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Research Paper

The Impact of Building Height on Microclimate Characteristic of Urban Open Spaces (Case Study: Narmak neighborhood)

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Abstract
Urban planning and morphology are one of the most important factors affecting land surface temperature (LST) and microclimate chrematistics. The production of anthropogenic heat, mainly for cooling systems and lighting, has resulted in significant impacts on the quality of the thermal environment. These impacts include poor air quality, increased temperatures, higher energy consumption, and the development of urban heat islands (UHIs). With the growing urban population and increased building height, especially in metropolitan areas, there have been significant changes in the urban geometry, rate of pollution, amount of heat released, and meteorological parameters. All these factors contribute to the heat island phenomenon and significantly alter the microclimate in urban areas. The goal of this article is measuring the effects of height changes in buildings around Tehran metropolitan squares in a detailed plan on microclimatic changes. As part of a research study, the Hafthoz Square in Tehran was chosen as a case study. The researchers used a combination of simulation techniques (Envi-met) and GIS to detect the spatial variation of Land Surface Temperature (LST) and determine its quantitative relationship with building height and density. This was achieved through simulation modeling for the Narmak neighborhood of Tehran. As Conclusion, the results indicate that comparison on the simulation between the existing conditions and proposed scenario area showed that in the proposed scenario, wind speed and relative humidity decrease and ground surface temperature (UHI) and PPD and PMV indices increase. Therefore, if the detailed plan of Tehran metropolis is realized and implemented in many squares, it will be accompanied by changes in micro-climatic parameters in order to reduce the thermal comfort of citizens.

Keywords: *Building height, Land surface temperature (LST), Microclimatic changes, Urban heat island (UHI), Urban climate, Urban open spaces, Tehran.*

1. INTRODUCTION

Increased urban population and the growing height of buildings, particularly in metropolitan areas, have resulted in significant changes in urban geometry, the amount of heat released, pollution rates, and meteorological parameters (Rezaeirad et al, 2014). Although urban areas occupy only about 3% of the Earth's surface, the impacts of urbanization on the environment are far-reaching on the global level (Griffiths P., Hostert P., Gruebner O., van der Linden S, 2010). In addition to the scientific aspect, it is also essential to consider the practical implications of urban excess heating and associated heat stress on city dwellers during hot spells (Mayer, 2006; Allen, 2012). The unprecedented rate of urbanization over the past century has led to various impacts on the environment, of which temperature increase and climate change are

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widely acknowledged. Land surface temperature (LST) is crucial in calculating the Urban Heat Island (UHI) effect. It influences the air temperature in the lower atmosphere of urban areas and governs the energy balance and surface radiation in these regions (Voogt, J. A., Oke, T. R, 1998).

Population increase, rapid industrialization rate, increased pollution levels in the lower layers of the atmosphere, and urban heat effects are among the main factors leading to considerable changes in weather conditions and microclimate of large cities. Urban form can affect the microclimate of the urban environment in various ways. For instance, changes in building density may cause variations in air temperature and pollution (Rezaeirad.H, Rafeiyan.M, 2016). They increased urban density by obstructing air movement and slowing down the nocturnal release of heat stored in the daytime, resulting in the UHI phenomenon.

Given this significant impact of density on the emergence of heat islands, density-related policies of urban development plans could directly and crucially impact changes in urban microclimate characteristics (Barros, 1997).

Oke's energy balance theory suggests that all the energy absorbed by the surface, whether from radiation or anthropogenic heat, has to go somewhere. It either warms up the air above the surface, evaporates with moisture, or gets stored in the material as heat. This study aims to improve our understanding of how the height of a building affects the local microclimate to save energy. We continuously measured land surface temperature and combined it with simulation modeling in a small urban area during summer. We determined the spatial variations in land surface temperature due to the distribution of building height and density in a local area.

Despite abundant literature on building height in general, there is not much research about microclimate characteristic of urban open spaces.

In this research, literature review is characterized by a logical flow of three key ideas including: ideas including: 1) Urban Climate, and 2) Land surface temperature (LST), and 3) Urban Heat Island (UHI).

2. LITERATURE REVIEW

2. 1. Urban Climate

Urban climate is defined by specific climate conditions which differ from surrounding rural areas (Eum J.-H., Scherer D., Fehrenbach U., Woo J.-H, 2011). It is a unified synthesis that brings together explanations of the ways cities interact with their atmospheres over scales that extend from walls and roofs up to whole cities. It aims to be an introduction accessible to students at the upper undergraduate and beginning graduate levels and professionals in cognate fields with interests in urban environments. It provides a coherent system to describe, study, and understand the essentials of urban climates. It is based on recognition of the climatic scales at play in a city and the resulting structure of urban atmospheres (Oke, T. R., Mills, G., Christian, A., Vooget, J.A, 2017).

The geometry and cross-section of the city, the shape, height and size of buildings, the direction of streets and buildings and the surface area of open spaces are all factors that determine the microclimate of a city (Rezaeirad et al, 2021). The amount of sunshine an urban area receives depends not only on cloud cover but also on-air pollution, shades provided by buildings, and even the orientation of the street network. Tall urban structures tend to influence radiation flows (Huang G., Zhou W., Cadenasso M.L, 2011). The impact of urbanization on climate is mainly described by urban heat islands (UHI), which represent a discrepancy in ambient temperature between cities and their surrounding areas (Nonomura A., Kitahara M., Masuda T, 2009). UHI phenomenon in urbanized areas, combined with the decreased vegetation and the anthropogenic heat discharge, is an example of this climate change. It is therefore advisable for countries and policy makers, to evaluate the UHI phenomenon in order to estimate and control this climate destabilization (Stamou. A, Manika. S, Patias, P, 2013). As a result, The UHI has gained attention of public administration in municipal governments, environmental protection offices and public health agencies (EPA-United States Environmental Protection Agency, 2008).

The urban climate also indirectly influences air quality (primarily due to pollutant emissions), given the atmosphere's different vertical temperature structure in the first 0.1–1.0 km above the Earth's surface and modified horizontal wind circulations. These can create ventilation issues, accumulating warm air and poor air quality, especially in dense, high-rise urban areas. For example, enhancing ventilation in Chinese megacities is now a priority for reducing the UHI and improving air quality.

Changes to surface characteristics in cities are also crucial to urban climate in the context of large-scale climate change. For example, imperviousness of urban surfaces increases the impacts of rainfall, such as floods, and also leads to higher surface temperatures that increase heat loading on urban inhabitants. Thus, modifications to the surface that help create local urban climates are also crucial to making cities less vulnerable to the impacts of climate change. (Masson, V., Lemonsu, A., Hidalgo, J., Voogt, J, 2020).

2.2. Land Surface Temperature (LST)

Land surface temperature (LST) is the main factor determining surface radiation and energy exchange (Weng, 2009), controlling the distribution of heat between the surface and atmosphere (Tan K. C., Lim H. S., MatJafri M. Z., Abdullah K., 2010). LST is an important parameter in the field of atmospheric sciences as it combines the result of all surface-atmosphere interaction and energy fluxes between the ground and the atmosphere and is, therefore, a good indicator of the energy balance at the Earth's surface (Wan, Z., Snyder, W., Zhang, Y, 1996). Weng (2001, 2003) examined LST pattern and its relationship with land cover in Guangzhou and in the urban clusters in the Zhujiang Delta, China. Studies using satellite-derived radiant temperature have been termed as the surface temperature heat islands.

Land Surface Temperature (LST) is a key variable that helps govern radioactive, latent and sensible heat fluxes at the interface (Guillevic P.C., Privette J. L., Coudert B., Palecki M. A., Demarty J., Ottlé C., 2012). It plays a critical role in Global climate change and is used in a range of hydrological, meteorological, and climatological applications. As needed for most modelling and climate analysis applications (Solanky, V., Singh, S., Katiyar, S.K, 2017).

Estimation of LST using emissivity will provide more accurate estimation with appropriate calibration of atmospheric contamination by a separation of surface emissivity and temperature from radiance at ground level and atmospheric corrections (Li, ZL., Wu, H., Wang, N., Qiu, S., Sobrino, JA, 2013). Estimating emissivity for ground objects from passive sensor data has been measured using different techniques. Among these techniques are the normalized emissivity method (Gillespie, 1985), thermal spectral indices (Becker & Li, 1990), spectral ratio method (Watson, 1992), Alpha residual method (Kealy & Gabell, 1990), NDVI method (Valor & Caselles, 1996), classification-based estimation (Snyder et al., 1998), and the temperature emissivity separation method (Gillespie et al., 1998). These techniques can be used to separate temperatures from emissivity so that the effect of emissivity on estimated LST can be determined (Weng Q., Lu D., Schubring J, 2004).

Therefore, analysis and comprehension of LST dynamics and their relation to changes of anthropogenic origin are necessary for the modeling and forecasting environmental changes (Mohan M.; Pathan S. K.; Narendrareddy K.; Kandya A.; Pandey S, 2011).

LST serves as an important indicator of chemical, physical and biological processes of the ecosystem. LST is influenced by such properties of urban surfaces as color, surface roughness, humidity, chemical composition etc (Tan K. C., Lim H. S., MatJafri M. Z., Abdullah K., 2010). Land surface temperature regulates the lower layers of the atmosphere, making it a critical factor for the urban environment. LST modulates the energy balance, and can therefore be considered a weather variable (Retalis A., Paronis D., Lagouvardos K., Kotroni V., 2010). Therefore, each urban human-made element forms a specific artificial climate around and above itself, which has always a reciprocal relationship with it (Rezaeirad et al, 2021).

2.3. Urban Heat Island (UHI)

Use of heat sources in district heating (DH) systems is gaining attention as a climate mitigation measure. Urban excess heat (UEH) from data centers, metro stations, sewage systems and service sector buildings' cooling system belong to these sources (Sandvall, A., Hagberg, M., Lygnerud, K., 2020).

Urban heat island (UHI) has long been a concern for more than 40 years. One of the earliest UHI studies was conducted in 1964 (Nieuwolt, 1966). Extensive urbanized surfaces modify the energy and water balance processes and influence the dynamics of air movement (Oke, 1987). Also, a high concentration of this type of building can cause environmental problems such as urban heat island (UHI), an effect that leads to thermal discomfort. As a result, providing thermal comfort requires more consideration in high-rise buildings (Rezaeirad & Afzali, 2021). When a city is characterized by significant variations in height, the released heat, as well as pollutants, is more easily trapped between the buildings and this intensifies HI effects (Smith, 1975). High daytime radiation, a negative radiation balance (Q*) in the evening and at night as well as a limited atmospheric exchange guarantee the development of a positive horizontal temperature difference between urban (tu) and rural, non-built-up surroundings (tr; $\Delta Tu\text{–}r > 0$ K). This phenomenon is called the urban heat island (UHI) (Kuttler, 2012). The intensity of Urban Heat Island (UHI) effect depends on parameters that show in Table 1.

Predicted mean vote (PMV) was developed for assessing thermal comfort. Following these considerations, Fanger proposes an index for the evaluation of the conditions of non-comfort (or discomfort) to an environment, expressed as a predicted percentage of dissatisfied (PPD). The PMV/PPD model was first developed by Fanger using heat-balance equations and empirical studies about skin temperature to define comfort (Rezaeirad et al, 2021)

This study goes further to measure the effects of height changes of buildings around squares on microclimatic changes in the detailed plan of Tehran city. The research history of several experts is shown in (Table 2).

Table 1. A selection of meteorological and structural factors influencing the UHI (Rezaeirad et al, 2017)

Influencing factor (IF)	Sign of correlation coefficient between UHI and IF
Cloud cover	-
Wind speed	-
Anthropogenic heat emission	+
Bowen ratio, β^1	+
Population	+
Sky view factor, (SVF)	-
Ratio building height/street width (H/W)	+
Surface sealing	+
Green- and water-surface area/total area	-
Latitude	+

β^1 = QH/QE; (QH/QE = turbulent sensible/latent heat flux density)

Table 2. Summary of the research history of various experts

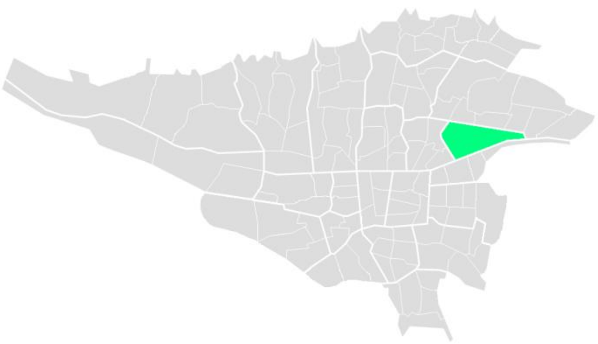
Results	research method	affecting factors	Study title	researchers
Streets that are in the same direction with the prevailing wind have lower temperatures than vertical streets in the direction of the wind.	Use of modeling software	Direction	Check the temperature of the streets of Qardaya city - Algeria	(Ali-Toudert & & Mayer, 2007)
Temperature increases with increasing impermeable surfaces and barren lands and decreases with increasing vegetation.	Smith method	Impermeable surfaces	Investigation of Earth surface thermal map with temperature classification of thermal images (1986)	(Shakiba et al., 2009)
Scattered cities have the highest temperature increases compared to compact cities.	-	Form	Investigating the Relationship between Spatial Configuration Scattering Index and Intensity of Land Use Concentration in 83 Cities of the United States in 1956-2005 Over Five 10-Year Periods	(Stone et al., 2010)
At high building densities, air retention is higher, velocity is lower, and air temperature is higher	simulation	Compression	Urban ambient heat simulation project on China Buzhou Industrial Park	(L. Yang et al., 2016)
Inverse relationship between LST and height.		Height	Study area around Jaipur city	(Mathew et al., 2019)
Significant relationship between morphology and location of buildings and vegetation with changes in microclimatic parameters and finally thermal comfort	simulation	Morphology and location of buildings and vegetation	Maslak neighborhood in Istanbul	(Rezaeirad & Afzali, 2021)
Significant relationship between the shape and form of high-rise buildings with wind speed and direction and finally thermal comfort	simulation	Morphology of high-rise complexes	Qeytariyeh neighborhood in Tehran	(Rezaeirad et al, 2021)

3. RESEARCH METHODOLOGY

A combination of qualitative and quantitative methods was used in this study. A comprehensive literature review was performed to identify the impact of building density on increasing LST in urban areas, as following steps:

- Step1: The conceptual model of the research, independent and dependent variables:
  - Independent variable (building height)
  - Dependent variables (LST[1], PPD[2], PMV[3], Wind speed, Specific humidity)
  - Step 2: Case study selection and data collection: GIS data (Area and height of buildings)
  - Climate data
  - Digitized data
- Step3: Measurement methods, simulations methods:
  - Simulation of microclimate using envi-met in 2 scenarios
  - Depict simulation in 2 scenarios
- Step4: Finding analysis:
  - Evaluate how height building have influenced microclimate in certain neighborhoods with simulation analysis

The proposed plan for District No. 8 of Tehran was reviewed for density requirements in the research study area, Haft-Hoz square, Narmak, Tehran.



The Envi-met microclimate modeling system analyzed the proposed detailed plan and available data on the existing situation of the study area. The data extracted from the review, such as the number of floors, type of paving, and vegetation, were used as input data for the analysis.

ENVI-met enables urban environment simulation from microclimate to local climate scale with 0.5-10 m spatial resolution and 10s temporal resolution with a maximum of 250 grids (Wang,y and et al, 2015). In this study, the building geometry, number of floors, vegetation, and surface materials in the surrounding buildings of the study area are defined on a 3D grid of 80×80×30 cells, with a 2 m grid cell size. This resolution allows us to investigate local microclimate variations.

LST for both status quo and future scenarios was calculated to analyze the proposed detailed plan further. The required meteorological data for this study were taken from the Dushantappe Synoptic Weather Station, which is the closest one to the case area. In addition, both models have been simulated in summer and 16:00 to make sure that the most appropriate meteorological data is used for analysis. Exploring the correlation between building size and height with LST distribution using a simulation model. The simulations also allowed us to understand the relationship between building height and microclimate variations, which impact human comfort.

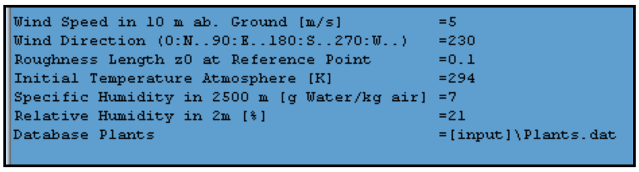


Fig 1. Input data in software for simulation in both scenarios

4. STUDY AREA

Selected area for this study that is known as Hafthoz, is located in the District No. 8 of Tehran at 1300 m above sea level on a plain with a mild slope towards the south. This area's climate is characterized by mild springs and autumns, hot, dry summers and cold, and dry winters (Rezaeirad, 2011). The average building density is 219%. which has been constantly increased in the recent years. Between 1995 and 2010, the population density in the eastern part of the study area increased from 220% to over 300% at an average rate of over 60% (Rezairad, 2011). Developers can now construct up to 11-story buildings in the area as per the proposed detailed plan. Figure 2.3 illustrates the height of buildings and vegetation for the status quo and proposed scenario.

Data obtained from Dushatappe Synoptic Weather Station were used to simulate general climatic characteristics of the case area. These characteristics and Metrological data are summarized in Table 3.

[1] Land Surface Temperature
[2] predicted percentage of dissatisfied
[3] predicted mean vote

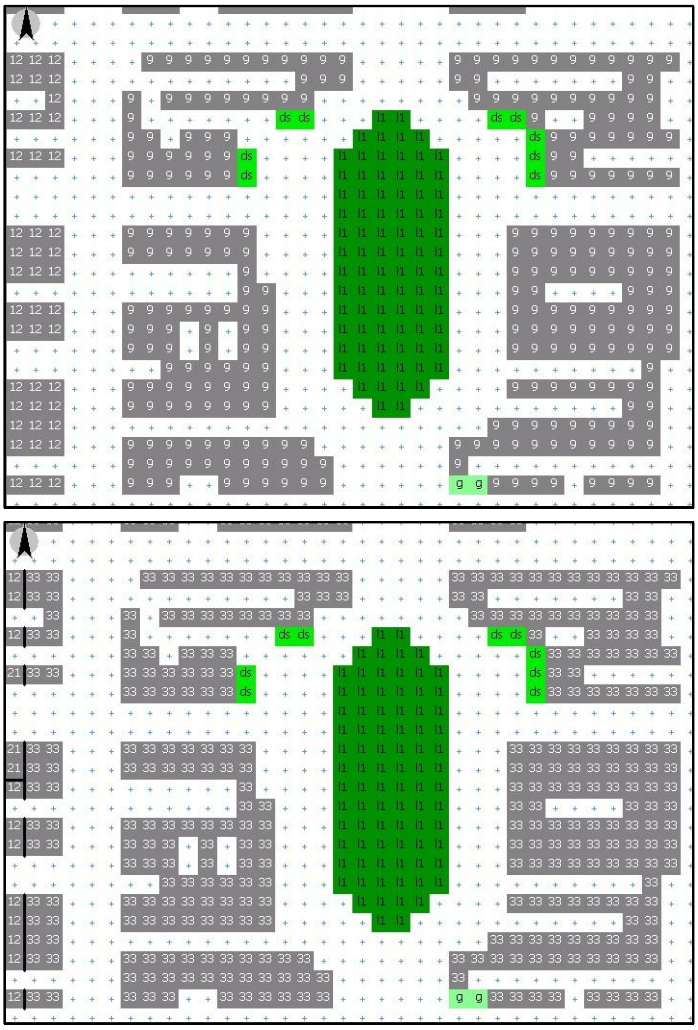


Fig 2, 3. Building height in the existing conditions and proposed scenario

Table 3. General Characteristics and Metrological data of Dushantappe Synoptic Weather Station (http://irimo.ir/)

Station	Type	Altitude	Latitude	Longitude	Statistical Period
Dushan-tappe	Synoptic	1209m	35° 42' N	51° 20''' N	1972-Present

DATA	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
AVE OF MEAN DAILY TEMP IN C°	2012	5.3	4.5	9.7	18	25	29	31	31.2	26	20	13	6.5
	2013	6.5	9.4	14	19	23	29	33	29.9	28	19	13	5.7
MONTHLY TOTAL OF PRECIPITATION IN MM	2012	17	49	13	41	10	2	17	0.4	3.2	15	54	54
	2013	35	16	16	14	13	0	0	0.4	0	2	36	34
AVE OF WIND SPEED IN M/S	2012	1.4	2.5	3.5	3.1	4.1	3.6	2.6	2.1	2.3	2.5	1.6	1.5
	2013	1.8	1.8	2.5	2.8	3.3	2.5	1.8	2.4	1.8	1.5	1.5	1.5

TEMPERATURE RECORDES HIGHEST IN C°																								
Year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Day	Temp	Day	Temp	Day	Temp	Day	Temp	Day	Temp	Day	Temp	Day	Temp	Day	Temp	Day	Temp	Day	Temp	Day	Temp	Day	Temp
2012	10	14.8	29	16.4	30	21	11	31	21	34.4	8	37.4	6	39	1.0	38.8	9.0	34.4	11.0	31.2	10	24.2	5	16.4
2013	23	17.7	9.0	17.4	17	25.4	30	28	28	32.8	15	37.4	24	42.8	5	38.8	5	38	5	32.2	30	23.4	1	1

TEMPERATURE RECORDES LOWEST IN C°																								
Year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Day	Temp	Day	Temp	Day	Temp	Day	Temp	Day	Temp	Day	Temp	Day	Temp	Day	Temp	Day	Temp	Day	Temp	Day	Temp	Day	Temp
2012	22	-3.8	4	-4.4	6	-2.6	1	8	1	14.8	20	14	16	20.6	19	24.4	29	16.4	30	10.4	30	4	28	-3.4
2013																								

FASTEST WIND DIRECTION AND SPPED IN M/S																								
Year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Spd	Day	Spd	Day	Spd	Day	Spd	Day	Spd	Day	Spd	Day	Spd	Day	Spd	Day	Spd	Day	Spd	Day	Spd	Day	Spd	Day
2012	12	24	13	18	16	15	23	17	20	26	15	18	12	8	12	26	9	23	11	25	7	14	10	17
2013	10	11	14	1	10	2	13	24	25	17	20	1	8	3	10	1	13	25	9	3	9	17	14	7

5. FINDINGS (STEP3)

Simulations were conducted using the Envi-met software to compare the current state of affairs with a proposed scenario. A 24-hour simulation with a half-hour interval was run to extract features from receptors on the land surface. The software includes default physical and environmental attributes such as topography, urban morphology, wind speed, building height and density, and vegetation information. To recreate the current conditions, data on building height and density were collected through site visits and field surveys.

Dark color in Figure 2 represents existing buildings with the average height of 9m and also green color for vegetation in the study area. The floors in the surrounding buildings fall between 2 and 4 (Figure 4). The analysis showed that the existing LST is between 20.1 C and 22.1℃. To make things clearer, the different variations of LST are represented using a blue-to-red color spectrum. In this spectrum, blue and red colors indicate those surfaces with the lowest and highest LST, respectively. Furthermore, the analysis reveals that the average LST currently stands at 20.86°C. Figure 4 illustrates how the trend of land surface temperature changes in different parts of the study area. Meanwhile, figure 5 shows the LST change trends in the existing conditions.

A simulation was conducted for the proposed scenario. All attributes, except for building height and density, were kept the same as the status quo. Data related to building height and density was extracted from the proposed detailed plan. The building heights for the proposed scenario are illustrated in Figure 3.

Dark color in Figure 3 represents proposed scenario with height over 33m and green color as vegetation in the study area. Number of floors in the surrounded buildings falls in arrange between 9 and 11. Figure 6 is also showed LST in range between 21.53℃ and 23.07℃ that represents a considerable increase compared with the status quo scenario. This change is specifically evident along the main north-south axis crossing the main square. In addition, average land surface temperature is 22.24℃.

As these simulations show, increase in building density and number of stories leads to increase temperature in the LST. increase temperature in the LST due to increase intensification of UH effects in the study area.

Figure 7 clearly indicates that increasing building height in the proposed scenario would causes increase the temperature in the trend of land surface temperature. In addition, the simulations with ENVI-met shows a significant difference in thermal comfort factors such as wind speed, PPD value, PMV value and specific humidity conditions proposed scenario. The following figures 8 until 15 show the output simulation of indicators of thermal comfort in both scenarios.

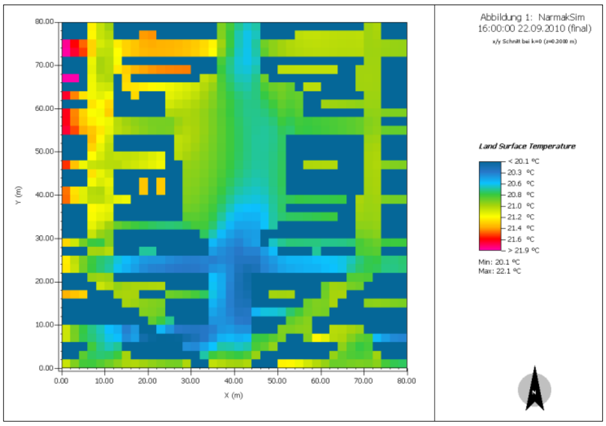


Fig 4. Land surface temperature in the existing conditions

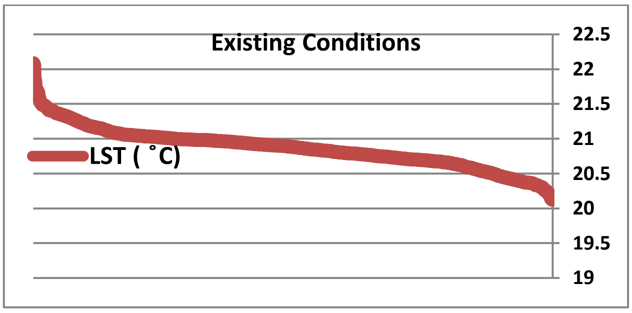


Fig 5. Land surface temperature trends in the existing conditions

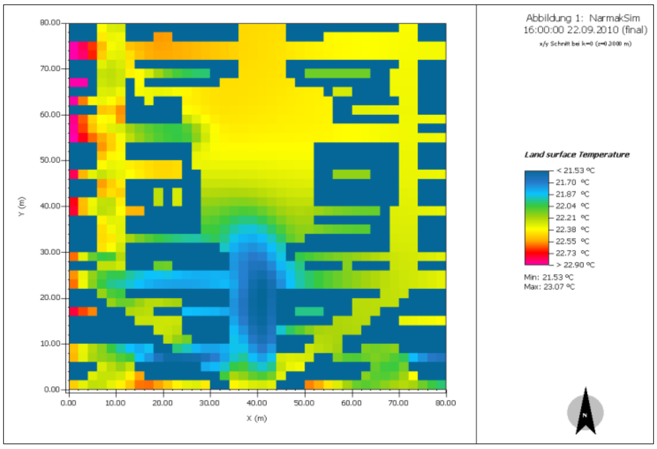


Fig 6. Building height and land surface temperature in the proposed scenario

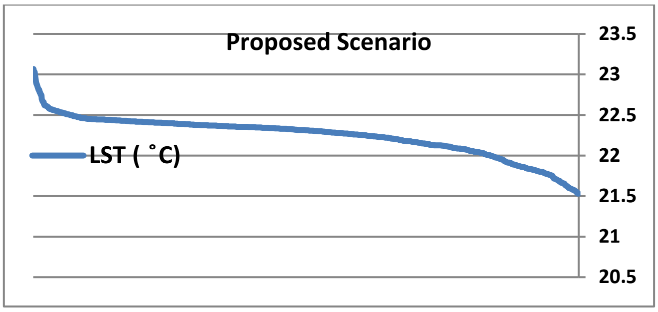


Fig 7. Land surface temperature trends in the proposed scenario

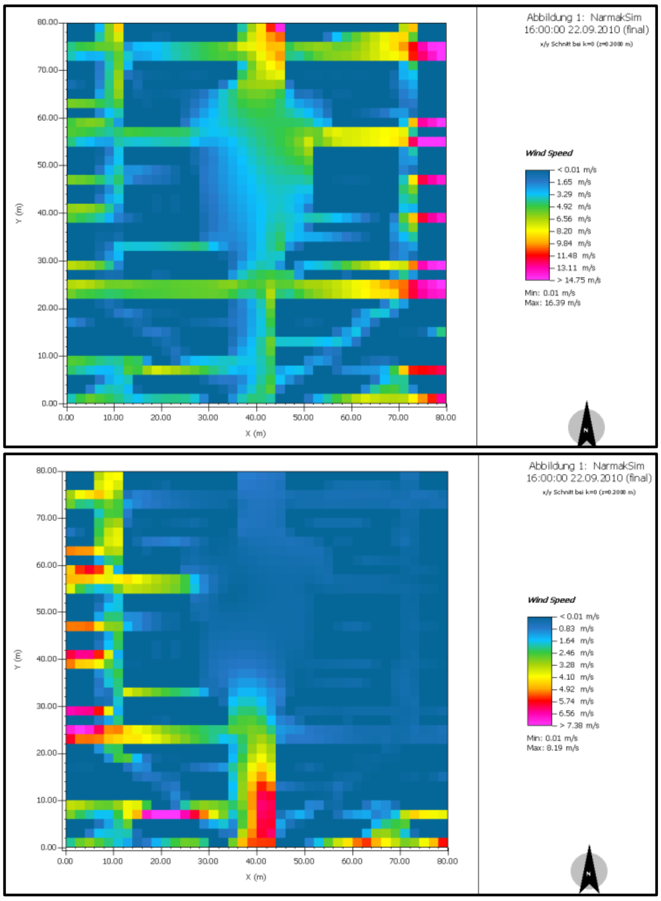


Fig 8, 9. Wind speed in the existing conditions and proposed scenario

Figures 8 and 9 illustrate the wind speed for the status quo and proposed scenario. The results show a decline maximum wind speed at the rate of 16.39 m/s to 8.19 m/s in proposed scenario.

Figures 10 and 11 show the PMV value for the status quo and proposed scenario. These results illustrate an increase index range for PMV value in proposed scenario.

Figures 12 and13 illustrate an increase index range for PPD value in proposed scenario. As it can be seen in???, increasing the height of building in proposed scenario led to increase PPD.

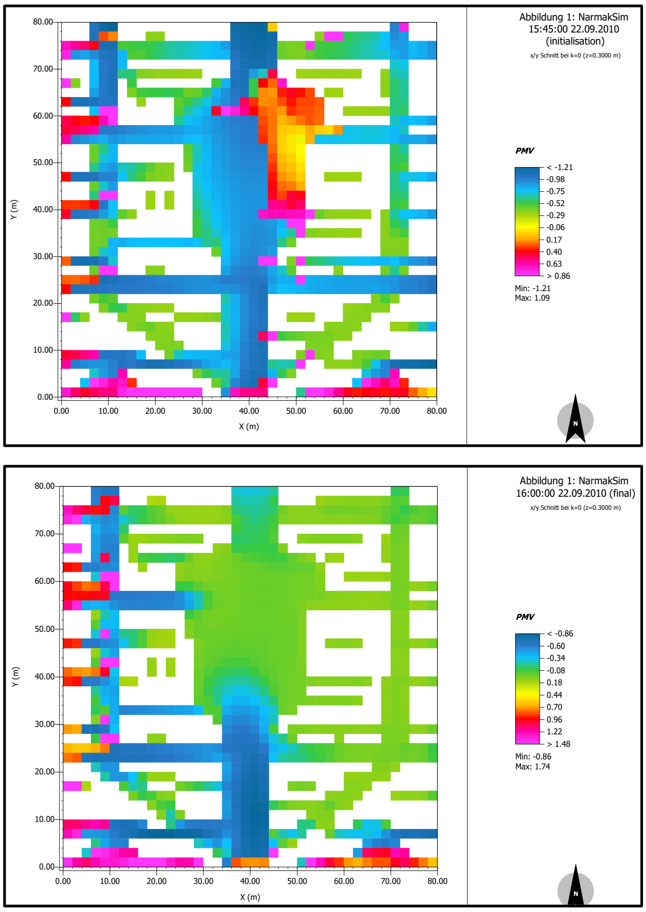
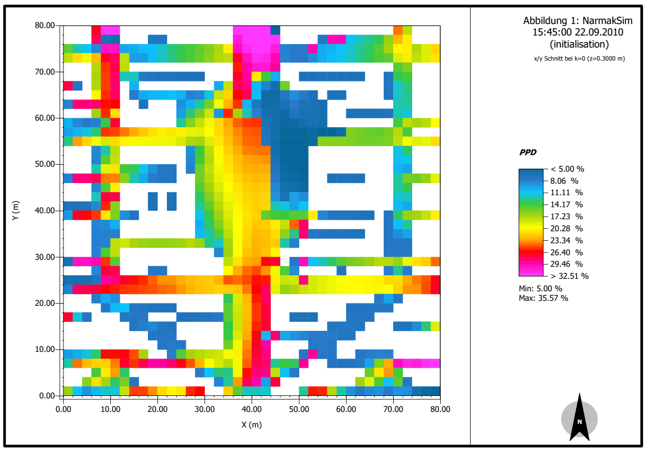


Fig 10, 11. PMV value in the existing conditions and proposed scenario



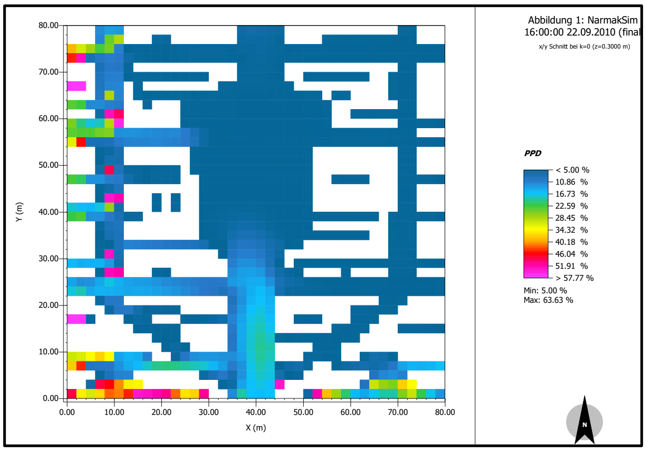
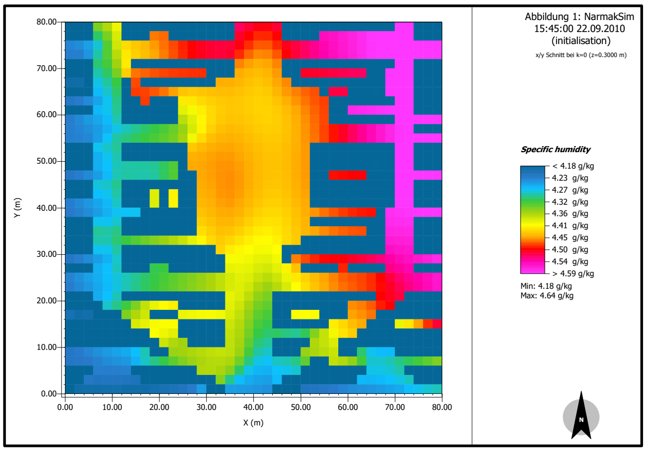


Fig 12, 13. PPD value in the existing conditions and proposed scenario



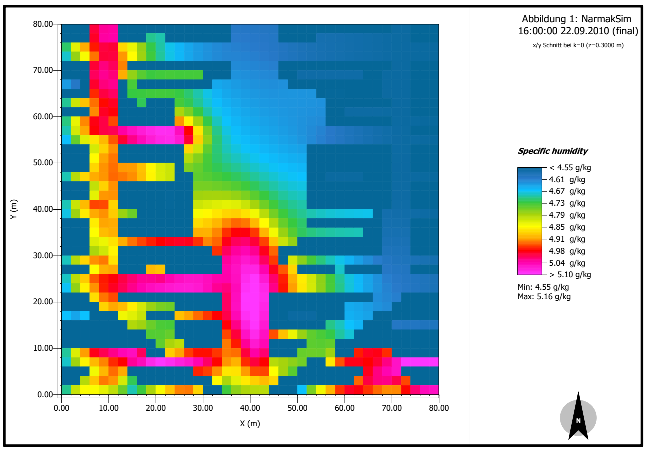


Fig 14, 15. Specific humidity in the existing conditions and proposed scenario

Figures 14 and 15 show the decline the range of specific humidity for proposed scenario compared with. the status quo.

6. DISCUSSION AND CONCLUSION (STEP 4)

This research focused on Commensurate with urbanization trends in many parts of the world, in the past few decades high rates of urbanization in Tehran have caused significant changes in the climatic and meteorological characteristics of the city.

The results from the simulations showed that building height altered the surrounding summer microclimate. The comparison on the simulation between the existing conditions and proposed scenario area showed that the daily average of land surface temperature increase amount 1.38 °C. Significant spatial LST variations were caused by the increase building height at a rate of 24m.

As explained in the literature review, changes in the building height and density may have considerable consequences for urban climate and lead to changes in various attributes such as land surface temperature, levels of air pollution, and wind environment. Furthermore, it is proved that in many occasions a significant relationship exists between building height and the intensity of HI and LST.

Hence, when studying the influence of building height on the microclimate, weather conditions must be considered, especially in the summer. Table 4 clearly indicates that increasing building height in the proposed scenario would cause increase in the LST, PPD and PMV, also decrease in the wind speed and specific humidity.

It is recommended that the height of buildings be taken into consideration during the planning and decision-making process for Tehran's development plan. A recent study conducted through field measurements and numerical modeling sheds light on the impact of building height and density on microclimate and land surface temperature (LST) in a local urban area. However, the study also revealed that if the proposed plan with taller buildings is implemented, it would lead to a significant increase in land surface temperature in the study area. This increase could have a negative impact on the microclimatic conditions and urban energy consumption balance.

To increase the height of building, this is suggested that the following actions be taken to prevent an increase in Land Surface Temperature:

Increase the distance between buildings for better air flow circulating

Increase vegetation and green space for more evapotranspiration

The use of materials with high albedo in building

The use of simulation analysis before implementation in detail plan

The conclusion of this research signifies the importance of height building in reducing excess heat and creating balanced microclimatic conditions in urban areas of Tehran.

Table 4. A Summarize of thermal comfort factors in two scenarios

Condition	Wind Speed (m/s)	Specific Humidity (g/kg)	PPD	PMV	LST
Existing Conditions	0.01-16.39	4.55-5.16	5-35.57%	(-1.21)-1.09	20.1-22.1 C°
Proposed Scenario	0.01-8.19	4.18-4.64	5-63.63%	(-0.83_-1.74	21.5-23.0 C°

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