

# Journal of Urban Management and Energy Sustainability (JUMES)

Homepage: <http://www.ijumes.com>



## CASE STUDY RESEARCH PAPER

### Investigation of the Physical Components and Indicators Responsive to Climate Change and Thermal Comfort with emphasis on hot-dry climate<sup>1</sup>

Arash Aghakarimi<sup>1</sup>, Seyed Abdolhadi Daneshpour<sup>2\*</sup> & Reza kheyroddin<sup>3</sup>

<sup>1</sup> Ph.D. Candidate, School of Architecture and Environmental Design. Iran University of Science & Technology- Tehran- Iran

<sup>2\*</sup> Professor, School of Architecture and Environmental Design. Iran University of Science & Technology- Tehran- Iran

<sup>3</sup> Associate Professor, School of Architecture and Environmental Design. Iran University of Science & Technology- Tehran- Iran

#### ARTICLE INFO

##### Article History:

Received 2024-03-15

Revised 2024-06-14

Accepted 2024-07-24

##### Keywords:

Building Density, construction type, Street pattern, Urban block, , Urban Fabric

#### ABSTRACT

Rapid urban expansion and industrialization have caused greenhouse gas (GHG) emissions and increased global temperatures. The continuation of global warming will not only cause many cities to depopulate but also cause a wave of mass migration. Since cities produce about 70 to 80 percent of greenhouse gases, they play a critical role in the formation and expansion of climate change, so it is necessary to review urban development plans, especially in the physical aspect, and responsive city plans according to the location of each city. The purpose of this research is to investigate and categorize the physical indicators affecting temperature changes in cities of hot and dry climates. The research methodology is practical in terms of purpose, and descriptive in terms of method, with quantitative and qualitative analysis. In this research, using remote-sensing software and literature analysis, physical indicators affecting climate comfort and climate change have been categorized and prioritized in four scales: city/neighborhood unit/block/building plot. To check the indicators with an emphasis on the urban block scale, five urban blocks with different physical characteristics were modeled and evaluated in Envi-met v5-4 software. The findings show that changes in the street pattern/orientation, Spatial arrangement of buildings, the pattern of distribution and vegetation density, and the height of buildings relate to creating climate comfort and reducing energy consumption. investigation of the physical indicators responsive to climate change and thermal comfort in other climates and spatial scales is suggested for future studies.

DOI: [10.22034/ijumes.2024.2024967.1204](https://doi.org/10.22034/ijumes.2024.2024967.1204)

Running Title: Physical Components and Indicators Responsive to Climate Change and Thermal Comfort



NUMBER OF REFERENCES

134



NUMBER OF FIGURES

08



NUMBER OF TABLES

07

\*Corresponding Author:

Email: [Daneshpour@iust.ac.ir](mailto:Daneshpour@iust.ac.ir)

Phone: +989121263374

ORCID: <https://orcid.org/0000-0003-2373-5985>

1. This article is based on the Ph.D. thesis of the first author. Second and third authors as the PhD thesis supervisors guide the whole project and also help by peer reviewing this article and give their comments to help with the errors.

## INTRODUCTION

After the Industrial Revolution, the consumption of fossil fuels reached its maximum; so the release of carbon dioxide (CO<sub>2</sub>) caused climate change. According to statistics, although cities cover about 3% of the earth's area, more than 50% of the world's population is living in cities and this amount will reach up to 80% by 2030. Cities use a large amount of energy resources, so more than 70% of carbon dioxide is emitted by cities. Therefore, the design of cities and urban districts responsive to climate comfort and climate change with an emphasis on reducing CO<sub>2</sub> emissions in various urban scales has been the focus of architects and urban planners.

Architects and urban planners have concentrated on the relationship between climate comfort, energy consumption, and urban block form since the 19th century. The relationship between buildings and their surroundings is an interdisciplinary challenge for urban designers, urban planners, and environmental designers (Sanaieian, et al., 2014) (Li, et al., 2023) (Herath, et al., 2024). Environmental designers were interested in the effect of urbanization on climate change, urban designers studied the impact of urban form on energy consumption, and thermal comfort in outdoor and urban environments also architects considered energy use and climate comfort mostly on the building scale.

From the 1970s, urban designers, and architects realized that to improve the thermal comfort of the urban environment, they should focus on the arrangement of groups of buildings or urban blocks rather than just focusing on buildings. They found that not only the thermal behavior of buildings change according to the interaction of spatial configuration, street pattern, density of buildings, and green spaces, but also one of the important aspects in planning urban blocks is the effect of its form on energy consumption and climatic comfort. In the meantime, there have been several studies focussing on urban blocks and neighborhoods.

The impact of urban form on the energy

performance of buildings and climate comfort is complex (Takebayashi & Yuan, 2024). According to Yamaguchi et al., effective urban design, planning, and strategic placement of buildings and energy-efficient equipment could potentially lead to a 60–90% reduction in current CO<sub>2</sub> emissions by the mid-21st century. (Zhu & Hu, 2023). The position of neighboring and building morphology directly influences the accessibility to solar radiation from indoor and outdoor environments.

Orientation (Xu, et al., 2024) and neighborhood patterns affect solar access, airflow patterns, and wind speed (Rodrigues, et al., 2023). In addition, the arrangement pattern of buildings within the site and the land use patterns strongly affect the outside air and the radiant temperature of the microclimate created by the urban blocks.

This paper reviews the literature on the effect and role of urban blocks on thermal comfort and climate change. It also specifies and refines the physical indicators affecting the climate change of cities in the four scales of city, neighborhood, urban block, and lot with more emphasis on the urban block scale. The method of refining indicators was content analysis and to determine the importance of these indicators, the AHP method was used with the participation of 15 experts on climate change. To validate the results of the AHP method five urban blocks with different physical features in hot climate were modeled in ENVI-MET, and the importance of the indicators was assessed.

### *Theoretical foundations*

Climate change and its effects have been seriously noticed by specialists since the 1970s and 1980s, and especially by politicians since the 1980s (Calthrope, 2016). Although many conferences are held with the presence of politicians from countries around the world regarding climate change, according to most researchers (Calthrope, 2016) (Bart, et al., 2022) (Kearl & Vogel, 2023) (Oliveira, 2016) (Stead, 2012) (Zhu & Hu, 2023) urban planners and knowledge of

urban studies can play a vital role in reducing the effects of climate change because cities have played the most crucial role in creating climate change (Calthrope, 2016).

Cities consist of the physical hierarchy of regions, districts, neighborhoods, urban blocks, and lots. Comprehensive planning in all these scales is necessary to respond to climate comfort and climate change to create livable cities (Aboagye & Sharifi, 2024). One of the most important scales in urban

design is the urban block, so many experts have highlighted its physical characteristics in creating climate comfort and its role in reducing the effects of climate change (Lin, et al., 2022) (Ma, et al., 2022) (Sanaieian, et al., 2014) (Lepänen, et al., 2024).

Considering the relationship between buildings and their outdoor environment in urban blocks, factors such as urban texture, shape, height of buildings, orientation and pattern of streets, materials, level of open spaces, and density of vegetation affect urban microclimate. Every urban element around it creates an artifi-

cial climate. The form of the city and its constituent elements can not only affect the quality of urban spaces but can also change the quality of the city's air. The analysis of diverse approaches regarding the study of urban blocks shows that there are various methods and aspects to investigate their characteristics. For example, many experts emphasize its physical (Lin, et al., 2023) (Sanaieian, et al., 2014) (Dhar & Khirfan, 2017) (Ajay, 2020), aesthetic (Fang, et al., 2024), historical (Ye, et al., 2024), and cultural (Liu, et al., 2024) aspects of studying the characteristics of an urban block.

Many theorists believe that urban planning is the design of the city form (Frey, 2003) (He, et al., 2020). Therefore, city form is one of the most vital urban planning tools, especially for designing optimal climate comfort in different urban scales and responding to climate changes. To investigate and evaluate the relationship between urban form, climate comfort, and climate change, many studies such as urban block ventilation (Li & Xie, 2024), urban network form and climate (Won & Chul, 2024), (Dhar & Khirfan,

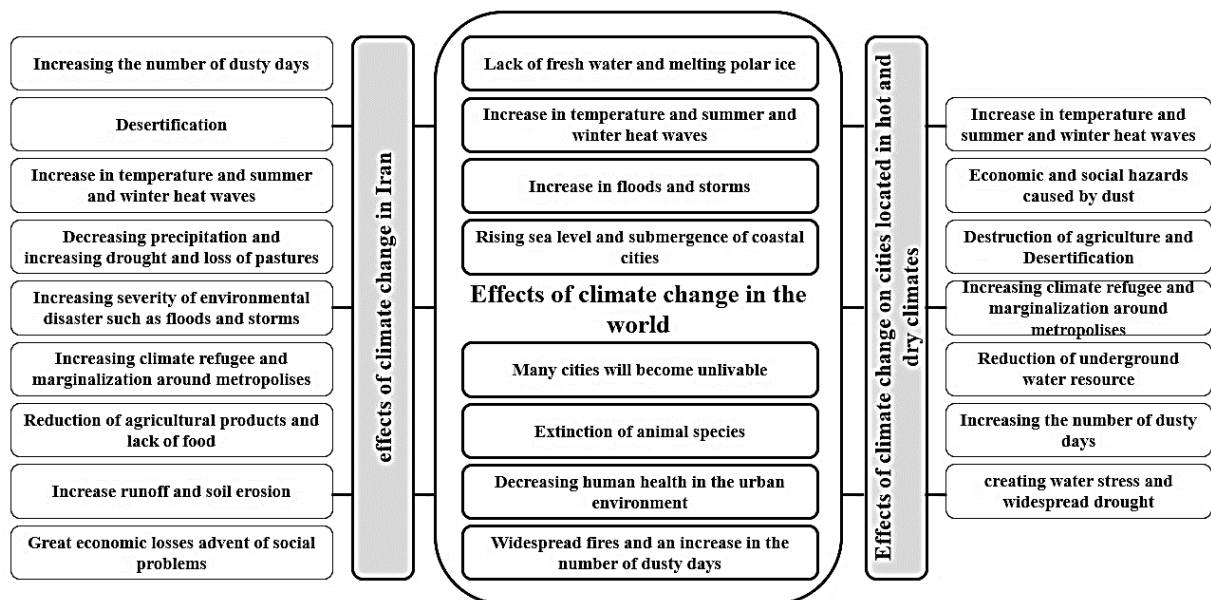


Fig 1: The effects and consequences of climate change in the world, Iran, and the cities on the edge of the Iranian desert (Authors)

2017), urban blocks and air pollution (Borna, et al., 2024), climate change and urban infrastructure (Ng, 2021), urban morphology and climate change (Privitera, et al., 2018) (Javanroodi, et al., 2023), green system and urban block (Hashem, et al., 2024), urban green infrastructure (Ramyar, et al., 2021), climate comfort and climate change (Kolokotsa, 2017), neighborhood units (Schlueter & Fonseca, 2015), urban block morphology and energy consumption (Geng, et al., 2024) have been conducted with an emphasis on the urban block form.

In addition to numerous studies in the field of reducing the effects of climate change, there have been developments in urban planning theories to address these effects. While some of these initiatives have a longer history, they have

adapted to new challenges. Table 2 provides an overview of the different perspectives and approaches to addressing climate change.

By reviewing theories and studies, it can be found that in the literature, there are two comprehensive responses to climate change: Mitigation and Adaptation strategies. Climate mitigation strategies emphasize reducing the causes of climate change, while climate adaptation refers to adapting to climate change in the future (Laukkonen, et al., 2009). Although mitigation strategies are mainly presented on a larger scale and adaptation strategies are often explained locally, a successful response to climate change involves the simultaneous application of mitigation and adaptation strategies in urban and regional scales.

Table 1: Investigating the influencing indicators on climate change and creating thermal comfort

Reserchers	Results	Practical Implications	indicators	Methods Used
(Wang & Su, 2022)	The paper analyzed the thermal comfort in cold coastal areas and tropical areas. The coupling relationship between outdoor environmental performance and building height was analyzed.	The paper analyzed the thermal comfort in cold coastal areas and tropical areas. The coupling relationship between outdoor environmental performance and building height was analyzed.	Vegetation density SVF Building Density Street Pattern Spatial arrangement of buildings	Field measurements and analysis of thermal comfort in different land categories and building types Subjective and objective analysis and model simulation of urban green infrastructure in Tianjin, China
(Khraiwesh & Genovese, 2023)	Maximize outdoor thermal comfort while reducing energy consumption. Propose an optimized urban block design for urban communities.	Negative correlation between canyon aspect ratio and urban block design performance. Recommendations for urban designers to consider design parameters in early stages.	Street Pattern Spatial arrangement of buildings Street Orientations	Positive correlation between canyon aspect ratio and environmental performance of urban block designs. North-south street canyons are more effective at enhancing microclimates.
( Sayad & Alkama, 2019)	Impact of vegetation and urban morphology on wind speed control. Study conducted in two spaces in Guelma, Algeria during winter.	Urban design can control wind speed for moderating microclimate. Vegetation and urban morphology impact microclimatic variations in winter.	Land use SVF Building Density Vegetation density	Study impact of vegetation and urban morphology on wind speed. Analyze microclimate behavior in spaces between buildings during cold season.
(Salvati & Cecere, 2015)	Urban morphology affects energy demand by modifying air temperatures and radiation. Warmer temperatures increase energy demand by 10% to 35%.	Urban morphology impacts energy demand and UHI intensity significantly. Neglecting urban morphology can lead to significant errors in energy calculations.	Land use Building Density	Parametric study on urban textures of Rome and Barcelona. Sensitivity analysis of building energy demand to outdoor conditions.

Reserchers	Results	Practical Implications	indicators	Methods Used
(Liu, et al., 2023)	Significant daytime UHI effects observed in central Beijing. UHI is correlated with 2D and 3D urban morphological indicators	Urban morphology optimization should focus on seasonality, spatial specificity, and indicator specificity for mitigating UHI. Tall trees may be more effective than other forms of vegetation at mitigating UHI in densely populated areas.	Street Pattern Vegetation density Street Orientations	Modeling urban morphological indicators in fine resolution. Using extreme gradient boosting (XGBoost) and Shapley additive explanations (SHAP)
(Qi, et al., 2023)	Building density and aspect ratio negatively correlated to UTCI. UTCI improved by increase in building density and aspect ratio.	Parametric-simulation framework. Observing the behavior of thermal comfort	SVF Building Density	Building density and aspect ratio affect thermal comfort. Street orientation is influenced by wind direction.
(Salman & Saleem, 2021)	The paper presents the state of the art on environmental benefits of UHI mitigation at the city scale level. The paper suggests that future studies should focus on design and planning characteristics to minimize the urban heat island effect.	The paper presents state-of-the-art research methods, concepts, procedures, and investigative tools. The paper suggests mitigation strategies such as green roofs, high albedo materials, and water bodies.	Vegetation density Building Density	Identifies mitigation strategies for reducing urban heat island effect. Suggests focusing on design and planning to minimize heat island levels

Table 2: Urban knowledge solutions to respond to climate change with emphasis on the urban block scale (Authors)

Approach	Response tool	Urban block	How to influence climate change
Blue urbanism	Blue and green belt, reforming the energy regime (fossil fuels), green roads along the coast, and blue and green roofs.	Vegetation density on Local scales Distribution of urban green pocket	Protection of water complications to prevent disasters
Low or no carbon city	Strengthening vegetation, using superior technologies to reduce carbon production, such as renewable energies	Application of bioclimatic architecture in local scale design Designing linear green corridors Densifying urban blocks and neighborhoods Walkable Neighborhoods	Sequestration of carbon emission, reduction of greenhouse gas production
Renewable energy city	Use of renewable energy such as solar energy, geothermal energy, wind, biomass, And others	The spatial arrangement form of the street based on the environmental perspective of the wind Urban blocks with green centers Walkable Neighborhoods	Reducing the production of greenhouse gases
Biophilic city	Adaptation and reduction strategies in energy supply sectors, construction, and urban development, planting trees and urban forests	green block construction designing various Types of Urban Blocks(-Formal) Green routes that stitch together urban blocks and neighborhoods	By reducing heating intensity, neutralizing carbon, and adapting to climate conditions.

Approach	Response tool	Urban block	How to influence climate change
New urban development	Connection and continuity, mixing of different uses, preservation, and strengthening of traditional structures, conventional urban fabric, public transportation and open and public spaces, optimal density, and observance of order in passages	Mixing of uses in all scales (from the urban block scale to the city) footpaths and walkable street design(Pedestrian-friendly street design) accessible public spaces Discernable center and edge for designing blocks and neighborhood	Reducing greenhouse gas emissions, reducing heat islands in cities
Smart growth	mixed land zoning, using high density, creating pedestrian-oriented communities, maintaining open spaces and agricultural lands, providing various transportation options, in-textual development, emphasizing public areas, Encouraging cluster development, encouraging development based on public transportation, protecting open and green spaces	Beautifying the streets with trees and green infrastructure in the city block Reuse existing infrastructure and buildings to take advantage of previous investment Encourage energy efficient buildings and mixed land use Encourage green roofs, parks, street trees, and other elements that can reduce ambient air temperatures and filter pollutants from stormwater runoff and the air Maximize density levels to create optional node activity footpaths and walkable street design(Pedestrian-friendly street design)	Reducing greenhouse gas emissions Reduction of heat islands in cities

Many physical factors such as permeability (Bart, et al., 2022) (Cui, et al., 2023), diversity of building density (He, et al., 2020), Land use mix (Zhu & Hu, 2023), Street connectivity (Cui, et al., 2023) (Jirón, et al., 2023), orientation of buildings and streets (Boeing, et al., 2024), and walkability (Aghakarimi & Bahrainy, 2016) (Boccalatte, et al., 2023) affect the response of urban blocks to climate changes and climate comfort. In a city with a grid-like street network and frequent intersec-

tions (i.e. small blocks), the distance between an origin and destination is shorter compared to a city with limited-access highways, cul-de-sacs, and large blocks. A street network with higher connectivity results in shorter trip lengths and reduces vehicular emissions. It also encourages walking and bicycling because of the reduced distances and the fact that walking and bicycling are safer and more pleasant on smaller, well-connected streets than on large highways.

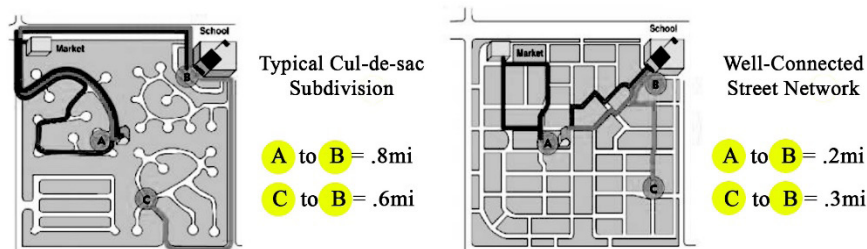


Figure 1: Greater street connectivity reduces trip lengths (Word bank, 2022)

In traditional urban configurations, the streets are typically well connected, as shown in Figure 2, compared to urban designs prioritizing automobiles. It's important to consider the proportion of intersections and the spatial density of intersections, which the number of intersections per square kilometer or the distance between intersections can measure. Pudong in Shanghai and new areas in Beijing have well-connected street networks, but they feature “superblocks” that are so large they negate the benefits of connectivity. Even if these superblocks were to have public pedestrian paths, they would still increase the distance that vehicles need to travel.

the urban heat island effect results in increased carbon emissions due to the need for additional energy for cooling. Urban geometry, i.e. the orientation of buildings and streets in urban blocks, can mitigate this effect by provid-

ing shade and allowing cooling breezes to flow. Wide streets (shallow street canyons) allow for better ventilation, while narrow streets (deep canyons) provide more shade (Li & Xie, 2024). Studies have shown that temperatures are higher in more open spaces, indicating that the cooling effect of increased shade is more significant than the impact of reduced wind (Khraiwesh & Genovese, 2023). More enclosed spaces are cooler during the day due to shade, but they are warmer at night when they release the heat absorbed during the day. Streets with an East-West orientation receive more prolonged exposure to the sun and, as a result, experience higher temperatures. Streets designed to allow breezes to flow can help lower temperatures. Ideally, streets should be positioned at a slight angle to the direction of the wind to prevent the formation of wind vortices that reduce wind speed.

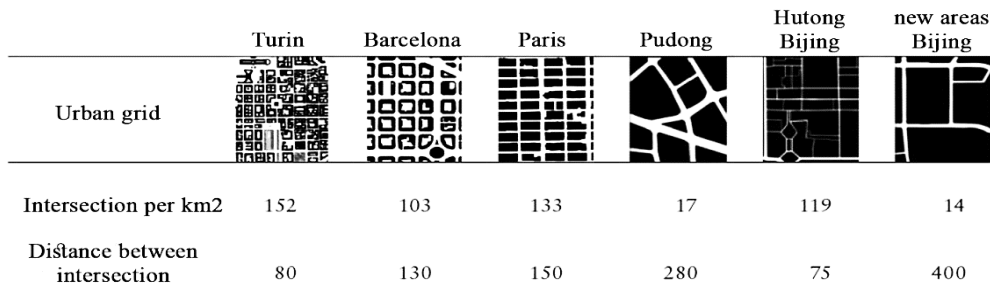


Figure 2: Traditional city blocks have more street connectivity than new blocks. These blocks are more walkable and, on the other hand, produce less carbon dioxide emission due to the reduction in the length of the vehicle route (World bank, 2022).

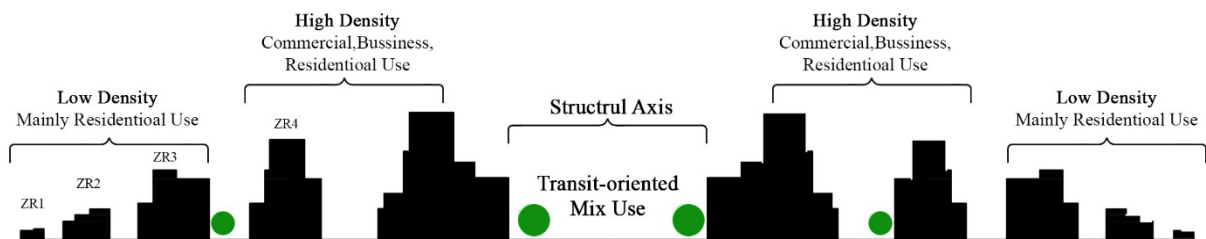


Figure 3: Hierarchical increase in building density from the block's edge to the city center (Leppänen, et al., 2024)

Increasing the density of urban blocks encourages walkability and reduces car trips and carbon dioxide emissions (Boeing, et al., 2024). It is important to gradually increase building density from the city block to the city center, as illustrated in Figure 3. Generally, semi-dense urban blocks supported by urban green spaces are more environmentally and socially responsive to climate change and contribute to better thermal comfort.

Frey (2003) believes the composite urban structure is the most responsive type of urban form. He admits that urban models with rigid geometry are less favorable, and multi-center networks with soft geometry are more profitable. After reviewing and analyzing 2439 reports from 2012-2021, Sun et al. (2022) determined that four indicators of land use, built environment, Street network, and development pattern have the most significant impact on the emission of greenhouse gases at the microclimate and urban scale.

Shen et al. (2022) believe fragmented and uncoordinated urban blocks will increase carbon emissions. Therefore, the responsive block has a compact urban fabric, central green space, and multi-center pattern. According to Sheng Shen et al(2022) the main factors that reduce carbon emissions in cities are compact development, reducing the area of building units, and developing green spaces. Caltrap (2016) acknowledges the compact green city, which is based on infill development, transportation-oriented development, mixed-use urban areas, Downsizing houses, human-scaled design, and strengthened public transportation, is a suitable model for responding to climate change.

Ruckert et al. (2014) admit that actions like using design for climate adaptation, compact city planning and development, mixed uses, using natural and artificial landscapes inside and outside the city, Development of a continuous and connected road network, connecting natural areas and Parks, as well as the use of smart and green infrastructure, can support a city responsive to climate change.

The form of urban blocks can play a crucial role in the response of cities to climate comfort and climate change because the combination of block forms first makes the form of neighborhoods and then the urban form.

The review of theories shows that blocks responsive to climate change have a medium-density (3-5 floors), dense urban fabric, and urban green areas, which are supported by the pedestrian network concept and sustainable transportation. In addition to showing the vital impact of cities on reducing the effects of climate change, the above discussions and principles emphasize the role of urban blocks in controlling and responding to the challenges of climate change in urban communities. In addition to showing the vital impact of cities on reducing the effects of climate change, the above discussions and principles emphasize the role of urban blocks in controlling and responding to the challenges of climate change in urban communities. It seems that cities can control or reduce climate change by understanding the effects of climate change, planning to deal with it, setting up a continuous urban monitoring system, increasing people's participation, and, Finally, envisioning future physical growth and development. Cities can manage climate change with various tools such as land use control, urban expansion prevention, green space development, smart infrastructure design, and pedestrian-oriented cities

## **MATERIALS AND METHODS**

---

### *Methodology*

In this research, the physical indicators affecting the reduction of the effects of climate change have been collected, and then the indicators have been categorized based on the spatial scales of the city(city and district/neighborhood/urban block/lot. Also, The indicators have been compared and prioritized in each of the scales by AHP.

Scientific databases were searched with the following keywords and their derivatives to find related study sources. The result was 1321 articles. authors selected studies meeting all three conditions below to find articles precisely related

to the topic. First, the most relevant studies contain all four words of urban block, urban morphology, climate change, and climate comfort or their derivatives. Second, those that mainly focus on climate change and urban block morphology. And finally, studies related to reducing the effects of climate change in cities. Based on this, 163 articles were selected as final studies.

Out of 163 papers, 46 were removed due to irrelevant content from other studies. Finally, 117 studies were left for the final analysis, from which frequent physical indicators affecting climate change and comfort were extracted.

After finding these indicators, the authors used the AHP method to categorize and rank them to determine the importance percentage of each indicator relative to the scale.

In the simulation part, the hottest hour on the hottest day of the past years in the period from 1969 to 2023 and the average summer temperature in five urban blocks with the following specifications (Figure 4) in ENVI-met software according to PMW indicators and PPD were simulated so that the physical indicators determined in theoretical studies could be investigated and refined.

Table 3: factors in searching and categorizing articles

Search title	Physical components and indicators affecting climate change	Keywords	Climate comfort,	The language of texts	English, Persian
Purpose	Extraction and stratification of physical indicators that reduce the effects of climate change with an emphasis on climate comfort and cities in hot and dry climates		Climate change	Database	Science Direct,
Question	Which physical indicators have the most impact on reducing the effects of climate change in the spatial levels of the city?		Mitigation and Adaptation,		Scopus, Web of Science
			Urban block	Publication date	Noormags, SID, Google scholar
			Morphology		<b>2000-2024</b>

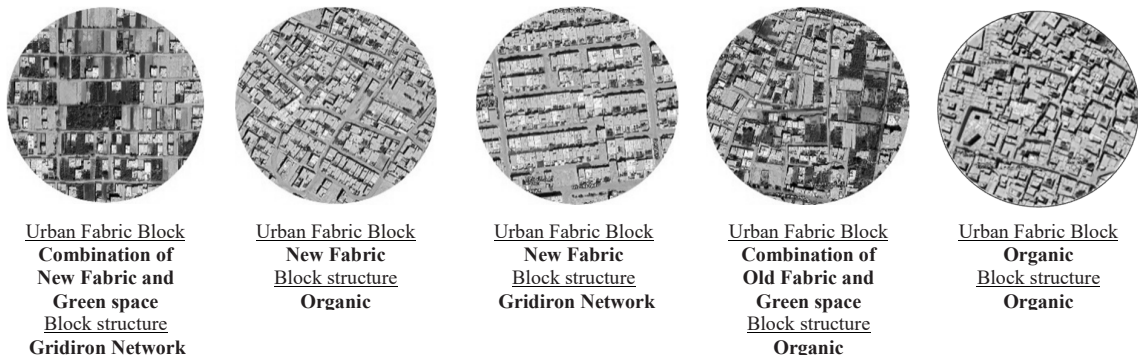


Figure 4: Urban urban fabric analyzed Mybod

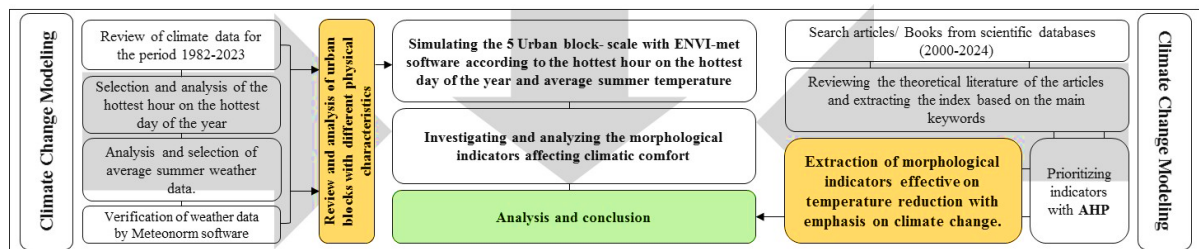


Figure 5: Research Process

### Case study

Maybod City is located in the north of Yazd province, and according to some evidence, this city is considered one of the first settled areas in the center of Iran. This city has a population of 99,226 people and is 7,000 years old. Maybod is located in the dry and desert region of Iran and has an organic and rich architecture. Despite the city's hot and dry climate, the per capita green space is somewhat suitable due to the use of the aqueduct system (Yazd governorate, 2022). The new urban fabric of Meibod was designed using modernist ideas in the form of a grid pattern. This design contrasts with traditional urban planning principles, the city's old architecture, and its historical and vernacular urban structure.

In Maybod, due to the decrease in rainfall, the increase in the consumption of factories, and the increase in the consequences of climate change, the amount of water storage in the city has decreased significantly. So, underground water reserves cannot supply urban potable water. Therefore, farmers migrate to cities due to the lack of water for agricultural purposes and its allocation to potable water. Desert cities in Iran will face harmful effects of climate change due to high heat and lack of water. Also, suppose the impact of climate change intensifies, in addition to their adverse social consequences, in the future, the migration of many people from cities like Maybod to other cities would happen (Khanian & Mohammadi, 2024).

### Estimated temperature

In this study, the temperature and precipitation data recorded by the Maybod Meteorological Department were used (Table 4). The time scale of

these data is daily, and the data is analyzed and reviewed in a 40-year statistical period from 1982 to 2023. Two criteria of data quality and location were taken into consideration in the selection of the Meteorological Department station.

The analysis of climate information in the studied period showed that the hottest day recorded in Maybod City from 1982 to the end of 2023 was 07/24/2022, and the most desirable hours were in the afternoon of the same day. The period is from 15:00 to 16:00 (49.95 to 52.46 °C) in the afternoon, and the average summer temperature in this city is 15.6 °C. This data shows the extreme temperature difference between day and night in desert cities.

The climate analysis of Maybod City from the past to the present shows that this city is warming up. Surveys show, that from 1982 to 2023, the temperature of Maybod City has become warmer on average by +0.7 degrees Celsius. According to new statistics on global warming and cities, 2023 was the warmest year in the 174-year observational record. (Fox, et al., 2024).

The climate analysis of Maybod City from the past to the present shows that this city is warming up. Surveys show, that from 1982 to 2023, the temperature of Maybod City has become warmer on average by +0.7 degrees Celsius. According to new statistics on global warming and cities, 2023 was the warmest year in the 174-year observational record. (Fox, et al., 2024)

Statistics show that the temperature of Meybood has increased by 0.7 degrees and the temperature of Iran by 1.8 degrees on average over the past 40 years (Statistical Centre of Iran, 2024)

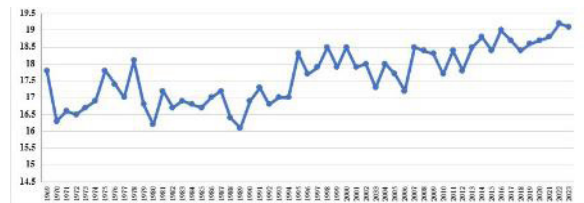


Figure 6: An overview of the 40-year trend of climate change in Iran (left) and Meybod (right)

*Simulation process*

This research simulated and analyzed five city blocks in 3D using ENVI-Met software. The simulation model includes the three-dimensional urban model and existing materials, including the building shell, soil type, and urban road network based on the weather information of the region.

The “intermediation” method was used to obtain climate data, and the data of meteorological stations in the surrounding area were used as the basis of climate data calculations. It should be noted that Meteororm software, which obtains weather data through intermediation, was used to obtain these data.

**DISCUSSION AND FINDINGS**

*Analysis of literature*

According to the review of the literature, various research has been conducted on the relationships between urban physical aspects and climate change at the scales of building, urban block, neighborhood, and district/city. However, most studies have been conducted on the relationship between urban physical aspects and climate change. It has been done on three scales: neighborhood, urban block, and city. Also, reviewing the literature, the most important and widely used spatial scales considered in analyzing urban form energy are the scale of the urban block and the neighborhood unit.

After reviewing the literature, 17 non-repetitive indicators were extracted. These indicators were categorized based on the four spatial levels of the city, district/neighborhood/city block, and building plot according to their reproducibility

in articles and experts’ opinions (Table 5). Analysis determines four physical indicators and the formal Pattern of urban blocks. These indicators include land use, design pattern and layout of building mass, street Pattern and orientation, and spatial continuity. Among these elements, the street pattern has a more significant role in determining the shape of the blocks. Since the shape of cities is created by the juxtaposition of buildings, blocks, and neighboring units, if the buildings and urban blocks are designed according to the principles of bio-environment and climate comfort, in the future, there will be cities with a better response to the threats of climate change.

As mentioned in Table 5, the indicators affecting climate comfort and climate change are examined according to each spatial level of the city.

The review and prioritization of indicators with the AHP method determined that street pattern/ orientation and spatial configuration have the most critical effect in terms of repeatability in articles and expert surveys to reduce the impact of climate change. At the neighborhood scale, Street Patterns, Orientations, and Construction type are the most critical indicators affecting climate comfort and minimizing the effects of climate change. At the scale of the urban block, Street Patterns and Orientations and Spatial arrangement of buildings are the most critical indicators. At the scale of the building lot, the shape and dimensions of the lot contribute the most to creating climate comfort and reducing the effects of climate change.

**Table 4:** Name and type of weather station available in Meybod

Organization	Station height(M)	Geographical attributes			Station
		latitude	Longitude	Station type	
Meteorological Organization	1110	32.230044	53.930766	synoptic station	Maybod

Table 5: Effective indicators to reduce the impact of climate change on various urban scales

City scales	Indicators	Reference
City/District-scale	Spatial configuration	(Gülten & Öztop, 2020); (Tavassoli, 2016); (Hurlimann & March, 2014); (Herath, et al., 2024); (Feng & Gauthier, 2021); (Calthrope, 2016); (Zanjani, et al., 2021)
	Street Orientations	(Deng, et al., 2012); (He, et al., 2020) (Xie, et al., 2020); (Peng, et al., 2020); (Vaccari, et al., 2013); (Ma, et al., 2022); (Tavassoli, 2016); (Boeing, et al., 2024); (Narimani, et al., 2022)
	Street Pattern	(Jirón, et al., 2023); (Georgakis & Santamouris, 2006); (He, et al., 2020); (Tavassoli, 2016); (Schwanen, 2019); (Aghakarimi & Bahrainy, 2016); (Cui, et al., 2023); (Boeing, et al., 2024)
	Vegetation density and Open space (public space)	(Wong, et al., 2024); (Cheng, et al., 2021); (Boeing, et al., 2024) (Yang, et al., 2019), (Badach, et al., 2020); (Nero, et al., 2017); (Privitera, et al., 2018); (Cheng, et al., 2023); (Simşek, et al., 2024); (Vaisi & Taheri, 2023); (Herath, et al., 2024)
Neighborhood /Community	ratio of the dimensions of the buildings	(Baglivo, et al., 2024); (Gülten & Öztop, 2020); (Tavassoli, 2016)
	Street pattern	(Yang, et al., 2019); (Badach, et al., 2020); (Boeing, et al., 2024); (Xu, et al., 2020); (Vaisi & Taheri, 2023); (Herath, et al., 2024)
	Vegetation density and Open space	(He, et al., 2020); (Vaisi & Taheri, 2023); (Herath, et al., 2024) (Schwanen, 2019);
	Street length	(Lin, et al., 2014); (Luo, et al., 2017); (Gülten & Öztop, 2020), (Peng, et al., 2020), (Boeing, et al., 2024)
	SVF (sky view factor)	(Tavassoli, 2016); (Lin, et al., 2022); (Fang, et al., 2021); (Curdes, 2013); (Xu, et al., 2020)
	Spatial continuity	(Tavassoli, 2016); (Narimani, et al., 2022)
Urban Block- scale	Construction type	(Kubota, et al., 2008); (Takebayashi & Yuan, 2024); (Baglivo, et al., 2024)
	Land use	(Luo, et al., 2017); (Wang, 2019); (Privitera, et al., 2018); (Hartman, 2017)
	Building Density	(Li, et al., 2023); (Panagiotou, et al., 2013); (Hang, et al., 2015); (Chen, et al., 2017); (Guo, et al., 2017); (Merlier, et al., 2017); (Kaseb, et al., 2020); (He, et al., 2020), (Fang, et al., 2021); (Peng, et al., 2020); (Privitera, et al., 2018); (Xu, et al., 2020); (Ma, et al., 2022); (Khakzand & Chahardoli, 2021)
	Spatial continuity	(Tavassoli, 2016); (Narimani, et al., 2022)
	Street length	(Lin, et al., 2014); (Luo, et al., 2017); (Gülten & Öztop, 2020), (Peng, et al., 2020); (Narimani, et al., 2022); (Boeing, et al., 2024); (Cui, et al., 2023); (Bagaei, et al., 2021)
	Street Pattern and Orientations	(Aghakarimi & Bahrainy, 2016); (Tavassoli, 2016); (Narimani, et al., 2022); (Jirón, et al., 2023)
	Enclosure	(Fang, et al., 2021); (Curdes, 2013); (Tavassoli, 2016); (Karkaj & Footami, 2022)
	The ratio of street dimensions	(Georgakis & Santamouris, 2006), (Yim, et al., 2009); (Martilli, 2014); (Narimani, et al., 2022)
	Spatial arrangement of buildings	(Zhou, et al., 2023); (Yang, et al., 2013); (Tavassoli, 2016)
	Land use	(Luo, et al., 2017); (Wang, 2019); (Privitera, et al., 2018); (Hartman, 2017)
Lot	Vegetation density	(Yang, et al., 2013), (Xu, et al., 2020), (Badach, et al., 2020), (Fang, et al., 2021); (Privitera, et al., 2018); (Vaccari, et al., 2013); (Xu, et al., 2020); (Tavassoli, 2016); (Schwanen, 2019); (Jamshidi, et al., 2023)
	The location of the lot in the block	(Zhou, et al., 2023); (Xiong, et al., 2023); (Rodrigues, et al., 2023)
	Lot land use	(Luo, et al., 2017); (Wang, 2019); (Privitera, et al., 2018); (Hartman, 2017)
	Shape of lot	(Zhou, 2023); (Scyphers, 2023) (Loeffler, et al., 2021)
	Dimensions of the lot	(Snaiki & Parida, 2023) (Boccalatte, et al., 2023)

Also, according to the investigations carried out at the spatial levels of the whole city, it was found that not only the indicators of Street pattern, Street orientation, Spatial configuration, spatial arrangement, and construction type have the most crucial role in determining the form of scales of three spatial levels (city, neighborhood, and block); but also, they have the most significant effect in reducing the impact of climate change and climate comfort in these scales. Also, the communication network and its sub-branches play an essential role in shaping the form and structure of cities (Frey , 2003) (Calthrope, 2016). They can have many positive effects on cities' response to climate change. For example, the appropriate proportions of a city street with vegetation along with its proper orientation towards the favorable wind can not only create natural ventilation of the city but also significantly reduce the adverse effects of heat islands.

*Simulation-based analysis*

Human thermal comfort conditions are known to be between 23 and 18 degrees Celsius (Cheung & Jim, 2019), so the analyses were made based on this temperature range. The study of

the maps (Table 6) shows that on the hottest day of Maybod, none of the five urban blocks had the necessary response to create comfortable climatic conditions, so the percentage of the PPD index shows 100% in all of them.

**Old urban fabric and organic structure:** the average temperature in summer is between 15.52 and 17.24 degrees, which shows that it is lower than the comfort temperature, which means the inside of the city is hotter than the outside (It is caused by the reduction of radiation on the building surface and the lack of penetration of cold wind at night). The maps show that compression, spatial confinement, and shading have caused the effects of heat to be reduced during the day, and the winding alleys prevent the penetration of hot winds during the day and cold winds during the night. subsequently, it can be said that in the city of Maybod, the air temperature is much higher than the human comfort level, and in some hours, the air is frigid, this temperature difference can be reduced to some extent with a better and more compact design. However, this does not mean that the conditions can be controlled so that the thermal comfort can be close to the ideal state at all hours.



Fig 7 : Prioritization of physical indicators by AHP

Table 6: Analysis and review of the simulated block in ENVI-met software

Block Urban Fabric Combination of New Fabric and Green space Block structure Gridiron Network	Block Urban Fabric New Fabric Block structure Organic	Block Urban Fabric New Fabric Block structure Gridiron Network	Block Urban Fabric Combination of Old Fabric and Green space Block structure Organic	Block Urban Fabric Organic Block structure Organic	Type/Title
					Site plan
					Hottest day of the year 2022/07/24
					PMW/ Hottest day of the years
					the average tempera- ture of the year(2022)
					PMW the average temper- ature
					PPD
0.68	0.56	0.67	0.61	0.53	SVF (average of 12 points)
grass- cement-asphalt	soil-cement-asphalt	cement-asphalt	soil-cement-asphalt	soil-cement-as- phalt-plaster of clay and straw	Material

**The old urban fabric with agricultural fields:** the examination of the conditions of this model on the hottest day also indicates that the temperature of the entire urban area is between 50.6 and 53.08 degrees Celsius and is hotter than comfort conditions. The presence and extent of farms in the old context have reduced the confinement and compression of the context; on the other hand, the creation of different accesses to these farms with relatively wide roads and dark materials such as asphalt has caused the temperature to rise in this area. On the other hand, parts of the city block with narrow alleys recorded the lowest temperature. In the places where there is more vegetation, shading and increasing air humidity have caused the temperature to be about 2 degrees cooler, and this means that if these two indicators are used, we can witness the improvement of climatic comfort conditions. As it is known, in this model, the average temperature of the environment was between 15.56 and 17.15 degrees. Specifically, in this climate, the more compact it is, the more cold wind penetration at low temperatures will decrease, and the amount of radiation on surfaces at high temperatures will improve the conditions.

**The new structure - new urban fabric:** The temperature investigation of the third model shows that this urban fabric has a higher average temperature in the urban network than textures one and two so that on the hottest day, the temperature in the entire texture is between 48.10 and 53.13. The density of building materials, the use of dark materials, facade construction with materials incompatible with the region's climate, and the low enclosure of the streets due to the blocks' distance from each other have caused the amount of ambient heat between the blocks to be high. In examining the average summer temperature, the environmental conditions governing the urban space are almost constant, and due to the significant distance between the blocks, there is a more negligible temperature difference between the different environments

of this texture and the temperature range of the entire environment was 15.06 to 17.12 degrees Celsius. In some places where there are streets, the temperature is slightly higher than in other areas, and this shows that in the new context, due to the openness between the blocks, it is not possible to have much effect on the ambient temperature of the city. The important point in this context is the Pattern and orientation of the streets towards the favorable wind so that the heat of the air is significantly reduced and moderated by the blowing of the winds.

If excessive heat shows up in the environment in the thermal comfort check using the PMV index, this means that at high temperatures, this Pattern cannot be considered a responsive fabric. However, if we study the values carefully, we can see that the amount of Thermal comfort in this model is better than the previous two models due to the orientation of the streets towards the favorable wind.

**The new context and agricultural fields:** by examining the images, it is clear that the temperature of our entire range is between 51.6 and 52.87 degrees, and an almost balanced temperature between the spaces is observed due to the absence of shading of buildings and the absence of compression in the context. The approximate temperature in the whole range will be between 52 and 52.36 degrees, which means that this texture will not affect the ambient temperature and practically cannot meet the needs of this area. Therefore, by examining the results, it can be concluded that it is not among the suitable models for the region. The PMV index of thermal comfort in this model shows that the effect of texture on people's thermal comfort is less, and in some places, the conditions have improved a little due to the sunlight on the environment. It can be said that this model will help improve the conditions when the air temperature is low in addition to the sunshine, but this is not possible in this region due to the hot and dry climate. The air temperature is low only in the middle of the night.

**Old structure-new urban factor:** According to the temperature survey of the area, it can be seen that the average temperature inside the construction area was between 51.18 degrees and, to some extent, 53.57 degrees due to the reduction of the distance between the buildings and the increase of the enclosure, these values are also dropped. The orientation of the streets, the enclosure, and the shading of some parts of this texture have made it about 5.5 cm cooler than the texture of the surrounding space.

If we look at the average summer temperature, it can be understood that tissue compression has been observed to some extent in this urban fabric. Still, due to low radiation, the temperature reaches 15.92 degrees in places with almost shade and the opportunity for wind to penetrate. It has been created, and in areas with more compression, this temperature is about 0.5 degrees higher, which shows that the effect of cold wind penetration has decreased.

According to the simulation, organic fabric with organic structure, new fabric with new structure, and new fabric with organic structure have received the highest points to respond to thermal comfort. It should be mentioned that the orientation of the streets in the unique texture with the new structure due to the alignment with the favorable wind was one of the essential reasons that caused the selection of this texture, so this shows the importance of the pattern index and street orientation.

The performed simulations show that each case study has characteristics that can be used to create urban fabric responsive to thermal comfort. The analysis of the urban fabric shows that the direction of the streets towards the favorable wind and its proportional width play a significant role in the natural ventilation of the environment and climatic comfort; on the other hand, compression creates confinement and shading in the texture. Urban areas support the achievement of climatic comfort. Developing and strengthening vegetation, in addition to shading, increases air humidity. The construc-

tion of winding alleys in the direction of adverse winds prevents the penetration of hot winds in summer and cold winds in winter and at night. Also, using dark and incongruous materials with the background in the walls causes concentration and intensification of heat in the urban fabric.

## **RESULT AND CONCLUSION**

Besides having a vital role in improving climatic comfort in the urban space, the extracted Physical indicators in this research can significantly reduce the adverse effects of climate change. At different spatial scales, various physical indicators can improve climatic comfort in the urban fabric and make it better equipped to deal with the adverse effects of climate change. The importance of indicators may be changed based on the differences in the climate. At the scale of the city, the Pattern of the street network is the most critical indicator for shaping the city form and, on the other hand, the most crucial indicator for reducing the effects of climate change and responding to cities. In addition to reducing traffic and the number of trips, the optimal design of the street network can increase the natural ventilation of the urban and mitigate the effects of heat islands by aligning it with the local climate.

Also, according to the investigations carried out in the spatial levels of the city, it was determined that not only the indicators of street pattern, street orientation, spatial configuration, and construction type play the most vital role in determining the form of scales of three spatial levels: City, neighborhood, and block, But also, play the most significant role in reducing the effects of climate change and climate comfort on these scales.

Table 6: Design principles based on modeling

The direction of the streets in case studies is related to the increase or decrease in temperature.	The design of the main streets in the direction of the prevailing wind brings the airflow into the block and causes natural ventilation. The streets oriented towards the prevailing wind, equipped with a network of green spaces, are the most responsive. Also, gridiron-road network streets seem to make air conditioning easier if they have enclosures.
The percentage of built-up area has a negative relation with the increase in temperature	Increasing the percentage of built-up area in the lack of vegetation, otherwise, through planting vegetation, eliminates the negative effect of open space. Designing compact urban blocks to create thermal comfort
The percentage of area covered by vegetation in the case studies has a negative relation with the increase in temperature	Small and scattered green spaces within the study areas are preferable to large green spaces for creating climate comfort.
The average building height has a negative relation with the increase in temperature	The average height of floors between 3 and 5 creates shading in the streets.
The percentage of vacant lots is related to the increase in temperature	Changing the use of vacant lots to plant vegetation in combination with trees

## REFERENCES

- Aboagye, P. D. & Sharifi, A., 2024. *Urban climate adaptation and mitigation action plans: A critical review. Renewable and Sustainable Energy Reviews, Volume 189, pp. 1-17.*
- Aghakarimi, A. & Bahrainy, h., 2016. *Formulation of design Criteria Based on Recognition and Comparison of User Patterns of Behavior, Emphasizing on the Role of Climate in UrbanPublic Spaces, Case Studies: Shahr-E- Kord and Bushehr. journal of environmental study, 42(1), pp. 151-168.*
- Ajay , G., 2020. *New Urbanism: Past, Present, and Future. Urban Planning, pp. 453-463.*
- Alijani, B., 2010. *Investigating climate changes in Yazd City in relation to urban and regional development. Research and Urban Planning Journal, Volume 3, pp. 35-42.*
- Anon., n.d. *Effects of street orientation and tree species thermal comfort within urban canyons in a hot, dry climate.*
- Badach, J., Voordeckers, D., Nyka, L. & Acker, M. V., 2020. *A framework for Air Quality Management Zones - Useful GIS-based tool for urban planning: Case studies in Antwerp and Gdańsk. Building and Environment.*
- Bagaei, M., Ziyari, Y., Zarabadi, S. S. & Majedi, H., 2021. *Evaluation of thermal comfort condition in urban morphology in approach to micro-climatic transformation in Tehran city. International Journal of Urban Management and Energy Sustainability, 2(2), pp. 43-53.*
- Baglivo, C., Albanese, M. P. & Congedo, M. P., 2024. *Relationship between shape and energy performance of buildings under long-term climate change. Journal of Building Engineering, Volume 84, pp. 2-18.*
- Balaban, O. et al., 2013. *Green economy and governance in cities: assessing good governance in key urban economic processes. Journal of Cleaner Production, pp. 138-152.*
- Bart, I., Bozzolan, E. & Shukla, R., 2022. *How climate change and unplanned urban sprawl bring more landslides. Nature, pp. 121-139.*
- Boccalatte, A., Fossa, M., Gaillard, L. & Menezo, C., 2023. *Microclimate and urban morphology effects on building energy demand in different European cite. Energy and Buildings.*
- Boeing, G., Pilgram, C. & Lu, Y., 2024. *Urban street network design and transport-related greenhouse gas. Transportation Research, Volume 127, pp. 1-11.*

- Boeing, G., Pilgram, C. & Lu, Y., 2024. Urban street network design and transport-related greenhouse gas emissions around the world. *Transportation Research Part D: Transport and Environment*, Volume 127, pp. 115-30.
- Borna, M., Giulia, T., Marchetti, M. & Phan, R. S., 2024. Evaluating the Influence of Urban Blocks on Air Pollution Concentration Levels: The Case Study of Golden Lane Estate in London. *Sustainability*, 16(2).
- Calthrope, P., 2016. *Urbanism in the Age of Climate Change*. Washington, DC: Island Press.
- Cheng, X. et al., 2023. Opposite climate impacts on urban green spaces' cooling efficiency around their coverage change thresholds in major African cities. *Sustainable Cities and Society*, Volume 88, pp. 1-14.
- Cheng, Y. et al., 2021. Climate change impacts and urban green space adaptation efforts: Evidence from U.S. municipal parks and recreation departments. *Urban Climate*, Volume 39, pp. 1-14.
- Chen, L. et al., 2017. The impacts of building height variations and building packing densities on flow adjustment and city breathability in idealized urban models. *Building and Environment*, pp. 344-361.
- Cheung, P. K. & Jim, C. Y., 2019. Improved assessment of outdoor thermal comfort: 1-hour acceptable temperature range. *Building and Environment*.
- Cui, P., Jiang, J., Zhang, J. & Wang, L., 2023. Effect of street design on UHI and energy consumption based on vegetation and street aspect ratio: Taking Harbin as an example. *Sustainable Cities and Society*.
- Curdes, G., 2013. Urban morphology and climate change. Which morphology can survive?. *Hamburg, ISUF*, pp. 35-49.
- D'Acci, L., 2019. A new type of cities for liveable futures. *Isobenefit Urbanism morphogenesis*. *Journal of Environmental Management*, pp. 128-140.
- Dasgupta, S. & Lall, S., 2022. <https://blogs.worldbank.org/>. [Online] Available at: <https://blogs.worldbank.org/sustainablecities/cutting-global-carbon-emissions-where-do-cities-stand>
- Deng, Q., Guangxing, H., Chan, L. & Weiwei, L., 2012. Urban Ventilation - A New Concept and Lumped Model. *International Journal of Ventilation*, pp. 131-140.
- Dhar, T. & Khirfan, L., 2017. A multi-scale and multi-dimensional framework for enhancing the resilience of urban form to climate change. *Urban Climate*.
- Dickert, C., 2023. *Wisevoter*. [Online] Available at: <https://wisevoter.com/> [Accessed 8 November 2023].
- Doherty, M., 2016. Climate change in the urban environment: Advancing, measuring and achieving resiliency. *Environmental Science & Policy*, pp. 310-313.
- Fang, Y. et al., 2021. Performance evaluation on multi-scenario urban ventilation corridors based on least cost path. *Journal of Urban Management*, pp. 3-15.
- Fang, Y. et al., 2024. Visual aesthetic quality assessment of the streetscape from the perspective of landscape-perception coupling. *Environmental Impact Assessment Review*, Volume 106, pp. 321-338.
- Feng, Q. & Gauthier, P., 2021. Untangling Urban Sprawl and Climate Change: A Review of the Literature on Physical Planning and Transportation Drivers. *Atmosphere*, Volume 12, pp. 2-19.
- Fox, K., Rohloff, K. & Jacobs, P., 2024. [/news-release/nasa-analysis-confirms-2023-as-warmest-year-on-record/](#). [Online].
- Frey, H., 2003. *Designing the City Towards a More Sustainable Urban Form*. 1 ed. Florida: Taylor & Francis.
- Fünfgeld, H., Fila, D. & Dahlmann, H., 2023. Upscaling climate change adaptation in small- and medium-sized municipalities: current barriers and future potentials. *Current Opinion in Environmental Sustainability*.
- Geng, X., Xie, D. & Gou, Z., 2024. Optimizing urban block morphologies for net-zero energy cities: Exploring photovoltaic potential and urban design. *Building Simulation*, Volume 17, pp. 607-624.

- Georgakis, C. & Santamouris, M., 2006. Experimental investigation of air flow and temperature distribution in deep urban canyons for natural ventilation purposes. *Energy and Buildings*, pp. 367-376.
- Grolleau, G. & Weber, C., 2023. The effect of inflation on CO2 emissions: An analysis over the period 1970–2020. *Ecological Economics*.
- Gülten, A. & Öztop, H., 2020. Analysis of the natural ventilation performance of residential areas considering different urban configurations in Elazığ, Turkey. *Urban Climate*.
- Guo, F., Zhu, P., Wang, S. & Duan, D., 2017. Improving Natural Ventilation Performance in a High-Density Urban District: A Building Morphology Method. *Procedia Engineering*, pp. 952-958.
- Hang, J. et al., 2015. City breathability in medium density urban-like geometries evaluated through the pollutant transport rate and the net escape velocity. *Building and Environment*, pp. 166-182.
- Hartman, T., 2017. *Property Rights and Climate Change: Land use under changing environmental conditions*. London: Routledge Complex Real Property Rights Series.
- Hashem, T., Elsharkawy, H. & Rashed, H. F., 2024. Urban Green Systems for Improving Pedestrian Thermal Comfort and Walkability in Future Climate Scenarios in London. *Buildings*, 14(3), pp. 1-18.
- He, B., Ding, L. & Prasad, D., 2020. Relationships among local-scale urban morphology, urban ventilation, urban heat island and outdoor thermal comfort under sea breeze influence. *Sustainable Cities and Society*, pp. 50-62.
- Herath, P., Bai, X., Jin, H. & Thatcher, M., 2024. Does the spatial configuration of urban parks matter in ameliorating extreme heat?. *Urban Climate*, Volume 53, pp. 1-15.
- Hurlimann, A. c. & March, A. p., 2014. The role of spatial planning in adapting to climate change. *Wires Climate Change*.
- Jabareen, Y., 2013. Planning the resilient city: Concepts and strategies for coping with climate change and environmental risk. *Cities*, pp. 220-229.
- Jamshidi, F., Ziari, Y., Zarabadi, Z. S. S. & Bahmanpour, H., 2023. Local model of urban green infrastructure in the direction of sustainability in the urban complex of Tehran city. *Journal of Urban Management and*, 4(4), pp. 125-141.
- Javanroodi, K., Perera, A., Hong, T. & Nik, V., 2023. Designing climate resilient energy systems in complex urban areas considering urban morphology: A technical review. *Advances in Applied Energy*.
- Jirón, L., Graw, K., Gangwisch, M. & Matzarakis, A., 2023. Influence of street configuration on human thermal comfort and benefits for climate-sensitive urban planning in Santiago de Chile. *Urban Climate*.
- Karkaj, E. & Footami, I., 2022. The importance of climate in determining the effect of rangeland enclosure on change some soil characteristics of rangelands. *Desert Ecosystem Engineering*, , 5(13), pp. 39-56.
- Kaseb, Z., Hafezi, M., Tahbaz, M. & Delfani, S., 2020. A framework for pedestrian-level wind conditions improvement in urban areas: CFD simulation and optimization. *Building and Environment*.
- Kearl, Z. & Vogel, J., 2023. Urban extreme heat, climate change, and saving lives: Lessons from Washington state. *Urban Climate*, pp. 1-19.
- Khakzand, M. & Chahardoli, S., 2021. Indoor thermal comfort and high residential buildings (Case study: two highrise buildings in two different microclimates in Tehran city). *Journal of Urban Management and Energy Sustainability*, 2(4), pp. 39-57.
- Khanian, M. & Mohammadi, S., 2024. Staying in Crisis: Choice or Coercion a Review of the Reasons of Rural-to-Urban Migrations Due to Environmental Changes in Iranian Villages. *Space and Culture*.
- Khraiwesh, M. & Genovese, P., 2023. Outdoor Thermal Comfort Integrated with Energy Consumption for Urban Block Design Optimization: A Study of the Hot-Summer Mediterranean City of Irbid, Jordan. *Sustainability*, 15(10), pp. 2-28.
- Kolokotsa, D., 2017. Smart cooling systems for the urban environment. Using renewable technologies to face the urban climate change. *Solar Energy*.

- Kosanic, A., Petzold, J., López, M. B. & Razanajatovo, M., 2022. An inclusive future: disabled populations in the context of climate and environmental change. *Current Opinion in Environmental Sustainability*, Volume 55.
- Kozlowsky, M. & My, Y., 2016. The role of urban planning and design in responding to climate change: the Brisbane experience. *International Journal of Climate Change Strategies and Management*, pp. 80-95.
- Kubota, T., Miura, M., Tominaga, Y. & Mochida, A., 2008. Wind tunnel tests on the relationship between building density and pedestrian-level wind velocity: Development of guidelines for realizing acceptable wind environment in residential neighborhoods. *Building and Environment*, pp. 1699-1708.
- Laukkonen, J. et al., 2009. Combining climate change adaptation and mitigation measures at the local level. *Habitat International*, pp. 287-292.
- Lee, G., Vine, K. & Atkinson, R., 2023. Impacts of Climate Change on Health and Health Services in Northern New South Wales, Australia: A Rapid Review. 20(13).
- Leppänen, P. K. et al., 2024. Impact of changing urban typologies on residential vegetation and its climate-effects – A case study from Helsinki, Finland. *Urban Forestry & Urban Greening*, Volume 96.
- Lin, L. et al., 2022. Developing practical techniques for rapid quantitative assessment of time-varying block-scale urban climate under varied landscape patterns. *Urban Climate*, pp. Volume 43, May 2022, 101-156.
- Lin, M. et al., 2023. Developing a CNN-based, block-scale oriented Local Climate Zone mapping approach: A case study in Guangzhou. *Building and Environment*, pp. 48-63.
- Lin, M. et al., 2014. Quantitative ventilation assessments of idealized urban canopy layers with various urban layouts and the same building packing density. *Building and Environment*, pp. 152-167.
- Li, T. & Xie, T., 2024. A New Method Based on Lattice Boltzmann Method and Unsupervised Clustering for Identification of Urban-Scale Ventilation Corridors. *Geo-information*, 13(6), pp. 183-198.
- Liu, B., Guo, X. & Jiang, J., 2023. How Urban Morphology Relates to the Urban Heat Island Effect: A Multi-Indicator Study. *Sustainability*, 15(14).
- Liu, J., Li, Y. & Yanhan, X., 2024. Impacts of Built Environment on Urban Vitality in Cultural Districts: A Case Study of Haikou and Suzhou. *Land*, 13(6).
- Li, Z., Quan, S. & Ju Yang, P. P., 2016. Energy performance simulation for planning a low carbon neighborhood urban district: A case study in the city of Macau. *Habitat International*, Volume 53, pp. 206-214.
- Li, Z., Zhao, Y., Xia, H. & Xie, S., 2023. A multi-objective optimization framework for building performance under climate change. *Journal of Building Engineering*, Volume 80, pp. 1-15.
- Loeffler, R., Österreicher, D. & Stoglehner, G., 2021. The energy implications of urban morphology from an urban planning perspective – A case study for a new urban development area in the city of Vienna. *Energy and Buildings*.
- Luo, Y., He, J. & Ni, Y., 2017. Analysis of urban ventilation potential using rule-based modeling. *Computers, Environment and Urban Systems*, pp. 13-22.
- Ma, D., Wang, Y., Zhou, D. & Zhu, Z., 2022. Cooling effect of the pocket park in the built-up block of a city: a case study in Xi'an, China. *Environmental Science and Pollution Research*, November. Volume 1.
- Maimaitiyiming, M. et al., 2014. Effects of green space spatial pattern on land surface temperature: Implications for sustainable urban planning and climate change adaptation. *ISPRS Journal of Photogrammetry and Remote Sensing*.
- Martilli, A., 2014. An idealized study of city structure, urban climate, energy consumption, and air quality. *Urban Climate*, 10(2), pp. 1-12.
- Merlier, L., Kuznik, F. & Rusaouën, G., 2017. Derivation of generic typologies for microscale urban airflow studies. *Sustainable Cities and Society*.
- Mosca, F., Canepa, M. & Perini, K., 2023. Strategies for adaptation to and mitigation of climate change: Key performance indicators to assess nature-based solutions performance. *Urban Climate*, pp. 1-14.

- Narimani, N., Karimi, A. & Brown, D. R., 2022. Effects of street orientation and tree species thermal comfort within urban canyons in a hot, dry climate. *Ecological Informatics*, Volume 69, pp. 1-14.
- Nero, F. B., Concha, C. D., Anning, A. & Denich, M., 2017. Urban Green Spaces Enhance Climate Change Mitigation in Cities of the Global South: The Case of Kumasi, Ghana. *Procedia Engineering*, Volume 198, pp. 69-83.
- Ng, W. S., 2021. Impact of Climate Change on Infrastructure. *Industry, Innovation and Infrastructure*, pp. 489-497.
- Oliveira, V., 2016. *Urban Morphology: An Introduction to the Study of the Urban Form of Cities*. s.l.:Springer.
- Panagiotou, I., Neophytou, M., Hamlyn, D. & Britter, R., 2013. City breathability as quantified by the exchange velocity and its spatial variation in real inhomogeneous urban geometries: An example from central London urban area. *Science of The Total Environment*, pp. 466-477.
- Peng, Y., Buccolieri, R., Gao, Z. & Ding, W., 2020. Indices employed for the assessment of "urban outdoor ventilation" - A review. *Atmospheric Environment*.
- Pouramin , F., Behzadfar , M. & Rezaeirad , H., 2019. The Quantitative Assessment of the Effects of the Morphology of Urban Texture on Urban Ambient Temperature Changes. *Urban and Regional Development Planning Journal*, Volume 11, pp. 157-189.
- Privitera, R. et al., 2018. Towards lower carbon cities: urban morphology contribution in climate change adaptation strategies. *European Planning Studies*, pp. 812-837.
- Qi, Y. et al., 2023. The Influence of Block Morphology on Urban Thermal Environment Analysis Based on a Feed-Forward Neural Network Model. *Building*, 13(2).
- Quan, S. et al., 2016. Urban Form and Building Energy Performance in Shanghai Neighborhoods. *Energy Procedia*, pp. 126-132.
- Ramyar, R., Ackerman, A. & Johnston, D., 2021. Adapting cities for climate change through urban green infrastructure planning. *Cities*.
- Ren, Q. & He, C., 2023. Impacts of global urban expansion on natural habitats undermine the 2050 vision for biodiversity. *Resources, Conservation and Recycling*, pp. 212-241.
- Rickwood, P., Gelazerook, G. & Glen, S., 2008. Urban Structure and Energy. *Urban Policy and Research*, 26(1), pp. 57-81.
- Rodrigues, E., Fereidani, N., Fernandes, M. & Gaspar, A., 2023. Climate change and ideal thermal transmittance of residential buildings in Iran. *Journal of Building Engineering*.
- Rückert, K. & Shahriari, E., 2014. *Guideline for sustainable, energy efficient architecture and construction*. 1 ed. Berlin: Universitätsverlag der TU Berlin.
- Salehi, A. & Hejazai, Z., 2019. Investigating the relationship between changes in urban morphology and the temperature of the earth's surface in order to manage the heat island. *Geography and Environmental sustainability Journal*, Volume 2, pp. 1-15.
- Salman , A. & Saleem, Y., 2021. The effect of Urban Heat Island mitigation strategies on outdoor human thermal comfort in the city of Baghdad. *Collection of Frontiers of Architectural Research*, 10(4), pp. 838-856.
- Salvati, A. & Cecere, C., 2015. Urban morphology and energy performance: the direct and indirect contribution in mediterranean climate. s.l., *Building Green Futures*, pp. 1-8.
- Sanaieian, H. et al., 2014. Review of the impact of urban block form on thermal performance,. *Renewable and Sustainable Energy Reviews*, Volume 38, pp. 552-560.
- Sayad, B. & Alkama, D., 2019. Study of the microclimate behavior in spaces between buildings: Which strategy to adopt during cold season in Guelma's public SPACES?. s.l., *AIP*, pp. 1-9.
- Schlueter, A. & Fonseca , J., 2015. Integrated model for characterization of spatiotemporal building energy consumption patterns in neighborhoods and city district. *Applied Energy*, pp. 247-265.
- Schwanen, T., 2019. Transport geography, climate change and space: opportunity for new thinking. *Journal of Transport Geography*.

- Scyphers, S., 2023. Residential Landscapes, Environmental Sustainability and Climate Change. Sustainable to Resilient Cities: Global Concerns and Urban Efforts.
- Sheng Shen, Y., Chen Lin, Y. & Cheah, W., 2022. Influences and pathways of urban form and lifestyle on carbon emission reduction. *Urban Climate*, pp. 100-118.
- Shen, P., Wang, M., Liu, J. & Ji, Y., 2023. Hourly air temperature projection in future urban area by coupling climate change and urban heat island effect. *Energy and Buildings*, Volume 279, pp. 1-15.
- Sim ek, Ç. K., Arabacı, D., Yücel, C. & Öztürk, B., 2024. Monitoring the climatic effects of street tree plantation in different urban patterns by synthetic image based BPNN simulations. *Building and Environment*, Volume 250, pp. 1-15.
- Snaiki, R. & Parida, S., 2023. Climate change effects on loss assessment and mitigation of residential buildings due to hurricane wind. *Journal of Building Engineering*.
- Somokanta, T., 2022. Urban climate change experiments in Gandhinagar, India. *Urban Climate*, pp. 101-129.
- Statistical Centre of Iran , 2024. <https://amar.org.ir>. [Online] Available at: <https://amar.org.ir/salnameh-amari> [Accessed 12 5 2024].
- Stead, D., 2012. Climate change, sustainability and urban policy: examining the validity and function of best practices. *Climate Change Governance*, pp. 243-258.
- Sun, C. et al., 2022. The Impacts of Urban Form on Carbon Emissions:A Comprehensive Review. *Land*, pp. 2-20.
- Takebayashi, H. & Yuan, J., 2024. *Urban Design Guidelines for Climate*. 1 ed. Basel: MDPI.
- Tavassoli, M., 2016. *Urban Structure in Hot Arid Environments*. s.l.:Springer.
- United Nations, 2019. *World Urbanization Prospects The 2018 Revision*, New York: United Nations.
- Vaccari, F. P., Gioli, B., Toscano, P. & Perrone, C., 2013. Carbon dioxide balance assessment of the city of Florence (Italy), and implications for urban planning. *Landscape and Urban Planning*, pp. 138-146.
- Vaisi, S. & Taheri, H., 2023. Developing the water-energy nexus performance of direct evaporative coolers in a hot and dry climate: Toward a green space cooling. *Water-Energy Nexus*, Volume 6, pp. 244-254.
- Waly, N. et al., 2023. Correlating the urban microclimate and energy demands in hot climate Contexts: A hybrid review. *Energy and Buildings*.
- Wang, B., 2019. *Urban Wind Energy Evaluation with Urban Morphology. Modeling, Simulation and Optimization of Wind Farms and Hybrid Systems*.
- Wang, Y. & Su, Y., 2022. Climate-Sensitive Urban Design for Thermal Comfort. In: *Digital Analysis of Urban Structure and Its Environment Implication*. s.l.:Springer Nature, pp. 207-262.
- Wong, G. et al., 2024. Visiting urban green space as a climate-change adaptation strategy: Exploring push factors in a push-pull framework. *Climate Risk Management*, Volume 43, pp. 1-14.
- Won, K. S. & Chul, J. J., 2024. Analysis of sustainable urban forms for climate change adaptation and mitigation. *Environmental and Sustainability Indicators*.
- Word bank, 2022. *Primer on Urban Form and Greenhouse Gas Emissions*, New York: Word bank.
- World Bank, 2023. <https://www.worldbank.org/en/topic/urbandevelopment/overview>. [Online].
- Xie, P. et al., 2020. A New method of simulating urban ventilation corridors using circuit theory. *Sustainable Cities and Society*.
- Xiong, J. et al., 2023. Predicting the response of heating and cooling demands of residential buildings with various thermal performances in China to climate change. *Energy*.
- Xu, F., Tian, D. & Zhang, J., 2024. The effects of cool materials, façade orientation, and morphological parameters on energy consumption at the residential neighborhood scale. *Building Simulation*, Volume 17, pp. 525-542.
- Xu, H. et al., 2020. Research on the relationship between urban morphology and air temperature based on mobile measurement: A case study in Wuhan, China. *Urban Climate*.

- Yang, F., Qian, F. & Lau, S., 2013. Urban form and density as indicators for summertime outdoor ventilation potential: A case study on high-rise housing in Shanghai. *Building and Environment*, pp. 122-137.
- Yang, J. et al., 2019. Local climate zone ventilation and urban land surface temperatures: Towards a performance-based and wind-sensitive planning proposal in megacities. *Sustainable Cities and Society*.
- Yazd governorate, 2022. <https://meybod.gov.ir/>. [Online] [Accessed 12 4 2022].
- Ye, J., Shumin, L., Youcheng, C. & Chen, L., 2024. A Study of the Effects of Historical Block Context on Soundscape Perception. *buildings*, 14(13).
- Yim, S., Fung, J., Lau, A. & Kot, S., 2009. Air ventilation impacts of the “wall effect” resulting from the alignment of high-rise buildings. *Atmospheric Environment*, pp. 4982-4994.
- You, Y. & Kim, S., 2023. Revealing the mechanism of urban morphology affecting residential energy efficiency in Seoul, Korea. *Sustainable Cities and Society*.
- Zanjani, N. E., Ziyari, Y. A., Zarabadi, Z. S. & Sabbaghi, H. R., 2021. Comparative Study of Energy Role in Urban Morphology with an Emphasis on the Formation of Spatial Structure (Case Studies: Tehran and Berlin). *International Journal of Urban Management and Energy Sustainability*, 2(3), pp. 45-53.
- Zhou, K., Wang, S. & Feng, Y., 2023. How Is Spatial Planning Adapting to Climate Change? A Textual Analysis Based on the Territorial and Spatial Plans of 368 Chinese Cities. *Land*, Volume 12, pp. 1-15.
- Zhou, Y., 2023. Climate change adaptation with energy resilience in energy districts—A state-of-the-art review. *Energy and Buildings*.
- Zhu, Y. & Hu, Y., 2023. The Correlation between Urban Form and Carbon Emissions: A Bibliometric and Literature Review. *sustainability*, 15(18), pp. 3-28.
- Zou, Y. et al., 2023. Comprehensive analysis on the energy resilience performance of urban residential sector in hot-humid area of China under climate change. *Sustainable Cities and Society*.

**COPYRIGHTS**

©2023 The author(s). This is an open access article distributed under the terms of the Creative Commons Attribution (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, as long as the original authors and source are cited. No permission is required from the authors or the publishers.



**HOW TO CITE THIS ARTICLE**

Aghakarimi, A., Daneshpour, S. A., & kheyroddin, R. (2024). Investigation of the Physical Components and Indicators Responsive to Climate Change and Thermal Comfort with emphasis on hot-dry climate. *International Journal of Urban Management and Energy Sustainability*, (), -. DOI: [10.22034/ijumes.2024.2024967.1204](https://doi.org/10.22034/ijumes.2024.2024967.1204)

