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Floor Area Ratio (FAR) and thermal environment: An Integrative Review

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Abstract: This review paper addresses a significant knowledge gap in the study of Floor Area Ratio (FAR) and its influence on urban thermal environments in Egypt. Recent policy changes have facilitated increased building heights through the application of FAR, prompting concerns regarding its environmental implications. To investigate the relationship between FAR, building height, and thermal comfort, a deductive approach was employed to analyze existing literature. Key factors influencing thermal comfort and their potential interactions with FAR were identified and analyzed. A review of existing literature reveals two primary approaches to studying the relationship between FAR and thermal performance:**1- Varying FAR Configurations:** This approach investigates the impact of different FAR configurations on thermal outcomes.**2- Fixed FAR and Building Height:** This approach explores the influence of building height or Building Coverage Ratio (BCR) while maintaining a constant FAR. Understanding the intricate interplay between these factors is crucial for effective urban planning and design. By optimizing urban design strategies, it is possible to enhance outdoor thermal comfort and create sustainable urban environments.

Keywords: Floor area ratio (**FAR**), Building coverage ratio (**BCR**), thermal comfort.

1. Introduction

Sustainable urban development has evolved from a welfare objective to a critical imperative for mitigating climate change risks. Urban open spaces play a critical role in promoting human health, physical well-being, environmental sustainability, and economic prosperity [1, 2]. Consequently, enhancing the thermal comfort of these spaces emerges as a key goal in urban planning and design. Improving outdoor thermal environments offers significant energy-saving potential. By reducing urban temperatures, cooling loads within buildings can be decreased [3]. Additionally, as individuals spend more time in thermally comfortable outdoor spaces, reliance on air conditioning and other energy-intensive equipment may reduce [4].

Urban policies and building codes can effectively shape urban development and direct urban form. While early regulations focused on deregulated urban environments characterized by high density, compactness, and low-rise buildings, contemporary trends have shifted towards new settlement models emphasizing lower density and reduced building heights. In response, urban policies have increasingly embraced Floor Area Ratio (FAR) [5]. as a tool for managing building heights and densities. The implementation of FAR has facilitated the development of high-rise buildings, although public concerns regarding its potential negative impacts persist. This research aims to theoretically investigate the feasibility and implications of employing FAR in thermal comfort within urban environments.

1.1 Research Problem:

The recent decision by the New Urban Communities Authority to implement Floor Area Ratio regulations for new settlements in Egypt underscores a critical knowledge gap. While FAR offers flexibility in urban design, its implications for the urban thermal environment in the Egyptian context remain largely unexplored, therefore, the research poses a crucial question: **Does FAR affect the urban thermal environment, and if so, to what extent and through which specific factors?**

1.2 Research Aim:

This research aims to conduct a comprehensive review and analysis of existing literature to elucidate the relationship between Floor Area Ratio and the urban thermal environment.

1.3 Research Method:

This review adopts a deductive approach to analyzing existing literature on the relationship between FAR and thermal comfort at the urban scale. The analysis focuses on identifying key factors influencing thermal comfort and their potential interactions with FAR, as explored in existing studies, Papers were selected based on their relevance to the Egyptian climate, with an emphasis on covering all thermal comfort parameters.

2. Historical Evolution of Building Height Regulations in Egypt

Early Egyptian construction regulations established a general limit for building heights, typically restricting them to 1.5 times the road width, with a maximum of 36 meters

[6]. However, subsequent legislation introduced exceptions to this rule, allowing for higher buildings in certain circumstances. Law No. 656 of 1954 **[7]** granted the Minister of Rural Affairs the authority to approve exceptions to height restrictions in specific areas. The allowable building height was linked to the width of the road and the floor area ratio (FAR), with higher FAR values permitted for higher buildings. Law No. 45 of 1962 **[8]** further expanded exceptions for building heights, allowing for deviations in certain areas. Law No. 106 of 1976 **[9]** provided additional flexibility, permitting buildings to exceed the 1.5 times road width limit for nationally significant projects. However, such exemptions required the payment of a land value surcharge.

The Unified Building Law of 2008 **[10]** integrated urban planning and building regulations, establishing a framework for determining building heights within the context of city-specific strategic plans. This approach recognized the interconnectedness of urban planning and building design at various scales.

Recent developments in Egypt have witnessed the adoption of Floor Area Ratio (FAR) regulations in several urban projects. Notable examples include the Northwest Coast project, where FAR was set at 0.6 [**11**]. Additionally, the partnership between the New Urban Communities Authority, Palm Hills Development Company, and Palm Urban Development Company in October Gardens City permitted the application of FAR within residential areas, subject to existing and future military restrictions [**12**]. Furthermore, the Southern Investors Area in New Cairo City, allocated to Makani for Investment and Real Estate Development, has embraced FAR for residential development [**13**]. These initiatives demonstrate a growing trend towards the utilization of FAR in contemporary urban planning.

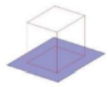
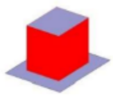
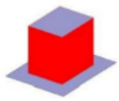
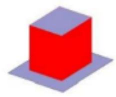
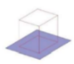
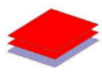
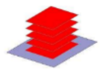
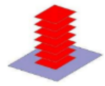
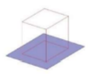
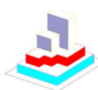
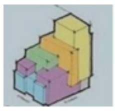
Floor Area Ratio (FAR), also known as Floor Space Ratio (FSR), Floor Space Index (FSI), or site ratio, represents the ratio of total gross floor area to the plot area. FAR limits urban density while indirectly regulating building occupancy without specifying structural constraints **[14].**

Size Theory [15] Introduced in 1954; size theory offers a framework for relating FAR to building height. Key principles include:

- Inverse relationship between FAR and building height: As FAR increases, building height tends to decrease.
- Conversion of FAR to metric cubes: FAR can be converted into volumetric units to assess building size without regard for shape or height restrictions.

These principles provide valuable guidance for urban planners and developers in balancing land use intensity with building dimensions.

Table 1 different between footprint, floor area ratio, and size rule for the same building height [16].

	Main size	Different forms for the same building		
First way Footprint with height				
	Building according to population density	Footprint and height	Same building shape	
second way Floor area ratio				
	Building according to population density	Floor area ratio	Different FAR with same population density	
Third way Size law according to Law No. 656 of 1954				
	Building according to population density	Building cubes 21 like the surface plot.	Same size with same population density and different shape.	

3. FAR and urban thermal environment

Historically, FAR regulations were implemented to mitigate the negative impacts of tall buildings on natural lighting and ventilation in urban areas. Jung et al. [**17**] studied the influence of FAR variations on microclimate and particulate matter within urban street canyons. A case study focusing on densely populated commercial areas in Seoul revealed a positive correlation between FAR and wind speed. Additionally, ambient temperature, mean radiant temperature, surface temperature, and various particulate matter indicators demonstrated negative correlations with FAR. These findings highlight the complex interplay between urban form, microclimate, and air quality.

While Dawodu et al [**18**] explored the link between urban form, energy consumption, and varying Floor Area Ratios in Ningbo, China. The study revealed a correlation between FAR, energy production, and consumption. Higher FAR values generally facilitated increased solar radiation gain, leading to higher energy production. However, the effectiveness of solar energy systems, such as solar facades, could be compromised in low-rise developments.

Also, Dwiputra et al **[19]** investigated the impact of urban block typology and building intensity on environmental performance within a hot-humid, high-density urban context. Employing ENVI-Met software, the study analyzed the influence of Building Coverage Ratio (BCR) and Floor Area Ratio (FAR) on microclimatic parameters. Results indicated a negative correlation between BCR and both relative humidity and wind speed. Conversely, FAR demonstrated a positive relationship with relative humidity while negatively influencing air temperature and solar radiation. These findings highlight the more pronounced impact of FAR on microclimatic parameters compared to BCR.

Salameh et al. [**20]** examined the influence of building height variations on urban layout and canyon environments within the hot arid climate of the United Arab Emirates. Employing ENVI-met software, the study found that strategically placing the tallest buildings in the direction of prevailing hot winds can mitigate urban heat island (UHI) effects. Additionally, reducing Sky View Factor (SVF) through increased shading and optimizing height-to-width (H/W) ratios for streets can further enhance thermal performance. These findings underscore the importance of urban design strategies in mitigating UHI and improving thermal comfort in hot arid regions.

And Widiyannita et al. **[21]** evaluated the influence of urban density, as characterized by Building Coverage Ratio (BCR) and Floor Area Ratio (FAR), on microclimatic factors within urban environments. Employing ENVI-Met 3.1, the study analyzed the impact of these variables on air temperature (Ta), mean radiant temperature (Tmrt), and relative humidity (RH). Results indicated a correlation between Tmrt and Ta under constant FAR conditions. Additionally, a negative relationship was observed between SVF and FAR when BCR was held constant. The study further revealed that increasing FAR led to decreased Ta and Tmrt, particularly when BCR remained unchanged. This effect was attributed to the increased building height and floor numbers associated with higher FAR values, which resulted in reduced SVF and enhanced shading. Furthermore, the study demonstrated a positive correlation between BCR and Tmrt while maintaining a constant FAR. Reduced building heights facilitated increased solar radiation penetration, leading to higher Ta and RH levels. Overall, these findings emphasize the complex interplay between urban density, building form, and microclimatic conditions.

Li et al. **[22]** studied the correlation between Floor Area Ratio (FAR) and wind speed within residential districts in China. The study found a negative relationship between FAR and wind speed ratio (WSR), indicating that higher FAR values are associated with reduced wind speeds and potentially compromised outdoor ventilation within residential areas and Nakarmi et al. **[23]** investigated the relationship between Floor Area Ratio (FAR) and energy consumption (heating and cooling) in Kathmandu, Nepal. The study analyzed three urban configurations with varying FAR values (1.75, 2.5, and 3.5). Results indicated a correlation between FAR, energy production, and consumption. Higher FAR values facilitated increased solar radiation gain, leading to higher energy production. The study concluded that FAR 2.5 represents an optimal balance between energy consumption and production, suggesting its potential as a valuable tool for urban planning and energy management.

While Li et al. **[24]** investigated the impact of building height, building density, and floor area ratio on indoor air temperatures in Singapore. Employing ENVI-met simulations, the study analyzed 18 scenarios to assess these relationships. Results indicated that building density exerted the most significant influence on indoor temperature, with a 4.7°C decrease observed for a rise in building density from 0.0625 to 0.766. While building height demonstrated a less pronounced impact, a 1.7°C drop in indoor temperature was associated with an increase in building height from 12 to 72 meters. The influence of floor area ratio on indoor air temperature was found to be more complex, with a combination of building density and height variations influencing the overall thermal performance.

And Chen et al. **[25]** employed ENVI-met software to investigate the influence of building geometry on surface temperatures within an urban environment. The study analyzed the impact of building density (λp), height (H), and Floor Area Ratio (FAR) on surface temperatures of various urban components. Results indicated that increased building density and height generally contributed to lower surface temperatures. However, the combination of a building density of 0.36 and a height of 10 meters, with a fixed FAR of 1.5, resulted in the highest surface temperatures across all components. The study further revealed that building height exerts a more dominant influence on surface temperature in denser urban environments, while building density becomes increasingly important in reducing heat loss in lower-density settings.

Bagaei et al. **[26]** evaluated the relationship between Sky View Factor (SVF) and urban form, as characterized by Building Surface Coverage (BSC) and Floor Area Ratio (FAR). Employing ENVI-met analytical software, the study demonstrated a negative correlation between SVF and BSC under constant FAR conditions. Conversely, SVF increased with rising FAR for a fixed BSC. Furthermore, the study revealed a strong association between enclosed temperature, average radiation temperature, and urban morphological parameters. These findings underscore the significance of BSC in mitigating urban heat island intensity and enhancing thermal comfort during summer nights, with a BSC of 25% emerging as an optimal configuration.

Shareef and Abu-Hijleh **[27]** explored strategies for enhancing shading within urban blocks in Dubai, focusing on variations in block orientation and building height. Utilizing ENVI-Met 4.1 software, the study compared alternative urban configurations. Results indicated that linear north-south and northwest-southeast orientations with a height-to-width ratio (H/W) of 2.5 exhibited optimal thermal performance, highlighting the significant influence of building geometry on thermal comfort within this climatic context.

Q. Li et al **[28]** studied effects of gross building coverage ratio, floor area ratio (FAR) and first floor overhead ratio on outdoor thermal environment by using CFD analysis in Guangzhou, China. the study conducted that wind speed decreases as the gross building coverage ratio rises from 10% to 70%, air temperature rises initially before falling, and relative humidity falls initially before rising when the gross building coverage ratio exceeds 40%. However, pedestrian-level thermal comfort around buildings is decreasing gradually, and this trend is seen when the gross building coverage ratio rises above 40%. When the building coverage ratio is fixed and floor area ratio increases from 0.8 to 7.6, all the buildings' height increases from 7.5m to 60m, wind velocity increases at first then decreases when the floor area ratio is over 5.6 and average building height is over 45m, the air temperature decreases and the relative humidity increases, but the pedestrian-level thermal comfort improves at first, then becomes worse, it arrives at the optimum when the floor area ratio is 5.6 and average building height is 45m.

And Adly et al. **[29]** studied the influence of densification parameters, including BCR, FAR, building height variation, and orientation, on Physiological Equivalent Temperature (PET) within New October City, Egypt. Employing ENVI-Met software to simulate 36 scenarios, the study revealed that optimizing density and building heights, particularly in diagonal orientations, could significantly improve average PET (08:00 to 18:00) by up to 8°C in mid-range densities. However, orientation was found to be less influential in low-density settings. Among the tested parameters, densification emerged as the most effective strategy for mitigating thermal stress.

Also, Abd Elraouf et al. **[30]** investigated the impact of urban geometry on thermal comfort in the hot-humid climate of Port Said, Egypt. The study employed ENVI-met and RayMan software to simulate and assess various urban configurations, considering factors such as street orientation, aspect ratio (H/W), and building typology and conducted that Higher aspect ratios (H/W = 2.5) generally lead to improved thermal comfort compared to lower aspect ratios, Tmrt is the most influential parameter affecting outdoor thermal comfort during daytime hours. Lower Tmrt values, achieved through increased shading and reduced solar radiation exposure, contribute to better thermal conditions, Higher H/W ratios, favorable street orientations (north-south and northwest-southeast), and linear building typologies can enhance wind flow and ventilation, leading to improved thermal comfort. Overall, the study emphasizes the significant impact of urban geometry on thermal comfort in hot-humid climates. By optimizing aspect ratio, street orientation, and building typology, it is possible to create more thermally comfortable urban environments.

And Tian and Xu **[31]** investigated the influence of quantifiable urban morphology characteristics on the solar potential of residential blocks in Wuhan, China. Using software tools like Rhinoceros and Grasshopper (Ladybug & Honeybee), they evaluated 36 randomly chosen blocks across 9 different residential block types. Their findings revealed that Floor Area Ratio (FAR), building density, and average building height are the most significant factors impacting the solar potential of residential blocks. Notably, the correlation between FAR and the overall solar potential of a block was found to be as high as 75%. This suggests that urban design decisions, particularly those affecting FAR, building density, and building height, can significantly influence the amount of sunlight reaching residential areas.

Shi et al. **[32]** proposed a novel parametric method to investigate the relationship between solar energy utilization and urban design by analyzing various block typologies. These typologies incorporated diverse combinations of block dimensions, building patterns, floor area ratio, and site coverage. The study applied this methodology to a case study of high-density neighborhoods in Singapore, developing eighteen distinct block typologies using the Urban Block Generator tool within the Grasshopper/Rhinoceros platform. The research findings revealed that block dimensions, building patterns, and building density all influence on-site solar energy utilization. However, the impact of floor area ratio was found to be the most significant, followed by site coverage and building pattern. These insights highlight the importance of considering these urban design factors when aiming to optimize solar energy potential in high-density urban environments.

Abdelhafez et al. **[33]** investigated the impact of aspect ratios and street canyon orientations on thermal comfort in two distinct climatic regions of Egypt: the coastal city of Alexandria (North Coast) and the arid city of Aswan (Southern Egypt). Using ENVI-met and RayMan software, various aspect ratio and street canyon orientation scenarios were simulated. The findings indicate that an aspect ratio of 2.5 consistently yielded the most favorable thermal conditions across all scenarios in both cities. Conversely, an aspect ratio of 1 resulted in the least comfortable conditions. While the Northeast-Southwest Street canyon in Aswan exhibited the highest Physiological Equivalent Temperature (PET) values, it also offered the fewest uncomfortable thermal hours. In contrast, the North-South Street canyon in Alexandria demonstrated the best overall thermal performance, followed by the Northwest-Southeast orientation. Overall, the study concludes that carefully selecting aspect ratio and street orientation can significantly enhance pedestrian thermal comfort in both coastal and arid regions of Egypt.

Abdulsalam et al. **[34]** aimed to investigate the impact of aspect ratio on outdoor thermal comfort within urban spaces. Using ENVI-met numerical simulations, a series of scenarios with varying aspect ratios were examined in the main entrance space of the British University in Egypt (BUE) campus in Cairo. The results indicate that an aspect ratio of H/W = 3 can be considered a starting point for achieving optimal outdoor thermal comfort.

4. Discussion

Outdoor thermal comfort is influenced by a complex interplay of environmental parameters and urban design elements. Floor Area Ratio (FAR), derived from the product of Building Coverage Ratio (BCR) and building height, plays a significant role in shaping urban environments. Variations in building density, aspect ratio, and other urban geometry parameters can further influence thermal comfort. Understanding the intricate relationships among these factors is crucial for optimizing urban design and enhancing outdoor thermal conditions. As illustrated in Figure 1, these factors collectively contribute to the overall urban environment.

This review identified two primary research approaches exploring the relationship between FAR and thermal performance. The first approach focuses on analyzing the impact of varying FAR configurations on thermal outcomes, providing insights into how different densities and building heights can lead to distinct microclimatic conditions. The second approach investigates the influence of building height or BCR while keeping the FAR constant, effectively isolating the effects of these individual parameters, Table 2 provides a classification of the reviewed studies based on these two approaches, offering a structured overview of the existing research.

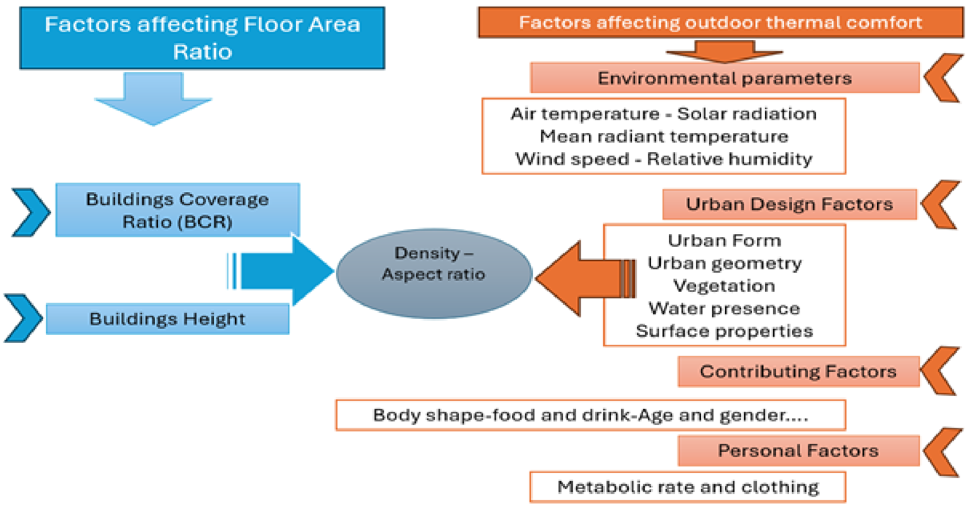


Figure 1 Factors affecting FAR and thermal comfort in urban spaces. Source: the authors

Table 2: studies classification (various and fixed FAR), (Building coverage ratio (BCR), Building height (BH), sky view factor (SVF), air temperature (Ta), Wind speed (Ws), relative humidity (RH), mean radiant temperature (Tmrt), urban heat island (UHI)), Source: the authors

Reference	Location	FAR								Study aim	Study method	Main findings
		Fixed FAR				Variable FAR						
		BCR		BH		BCR		BH				
		Fixed	Variable	Fixed	Variable	Fixed	Variable	Fixed	Variable			
Analysis of the Effects of Floor Area Ratio Change in Urban Street Canyons on Microclimate and Particulate Matter, 2021	Seoul, South Korea	●			●					To study the effect of FAR change in urban street canyons on Microclimate and Particulate Matter	Using Envi-met to simulate real case study and virtual scenarios with different FAR	FAR negative correlations with Particulate Matter. FAR positive correlation with wind speed (WS), negative correlation with ambient temperature Ta, Tmrt.
Impact of Floor Area Ratio (FAR) on Energy Consumption at Meso Scale in China: Case Study of Ningbo, 2017	Ningbo, China	●			●					To investigate several urban forms and their impact on energy consumption at various FARs	Using Eco-Tect to simulate Real case study, and virtual 4 scenarios with different FAR configurations	Higher buildings provide for more energy loss and less gain Comparison of various FAR. FAR 2.5 and 3 provide optimum solution to China's population.
Impact of Urban Block Typology on Microclimate Performance in a Hot-Humid High-Density City, 2021	Bandung, China		●		●					To analyze the influence of Building Coverage Ratio (BCR) and Floor Area Ratio (FAR) on microclimatic parameters	Using Envi-met to simulate proposed building typology.	The relative humidity rises dramatically as the FAR is raised while the air temperature and solar radiation decrease. The relative humidity and wind speed will decrease as the BCR rises.
The Effect of Building Height on Thermal Properties and Comfort of a Housing Project in the Hot Arid Climate of the UAE, 2023	Ajman, UAE	●			●					To examine the influence of building height variations on urban layout and canyon environments	Using Envi-met to simulate real case study and virtual scenarios with various height configurations	Building height is a key factor in determining outdoor air temperature, UHI phenomena. Place the highest masses in the direction of the hot prevailing wind in various building heights.
Impact of Urban Density on the Outdoor Thermal Comfort Case Study: Yogyakarta Tagu Station Area, 2021	China		●		●					To evaluate the influence of urban density, as characterized by Building Coverage Ratio (BCR) and Floor Area Ratio (FAR), on microclimatic factors.	Using Envi-met to simulate plot model with different FAR and BCR.	GCR and BCR high correlation with the UHI. FAR is positive correlated with UHI.

CFD Simulation Analysis of the Influence of Floor Area Ratio on the Wind Environment in Residential Districts, 2018.	China		●		●					To study the correlation between Floor Area Ratio (FAR) and wind speed	A simulation model with different FARs was constructed via computer numerical simulation (CFD)	FAR is negatively correlated with wind speed ratio (WSR), affecting comfort.
Impact of Floor Area Ratio (FAR) on Energy Load in Kathmandu: Case of Sinamangal Town Planning, 2020.	Nepal									To investigate the relationship between Floor Area Ratio (FAR) and energy consumption	A comparison study is conducted using Ecotect software	clear correlation between FAR, energy production, and consumption.
Effects of Residential Building Height, Density, and Floor Area Ratios on Indoor Thermal Environment in Singapore, 2022.	Singapore	●			●					To investigate the impact of building height, building density, and floor area ratio on indoor air temperatures	Using Envi-met to simulate 18 scenarios with different density, height and FAR.	The indoor temperature was most impacted by building density. The most complicated effect of FAR is on the temperature of indoor air.
Evaluating the Impact of the Building Density and Height on the Block Surface Temperature, 2020.	Beijing	●			●				●	to investigate the influence of building geometry on surface temperatures	Using Envi-met to simulate scenarios with different density, height and FAR.	building height, density, and FAR, block surface temperature. **Density (low, medium, and high densities), height (small, medium, and large heights) and FAR (different densities and heights at a fixed FAR).** increased building density (λp) and height (H) cool blocks at unfixed FARs.
Evaluation of thermal comfort condition in urban morphology in approach to micro-climatic transformation in Tehran city, 2020.	Tehran		●		●	●			●	To evaluate the relationship between Sky View Factor (SVF) and Building Surface Coverage (BSC) and Floor Area Ratio (FAR).	Using Envi-met to simulate scenarios with different BCR and FAR.	SVF decreases as the BSC rises at a constant FAR.
The Effect of Building Height Diversity on Outdoor Microclimate Conditions in Hot Climate. A Case Study of Dubai-UAE,2020.	Dubai-UAE					●			●	To study strategies for enhancing shading within urban blocks in Dubai, focusing on variations in block orientation and building height.	Using Envi-met to simulate plot model with different orientation and height.	H/W has the highest effectiveness on thermal comfort followed by street orientation and building typology.
STUDY ON OUTDOOR THERMAL ENVIRONMENT AROUND THE RESIDENTIAL BUILDINGS, 2009.	Guangzhou, China		●		●					To studied effects BCR and FAR on outdoor thermal environment	A real case was simulated via computer numerical simulation (CFD)	Wind speed decreases as the gross building coverage ratio rises. When building coverage ratio is fixed and floor area ratio increases from 0.8 to 7.6, all the buildings' height increases from 7.5m to 60m, wind velocity increases.
The impact of densification and orientation manipulation on outdoor thermal comfort at social housing in arid regions: a sensitivity analysis, 2023.	October, Egypt		●		●					To study the influence of BCR, FAR, building height variation, and orientation, on PET.	Using Envi-met to simulate real case study and virtual scenarios with different FAR, BCR, height, and orientation	optimizing density and building heights, particularly in diagonal orientations, could significantly improve average PET.
The Impact of Urban Geometry on Outdoor Thermal Comfort in a Hot-Humid Climate, 2022.	Port Said, Egypt					●		●		To investigate the impact of urban geometry on thermal comfort in hot-humid climate.	Using Envi-met to simulate real case study with different H/W ratio.	The higher the H/W, the greater the comfort level. Tmrt is the most influential parameter that affects outdoor thermal comfort in a hot-humid climate. street orientation and building typology can significantly change the PET values
A Morphology-Based Evaluation on Block-Scale Solar Potential for Residential Area in Central China, 2021.	Wuhan, China		●		●					To investigate the impact of quantitative morphological characteristics on residential blocks' solar potential	Using software tools like Rhinoceros and Grasshopper to simulate Real case study.	floor area ratio, building density, and average building height. The correlation between floor area ratio and solar potential of whole block can reach 75%.
A Parametric Method Using Vernacular Urban Block Typologies for Investigating Interactions between Solar Energy Use and Urban Design, 2021.	Singapore		●		●					to investigate the relationship between solar energy utilization and urban design	Using software tools like Rhinoceros and Grasshopper to simulate Real case study.	parameters of block dimensions, building patterns, and building density all impose their impacts on the on-site solar energy use, The impact of floor area ratio is dominant, followed by site coverage.
Achieving Effective Thermal Performance of Street Canyons in Various Climatic Zones, 2022.	Alexandria, Aswan, Egypt					●			●	investigated the impact of aspect ratios and street canyon orientations on thermal comfort in two distinct climatic regions of Egypt	Using ENVI-met and RayMan software, various aspect ratio and street canyon orientation scenarios were simulated.	the aspect ratio (AR = 2.5) gives the best thermal conditions in all the scenarios evaluated in both cities, whereas the aspect ratio (AR = 1) provides the worst.
Implications of urban space aspect ratio on campus outdoor thermal comfort (Case study, BUE campus, Cairo, Egypt), 2021.	Cairo, Egypt					●			●	to investigate the impact of aspect ratio on outdoor thermal comfort within urban spaces	Using Envi-met to simulate real case study and virtual scenarios with different H/W.	The results show that aspect ratio (H/W=3) could be considered starting point to respect outdoor thermal comfort.

5. Conclusion

The present review addresses the complex interaction between urban morphology, specifically focusing on Floor Area Ratio, and its impact on outdoor thermal comfort in urban environments. As urban densification continues to reshape our cities, understanding the implications of design elements on pedestrian-level comfort becomes crucial. A review of 18 studies showed that FAR has a huge impact on thermal and urban environment. An analysis of 18 studies revealed that FAR has a tremendous effect on the thermal and urban environment. Approximately 45% of these studies influence the relationship between FAR and parameters such as air temperature, wind speed, mean radiant temperature, and relative humidity, which directly influence outdoor thermal comfort. Additionally, 15% of studies focused on indoor thermal comfort, 20% on energy demand, 15% on Sky View Factor (SVF), and 5% on Urban Heat Island (UHI) effects.

Key findings from this review include:

- FAR exerts a multifaceted influence on urban environments, affecting factors such as energy consumption, air quality, and thermal comfort. Understanding the combined effects of FAR and building height is crucial for effective urban planning.
- FAR significantly influences aspect ratio which can enhance outdoor thermal comfort and mitigate urban heat island effects.
- Using FAR can achieve Variations in building height which significantly influence outdoor air temperature and thermal comfort.
- FAR can be a powerful tool for controlling urban density, it can have both positive and negative impacts on thermal comfort. While higher densities can improve ventilation and reduce solar radiation exposure, careful consideration of building height and orientation is essential to avoid adverse effects.

6. Recommendation

The importance of FAR was discussed including its relevance to thermal comfort in building systems and energy consumption in this case. However, it is essential to undertake fieldwork in Egypt covering different climatic zones.

This research thoroughly advocates for the conduct of field studies to determine the effects of Floor Area Ratio (FAR) on thermal environment in the specific geographical Egyptian climatic areas mentioned. The outcomes of this research will be beneficial to the urban planners and policy makers interested in promoting the improvement of building systems and urban policies on the limits of FAR.

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