE OF AREA 1

UCL	Air temperature°C		Mean radiant temp.°C		Relative humidity %		Wind speed m/s		UTCI°C	
	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.	Peak hr.	Minimal hr	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.
0.5M	31.77	26.41	54.42	48.03	60.14	70.6	2.11	2.9	30.04	31.07
6M	31.96	26.6	54.4	48.01	58.05	67.2	3.61	3.12	35.48	30.73
12M	32.15	26.64	54.23	47.87	56.28	62.14	3.69	3.22	35.47	30.29
18M	31.78	26.63	53.77	47.61	54.3	62.18	3.91	3.26	34.72	30.16
24M	31.47	26.64	53.09	47.21	53.9	62.17	3.67	3.2	34.56	30.15
30M	31.17	26.62	57.09	17.39	54.2	62.16	3.21	3.11	34.74	22.68

Table 9.UTCI April

UCL	Air temperature°C		Mean radiant temp.°C		Relative humidity %		Wind speed m/s		UTCI°C	
	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.	Peak hr.	Minimal hr	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.
0.5M	22.32	18.59	45.03	49.4	52.61	60.62	2.91	2.92	25.78	24.51
6M	22.36	18.23	44.77	49.28	51.86	61.12	3.57	3.15	24.64	23.78
12M	21.89	17.92	44.22	49.17	52.82	61.36	3.55	3.21	24.17	23.4
18M	21.38	17.85	44.12	49.14	53.55	61.45	3.7	3.08	23.5	23.61
24M	21.11	17.82	44.15	49.15	53.96	61.51	3.39	2.83	23.81	24.1
30M	20.9	17.79	44.25	16.17	54.27	61.55	3.03	2.6	24.31	14.37

Table 10.UTCI December

The UTCI of area 1 during April month in peak hour experiences strong heat stress across UCL due to increase in air temperature and mean radiant temperature. During minimal hours due to increase in relative humidity results to moderate heat stress till 24M UCL.

During the month of December in peak and minimal hour the UTCI is under no thermal stress due to low air temperature across UCL.

5.3.2. INFERENCE OF AREA 2

UCL	Air temperature°C		Mean radiant temp.°C		Relative humidity %		Wind speed m/s		UTCI°C	
	Peak hr.	Minimal hr	Peak hr.	Minimal hr	Peak hr.	Minimal hr	Peak hr.	Minimal hr	Peak hr.	Minimal hr
0.5M	29.29	26.81	23.45	55.11	61.1	70.22	2.61	2.36	27.63	32.63
6M	29.3	26.71	22.37	55.03	60.21	68.35	2.73	2.48	27.18	32.25
12M	29.55	26.61	21.48	54.03	59.52	67.26	3.31	2.95	26.65	31.45
18M	29.53	26.52	21.52	54.76	59.05	65.02	3.53	3.03	26.4	31.12
24M	29.52	26.55	21.74	54.78	58.85	64.38	3.77	3.18	26.22	30.91
30M	29.51	26.54	22.49	28.39	58.27	63.78	3.73	3.16	26.36	25.48

Table 11.UTCI April

UCL	Air temperature°C		Mean radiant temp.°C		Relative humidity %		Wind speed m/s		UTCI°C	
	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.	Peak hr.	Minimal hr	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.
0.5M	22.29	18.54	44.15	53.86	52.69	72.55	2.79	2.05	25.71	26.81
6M	22.37	18.4	44.14	53.34	51.78	70.18	3.29	2.18	24.92	26.37
12M	21.85	17.92	43.63	53.35	52.69	64.29	3.08	2.62	24.74	24.95
18M	21.31	17.73	43.62	53.06	53.47	63.01	2.85	2.88	24.73	24.24
24M	21.09	17.61	43.68	52.69	53.89	62.47	2.79	2.98	24.7	23.93
30M	20.89	17.6	43.81	21.95	54.25	62.39	2.83	2.68	24.53	15.94

Table 12.UTCI December

The UTCI of area 2 during April month in peak hour and minimal hours experiences moderate heat stress across UCL due to increase in air temperature in peak hours and increase in mean radiant temperature during minimal hours.

During the month of December in peak and minimal hour the UTCI is under no thermal stress due to lower air temperature across UCL. During minimal hours at 0.5M and 6M UCL the UTCI is moderate heat stress due to increase in relative humidity.

5.3.3. INFERENCE OF AREA 3

UCL	Air temperature°C		Mean radiant temp.°C		Relative humidity %		Wind speed m/s		UTCI°C	
	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.	Peak hr.	Minimal hr	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.
0.5M	28.56	26.24	26.98	47.62	65.14	70.41	2.93	2.65	27.7	31.14
6M	28.68	26.52	26.85	47.6	64	67.35	3.02	3.57	27.61	29.98
12M	28.34	26.61	26.48	47.46	62.72	62.5	3.87	3.63	26.17	29.65
18M	28.12	26.59	26.04	47.09	61.81	62.24	4.16	3.55	25.47	29.63
24M	27.71	26.58	25.62	46.59	61.32	62.23	4.06	3.42	24.94	29.62
30M	27.87	26.56	24.98	17.39	60.96	62.24	3.94	3.1	25.05	22.62

Table 13.UTCI April

UCL	Air temperature°C		Mean radiant temp.°C		Relative humidity %		Wind speed m/s		UTCI°C	
	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.	Peak hr.	Minimal hr	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.
0.5M	22.27	18.61	45.01	52.16	52.74	69.72	3.53	2.48	24.73	25.92
6M	22.35	18.36	44.71	52.03	51.7	67.61	3.73	2.56	24.36	25.5
12M	21.84	18.05	44.17	51.89	52.79	63.69	3.7	3.32	23.87	23.61
18M	21.33	17.94	44.16	51.84	53.51	62.79	3.51	3.57	23.78	23.01
24M	21.09	17.85	44.14	51.92	53.96	62.36	3.29	3.57	23.97	22.91
30M	20.9	17.5	44.19	21.89	54.28	62.13	2.99	3.55	24.37	14.09

Table 14.UTCI December

The UTCI of area 3 during April month in peak hour experiences moderate heat stress from 0.5M till 12M UCL due increase in air temperature. During minimal hours because of increase in relative humidity results to moderate heat stress till 24M UCL.

During the month of December in peak and minimal hour the UTCI is under no thermal stress due to low air temperature across UCL.

5.4.CASE STUDY OF NANDED CITY TOWNSHIP

Fig.12. Nanded city Township Plan

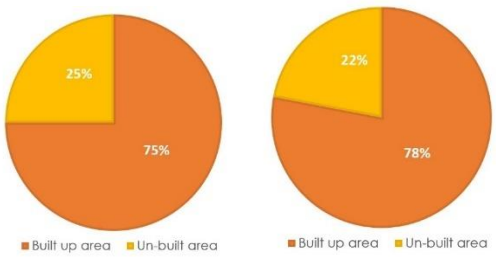
Legend

- Open space
- Parks and garden
- Children play area
- Amenity
- Sports facilities
- Natural and semi natural greenspace
- Water body

Township name: Nanded city
Location: Pune,India
Total area: 700 acres
Status:On Going

Fig.13. Area 1

Fig.14. Area 2



Area 1 Area 2

5.4.1. INFERENCE OF AREA 1

UCL	Air temperature°C		Mean radiant temp.°C		Relative humidity %		Wind speed m/s		UTCI°C	
	Peak hr.	Minimal hr	Peak hr.	Minimal hr	Peak hr.	Minimal hr	Peak hr.	Minimal hr	Peak hr.	Minimal hr.
0.5M	29.57	26.54	41.82	48.11	64.75	69.83	3.07	3.5	32.13	30.36
6M	28.91	26.61	41.74	48.08	64.14	67.68	3.12	3.75	31.33	29.94
12M	28.37	26.64	41.44	47.91	63.12	62.34	3.61	3.88	30.05	29.88
18M	28.16	26.6	25.86	47.62	62.7	62.24	3.96	3.72	25.73	29.56
24M	28.04	26.59	25.55	47.24	62.28	62.23	3.93	3.74	25.51	29.43
30M	27.9	26.58	25.1	17.2	61.35	62.24	3.42	3.16	25.67	22.53

Table 15.UTCI April

UCL	Air temperature°C		Mean radiant temp.°C		Relative humidity %		Wind speed m/s		UTCI°C	
	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.	Peak hr.	Minimal hr	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.
0.5M	20.85	18.29	50.35	49.9	55.28	61.58	3.51	2.82	25.1	24.68
6M	20.81	17.87	50.16	49.87	55.15	61.89	4.17	3.38	23.97	23.25
12M	20.3	17.57	49.98	49.91	56.04	62.11	4.1	3.53	23.68	22.74
18M	19.98	17.54	49.86	49.81	56.5	62.13	3.84	3.55	23.84	22.65
24M	19.81	17.53	49.73	49.61	56.92	62.14	3.33	3.42	24.59	22.84
30M	19.61	17.52	16.24	16.22	57.25	62.12	2.82	3.21	15.39	12.98

Table 16.UTCI December

The UTCI of area 1 during April month in peak and minimal hour experiences moderate heat stress at 0.5M to 12M UCL at peak hours and 0.5M to 24M UCL during minimal hours due to increase in mean radiant temperature and no heat stress at 18M to 30M in peak hours due to increase in wind speed and at 30M UCL decrease in mean radiant temperature in minimal hours.

During the month of December in peak and minimal hour the UTCI is under no thermal stress due to low air temperature across UCL.

5.4.2. INFERENCE OF AREA 2

UCL	Air temperature°C		Mean radiant temp.°C		Relative humidity %		Wind speed m/s		UTCI°C	
	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.	Peak hr.	Minimal hr	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.
0.5M	28.55	26.22	22.39	49.19	81.42	69.76	2.49	2.6	28.81	31.53
6M	28.57	26.51	21.57	49.27	81.26	61.32	2.55	2.8	28.57	31.02
12M	28.9	26.62	20.62	49.03	77.1	62.68	2.97	2.88	27.84	31.04
18M	28.97	26.61	20.54	48.54	67.16	62.24	3.24	2.58	26.53	31.28
24M	29.01	26.59	20.73	47.74	59.86	62.25	3.11	2.85	26.05	30.71
30M	29.04	26.58	20.8	17.57	59.07	62.24	2.86	2.31	26.27	23.58

Table 17.UTCI April

UCL	Air temperature°C		Mean radiant temp.°C		Relative humidity %		Wind speed m/s		UTCI°C	
	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.	Peak hr.	Minimal hr	Peak hr.	Minimal hr.	Peak hr.	Minimal hr.
0.5M	26.56	18.16	44.04	49.61	56.34	61.67	3.64	2.64	28.38	24.87
6M	26.69	17.9	44.03	49.91	54.12	61.84	3.8	2.8	28.18	24.45
12M	26.43	17.57	44.05	49.82	53.21	62.11	3.82	2.93	27.85	23.94
18M	25.85	17.54	43.95	49.83	53.64	62.13	3.6	2.72	27.57	24.35
24M	25.54	17.53	43.71	49.85	53.88	62.17	3.32	2.77	27.61	24.25
30M	25.25	17.56	43.08	16.13	54.17	62.12	2.69	2.46	28.08	14.47

Table 18.UTCI December

The UTCI of area 2 during April month in peak hour experiences moderate heat stress across UCL due to increase in air temperature which results to moderate thermal stress. Because of high rate of humidity and the mean radiant temperature is lower.

In month of April during minimal hour the UTCI is moderate thermal stress due to increase in mean radiant temperature.

During the month of December in peak hours the rise in temperature affects the UTCI and results in moderate heat stress.

6.RESULTS AND DISCUSSION

6.1.SURFACE ALBEDO

Township: Magarpatta

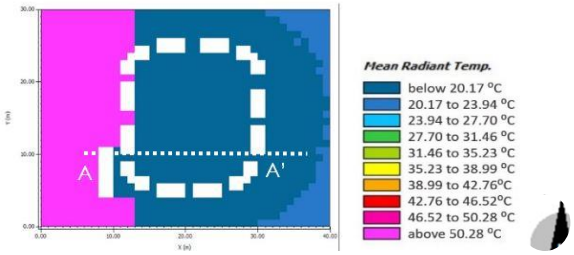


Fig.15.UCL: 0.5M

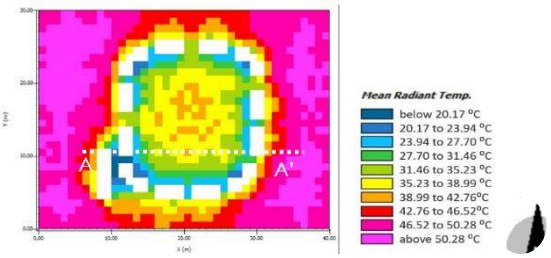


Fig.16.UCL: 24M

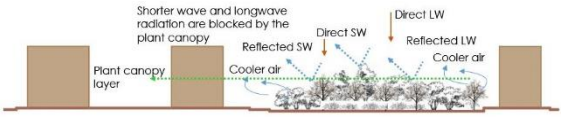


Fig.17. Schematic Section at AA'

The mean radiant temperature in the open space of Magarpatta at UCL 0.5M is 35 to 38ºC whereas at UCL 24M it is below 20 ºC

It is due to the higher reflectivity of solar radiation and less heat is absorbed by plant canopy.

Shortwave and longwave radiation are blocked by plant canopy layer.And due to the less heat absorbed the air temperature gets lower

6.2.SKY VIEW FACTOR

Township: Magarpatta

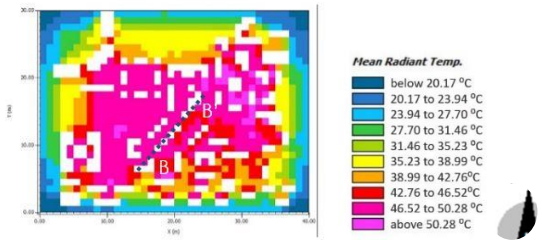


Fig.17.UCL: 24M

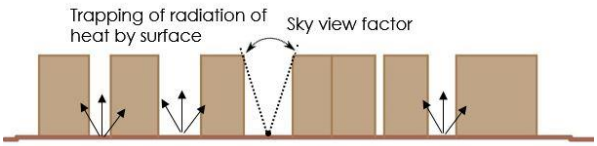


Fig.18. Schematic Section at BB'

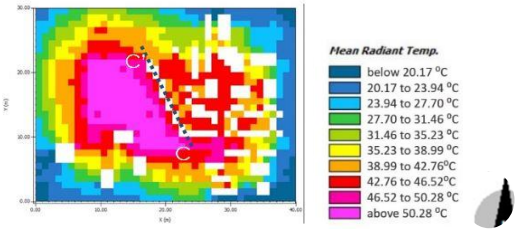


Fig.19.UCL: 24M

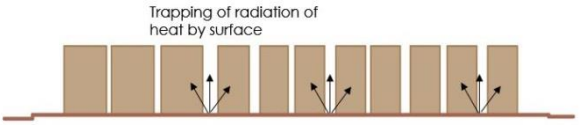


Fig.20. Schematic Section at CC'

The Sky view factor effect on the mean radiant temperature which is increased in both area of the Magarpatta township.

It is due to the trapping of radiation of heat by the surface.

6.3.ASPECT RATIO

Township: Amanora

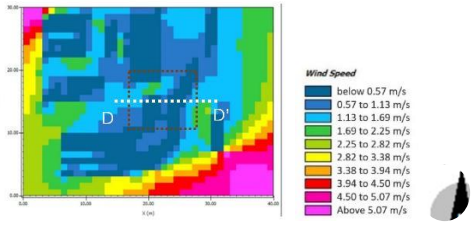


Fig.21. UCL 0.5M

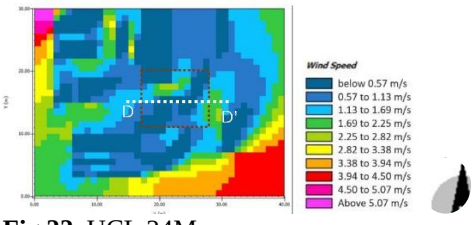


Fig.22. UCL 24M

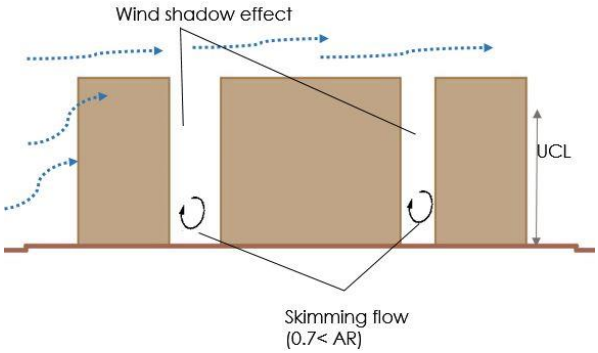


Fig.23. Schematic Section at DD'

There is lower wind speed which is 0.57m/s.It is because of the aspect ratio is mean height to width ratio of building spacing which is less than the aspect ratio.

And because of that there is wind shadow effect which creates a skimming flow.

6.4.BUILDING SURFACE FRACTION

Township: Amanora

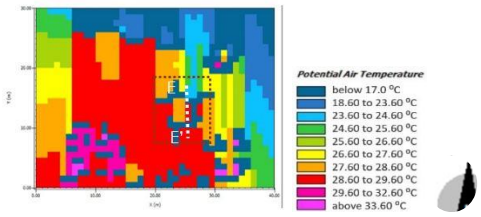


Fig.24. UCL 0.5M

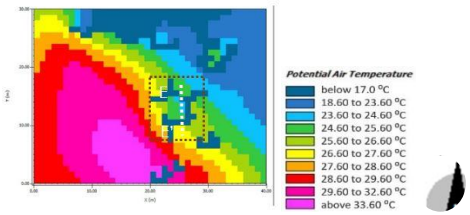


Fig.25. UCL 30M

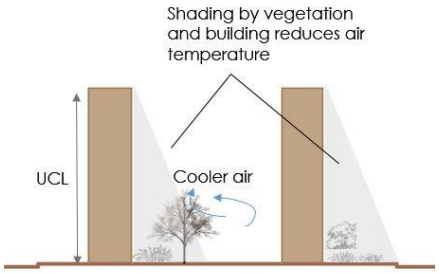


Fig.26. Schematic Section at EE'

The air temperature in open space in Amanora township has been decreased from 28.60 ºC to 24.60 ºC.

Due to reduction of direct solar radiation by shading of the building and vegetation of trees which provide shading and high albedo material grass which has high emissivity decreases the air temperature.

6.5. PERVIOUS SURFACE FRACTION

Township: Magarpatta

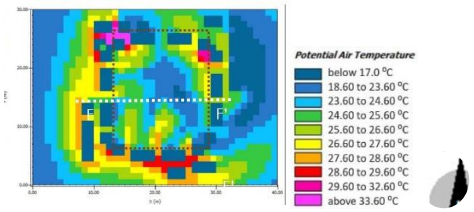


Fig.27. UCL 12M

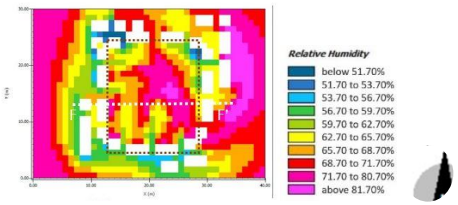


Fig.28. UCL 12M

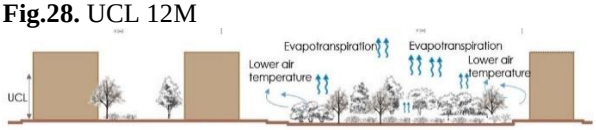


Fig.29. Schematic Section at FF'

The relative humidity in the open space of Magarpatta township is highest due to the evapotranspiration of pervious surface such as lawn and natural soil and due to the dense vegetation.

Due to higher humidity there is lower air temperature observed in this area. The ratio of pervious area is greater than that of the total plan area.

6.6. IMPERVIOUS SURFACE FRACTION

Township: Magarpatta

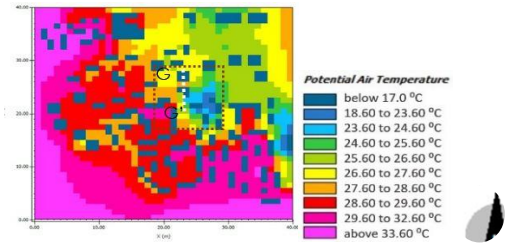


Fig.30. UCL 0.5M

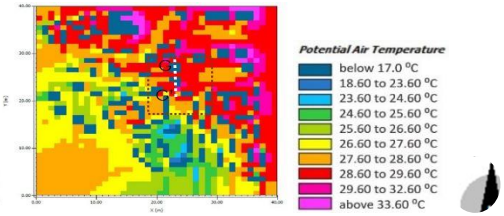


Fig.31. UCL 1.5M

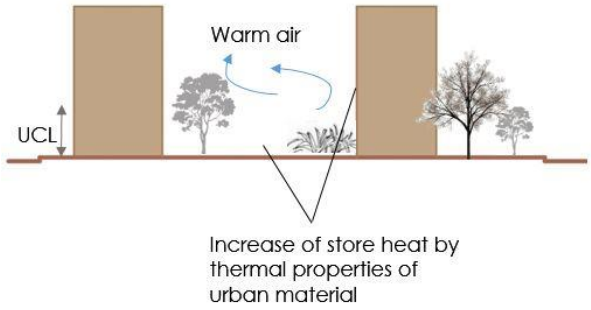


Fig.32. Schematic Section at GG'

The air temperature in the open space at UCL 0.5M is 27.60 ºC which has increased to 28.60ºC at UCL 1.5M

It is because due to the impervious surface which increased stored heat by thermal properties of urban materials and creates to increase air temperature.

6.7. COMPARATIVE ANALYSIS

Township name	Area	Open space typology	UTCI: April (Peak hour)	UTCI: December (Peak hour)	UTCI: April (Minimal hour)	UTCI: December (Minimal hour)
Magarpatta	Area 1	Children play area, amenity space, Garden	Strong heat stress	Moderate heat stress	Moderate heat stress	No thermal stress
Magarpatta	Area 2	Sport facility	Moderate heat stress	No thermal stress	Moderate heat stress	No thermal stress
Magarpatta	Area 3	Children play area, amenity, Garden	Strong heat stress	Moderate heat stress	No thermal stress	No thermal stress
Magarpatta	Area 4	Park and Garden	No thermal stress	No thermal stress	No thermal stress	No thermal stress
Amanora park town	Area 1	Sport facility, Children play area, amenity space	Strong heat stress	No thermal stress	Moderate heat stress	No thermal stress
Amanora park town	Area 2	Amenity space, garden	Moderate heat stress	No thermal stress	Moderate heat stress	No thermal stress
Amanora park town	Area 3	Garden, children play area.	Moderate heat stress	No thermal stress	Moderate heat stress	No thermal stress
Nanded city	Area 1	Park, Children play area, amenity space	Moderate heat stress	No thermal stress	Moderate heat stress	No thermal stress
Nanded city	Area 2	Children play area, amenity, Garden	Moderate heat stress	Moderate heat stress	Moderate heat stress	No thermal stress

Table 19. Comparitve Analysis

The UTCI across the township is compared. In month of April during peak and minimal hours there is strong to moderate heat stress. In other month which is December there is no thermal stress across the townships.

7. RECOMMANDATION AND CONCLUSION

7.1.STRATEGIES TO IMPROVE MICROCLIMATE OF THE OPEN SPACES IN TOWNSHIPS

Use of cool pavements cool materials present a hig
diffuse reflectivity to solar radiation and also has
high emissivity. Because of their optical characteristi
they present lower surface temperatures and contribu
to decreased convection of heat to the ambient ai
Cool pavements have been selected to be replaced
the open space of children play area and ameni
space. Cool pavements are concrete tiles colored b
infrared reflective colors. Paints presenting hig
reflectivity in the infrared have been developed recently.

Asphalt roads have been selected to be replaced by Cool asphalt refers to light colored asphalt pavements presents much higher diffuse reflectivity to solar radiation. Although conventional black asphaltic products have a reflectivity close to 5% industrial cool asphaltic pavements present a reflectivity higher than 50%.

Areas with lack of shading have been selected by replacing tress provide shading decrease convection of heat to the air while contributing to reduced ambient temperatures through evapotranspiration.

7.2. CONCLUSION

The process of urbanization brought to reduction of open spaces and impact on microclimate. The research was conducted for three different townships for various categories of open spaces at microscale. The research aim was to study effect of open spaces of varied scale and types on urban micro climate in different townships in Pune city.

Vegetation in open space affects the microclimate it reduces air temperature while providing shade. Area under shading has a significant impact on the reduction of heat stress. The results obtain through simulation had shown that there are significant differences in temperatures across the Urban Canopy Layer(UCL) The microclimate parameters has different impact on different open spaces at various urban canopy layer(UCL) in the townships.

The analysis of results obtained through simulation shows that effect of microclimate changes because of different spatial characteristics such as size of the open space, vegetation density and materials differ at various categories of open spaces. Based on the UTCI assessment scale the effect of microclimate on open space is been analyzed for the thermal comfort.

The effect of microclimate on the open spaces such as children play area and amenity space at outdoor thermal comfort results to strong heat stress due to impervious surface which is having low albedo materials. Because of low albedo materials the solar radiations were absorb which affects to rise in air temperature and mean radiant temperature. The area gets heat up and results to strong heat stress.

The effect of microclimate on open spaces such as sports facility area at outdoor thermal comfort results to moderate heat stress due to the soil cover and absence of grass and shrubs and less number of tress near this open space results to moderate heat stress.

The effect of microclimate on the open spaces such as parks and gardens at outdoor thermal comfort results to no thermal heat stress due to dense vegetation of trees which provide shading and high albedo material grass which has high emittance and thus prevent in heating up and decreasing the mean radiant temperature and keeping the air temperature low as natural cooling due to plants evapotranspiration which results to no thermal heat stress. Therefore, this

study will be helpful for the further conception of master plan of townships.

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