# Impact of Urban Orientation on Environmental Comfort factors for Residential Buildings - A Comparative Analysis

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## Abstract:
Providing a comfortable climatic environment in the residential shelter is one of the renewed challenges in the field of architecture, especially in the desert environment. Therefore, the study focused on taking advantage of negative design concepts in the field of energy conservation, by modifying the selection of the optimal orientation of buildings in urban fabric and studying the relationship between residential buildings and their mutual effects on shading rates. Thus rationalizing the amount of energy consumed as an alternative to providing a comfortable environment. One of the neighborhoods of New Cairo was chosen as an applied example for the new cities, as it represents an organic extension of the city of Cairo in the desert back of the city. By making a comparison between a proposed model in which the optimal orientation of the buildings and the compact urban fabric was taken into account mainly to clarify the discrepancy in the effect of not taking into account the most appropriate orientation of the buildings with the movement of the sun and wind in the current urban coordination model. Shows the effect of reducing thermal loads on residential buildings and maximizing the use of good ventilation, and the extent to which environmental comfort is achieved within residential buildings with the least amount of energy consumed in the proposed model. The study concludes with recommendations that take into account the local climatic environment in planning urban expansions in the next phase.

## Keywords:
Best orientation, Desert town, Rationalize energy, Urban fabric, passive design

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## 1. Introduction:
The human need for shelter was and remains the most important priority, as it protects him from the severe changes of the surrounding environment and provides life comfort factors, the most important of which are physical factors such as lighting, ventilation, and appropriate temperature. Many variables contribute to this, some of which are natural and some that require a lot of energy consumption. The challenges are seen in the difficulty of covering the needs of big cities and supplying energy, for long periods. These challenges push us to seek energy-saving architectural designs that depend on their structure to improve the building's design performance in a manner that makes it an energy-saver. If integrated with a renewable energy structure, it will become a low-energy consumption building (P´erez-Lombard, 2008)
The global buildings sector accounts for 40% of the world's total energy consumption, and the proportion of residential buildings consumption is within the limits of two-thirds and commercial buildings within one-third, according to the Organization for Economic Co-operation and Development (ECDO) (Hussein, 2001). Energy consumption in Egypt is increasing steadily due to population growth. The increase in energy demand in Egypt reached 7.5% annually (MOEE, 2013). This increase is significant compared to the annual average growth in energy consumption of 2.6% (Setiawan, 2015).
Building orientation represents the relation between its elevations and the original geographical direction. In the design process, it is important to consider the actual quantity of solar radiation on the facades of a building as a whole, as it affects the thermal load of the building and controls the thermal behavior and the amount of thermal comfort of the space (Morrissey, 2011)In addition, it affects the quantity of ventilation crossing inside the building, which in turn affects the quantity of energy consumed in it to achieve the thermal and life requirements.
The research focuses on one of the most important factors, that the designer can control to reduce the impact of the undesirable surrounding environment, especially in hot regions, through passive design as a concept to reduce energy consumption and improve thermal comfort (Council, 2009). And the use of optimal building orientation as a tool to achieve better interaction with the surrounding environment.; Such as reducing the rate of exposure of the building to solar radiation, while maximizing the area exposed to the relatively cold winds, in addition to studying the forms of buildings,

methods of assembly, and their reciprocal effects, which ultimately contribute to reducing the energy required to achieve an appropriate environment inside the building.

New cities are a good field of study, as it is assumed that the design and planning phase can be controlled from the outset. Therefore, one of the neighborhoods of the New Cairo city was chosen as an applied example for the new cities, as it represents an urban extension of the city of Cairo. In addition, this imposes different climatic variables that must be taken into account in the initial design stages, and by studying them, it is possible to identify the characteristics of the current design at the urban level and to determine what should have been followed to reduce the negatives and maximize the positives in the field of the physical comfort environment in residential buildings.

To clarify the impact of choosing the optimal orientation of the buildings on providing a comfortable environment, the study followed a methodology comparing a hypothetical model designed by rephrasing the determinants of the distribution of buildings in the site and the effect of building forms and their interrelationships, in light of the optimal orientation of the buildings and the current situation that did not benefit from these features. Thus, the effect of ignoring the most appropriate orientation of buildings with the movement of the sun and wind appears in the current urban coordination model. Using the programs: (Ecotect program) to calculate the heat energy gained from solar radiation for the building, (Shadow Analysis Software SKP) for tracking shadow periods, and (Speed Wind Analysis Software in Autodesk Forma) for appropriate wind flow throughout the year.

Ultimately, the impact of reducing thermal loads on residential buildings while maximizing the use of good ventilation is evident. The extent to which environmental comfort is achieved within residential buildings with the least amount of energy consumed; In the case of observing the optimal orientation of buildings. The study concludes with recommendations that take into account the local climatic environment and the optimal orientation of buildings, as an influencing factor in planning urban expansions in the next stage. To reduce the energy consumed in providing a comfortable living environment.

### 1.1 Research objective

This research aims to maximize the benefits of the local climatic environment and reduce its negative effects through the application of passive design concepts, to rationalize the energy consumed to provide a comfortable thermal environment inside residential buildings.

### 1.2 Research Methodology

In this context, it is necessary to take into account the provision of shelter that uses environmental solutions that focus on harmony with the prevailing climatic environment, and in a way that provides a healthy and comfortable environment with rationalization of consumed energy, in a simplified and accessible way for all. To achieve the United Nations Charter affirming the right to housing in Article 25: “Everyone has the right to a standard of living adequate for the health and safety of himself and his family” (GIZ 2011). So the research approach depends on formulating a methodology through which research objectives can be achieved on four levels as follows:

1- Reviewing the prevailing features of the semi-desert environment and the tools that can be used to maximize the positives and reduce the negatives.
2- Determining the scope of the study, and documenting the current situation of a sample, as an applied model by studying the case of a neighborhood in “New Cairo” as an example.
3- Presentation and analysis of the problems of the current situation using the program (ECOTECT) on the applied model.
4- Using passive design concepts, especially the optimal orientation of buildings, in achieving appropriate heat levels within residential buildings, and proposing a modification of a hypothetical design for the same study sample. To clarify the comparison between the current situation and what could have been achieved if the optimal orientation of residential buildings had been taken into account.

## 2. Terms and Definitions

### 2.1 Climate definition

The climate is the average weather for a particular region and period, usually taken over 30 years. When scientists talk about climate, they're looking at averages of precipitation, temperature, humidity, sunshine, wind velocity phenomena such as fog, frost, and hail storms, and other measures of the weather that occur over a long period in a particular place. In short, climate is the description of the long-term pattern of weather in a particular area (Gutro, 2017).

It is important to differentiate between weather and climate. Weather relates to short-term atmospheric conditions, such as sunny or rainy days, while climate includes average recurring weather patterns characteristic of an area.

Climate plays a fundamental role in shaping the conditions of the natural world, and its influence extends to the design and construction of buildings closely related to the prevailing climate in a particular area. Understanding climate and its impact on creating a comfortable living environment within buildings is critical to providing spaces that promote well-being and sustainability.

### 2.2 Review of the Applied Climatology

Applied Climatology is a branch of climatology that focuses on the practical application of climate data and knowledge to various fields and sectors. It involves the study and understanding of climate patterns, variations, and their impacts on human activities, ecosystems, and the environment. Knowledge of local climate conditions helps urban planners design cities that are more resilient to extreme weather events, reduce the urban heat island effect, and optimize energy consumption. “If we consider climate as the statistical collective of individual conditions of weather, we can define applied climatology as the scientific analysis of this collective in the light of a useful application for an operational purpose. The term weather includes all atmospheric events and the observation of individual weather elements as single series synoptically.” (Landsberg, 1951)

### 2.3 Passive design

With increasing concerns about climate change, sustainable building design is gaining importance as a way to mitigate construction environmental impact. Climate-responsive architecture takes advantage of local climatic conditions to create energy-efficient and environmentally friendly buildings. Through passive design and its principles, such as solar orientation, shading, and natural ventilation. These strategies reduce dependence on mechanical systems, reduce energy consumption, and reduce greenhouse gas emissions. “Passive design is an approach to building design that uses the building architecture to minimize energy consumption and improve thermal comfort. The building form and thermal performance of building elements (including architectural, structural, envelope, and passive mechanical) are carefully considered and optimized for interaction with the local microclimate." (Council, 2009)
“Building shape, orientation, and composition can improve occupant comfort by harnessing desirable site-specific energy forms and offering protection from undesirable forms of energy" (Council, 2009)

### 2.4 Impact of the environment with the direction of the building

The methods used in urban planning, especially in environments with hot or semi-hot climates, directly affect the thermal performance system of the internal environment in buildings. Urban formation is an integral part of the thermal comfort system inside buildings. (Hussein, 2001)
The orientation of the building and its relationship with the original geographical orientation is an important factor in the design process, it is necessary to take into account the actual amount of solar radiation on the facades of the building, as it affects the building’s thermal load and controls the thermal behavior and the amount of thermal comfort in the interior spaces (Morrissey, 2011)In addition, it affects the amount of ventilation inside the building, which in turn affects the amount of energy consumed in it to achieve a comfortable thermal level with good ventilation. By using the ECOTECT program and determining the climatic rates for New Cairo, the program determines the months of the hot period and the cold period, and then the program determines the optimal and worst direction for buildings on the Sun Path diagram, according to the data given in advance. Fig 1, Fig 2

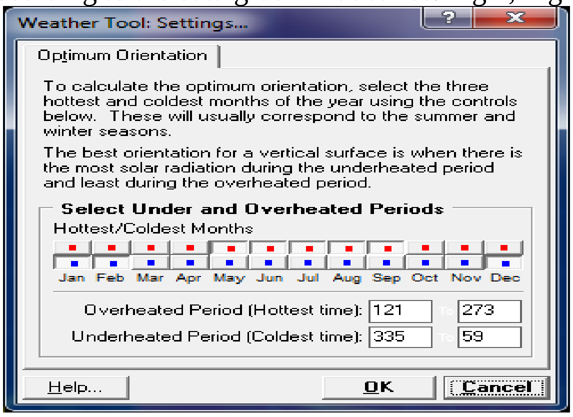


Fig 1. Ecotect Weather Tool setting optimum orientation by selecting hottest/ coldest Months.

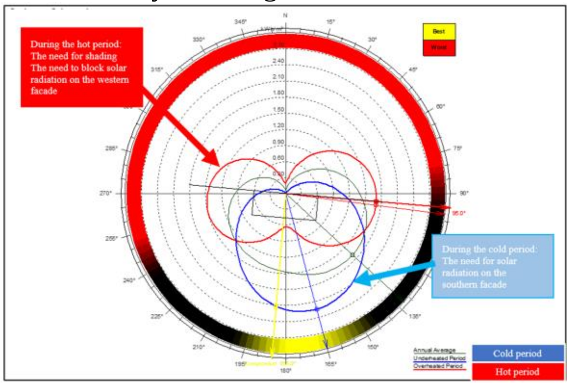


Fig 2. Best/Worst orientation determining the climatic rates for New Cairo on the sun Path. Diagram.

## 3. Determining the current scope of the study, and documenting.

Cairo is the capital city of Egypt and the largest city in the country. It is located in the northern part of Egypt, near the Nile River, and is a significant cultural, political, and economic hub in the region. Cairo is not only a city but also a governorate (province) that includes the city and its surrounding areas. The total area of the Cairo Governorate is around 308 square kilometers (Citypopulation, 2021). It has experienced significant growth over the years. According to estimates from 2021, the population of Cairo Governorate was over 10 million people, which includes both the densely populated urban areas of Cairo city and the surrounding suburbs.

The city contains different land uses such as residential, industrial, recreational, and service areas. For this study, the land use is divided into two main groups, which are urbanized and un-urbanized areas; the urbanized areas include areas under construction, fully urbanized areas, and urban areas that have more than 50% green space, while the un-urbanized areas are rural. The city was constructed on a fluvial area, where the topography is high at the southeastern boundary with an elevation of 420 m above mean sea level (AMSL) and low towards the northwestern boundary of the study area with an elevation of 142 m AMSL, while the slopes average between 0º and 5º, reaching 13º on the western side.

**3.1 The Scope of the Applied Study.**

New Cairo is a planned city located east of Cairo, the capital of Egypt. Fig 3 It is located in the path of increasing growth in the direction of the New Administrative Capital and is considered for decades to come under construction and expansion, so it is a good model for studying the current situation and identifying the disadvantages of not taking advantage of negative design in reducing the energy consumed inside buildings, especially in a hot semi-desert climate such as the one that characterizes the city of New Cairo. It was built as part of an effort to accommodate population growth and ease congestion in downtown Cairo. It is distinguished by its modern infrastructure, wide streets, and many residential and commercial projects. The total area of New Cairo can vary depending on the specific administrative boundaries, as the city is still expanding. As of 2021, it covered an area of about 70,000 acres, which is roughly equivalent to 283 square kilometers. Fig 5 The elevation of the city's topography is gradual, starting from the northwest towards the southeast. Fig 4. The population of New Cairo is increasing steadily due to continuous development and urbanization. As of 2021, the population is estimated to be over 2 million. (USGS, 2017)

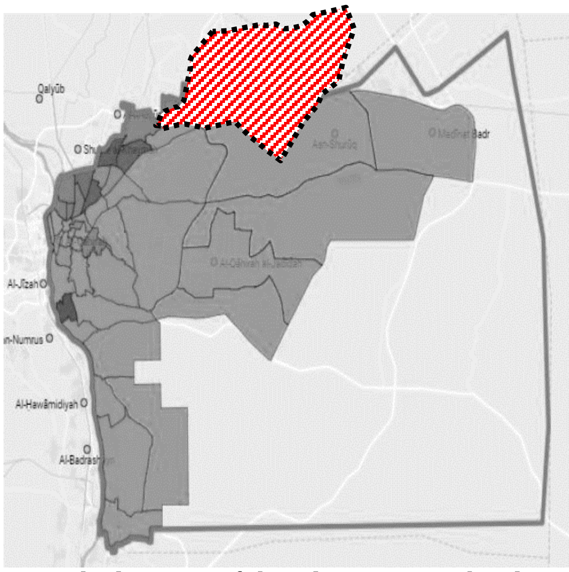

Fig 3: The location of the administrative borders of New Cairo, east of Cairo. (Citypopulation, 2021)

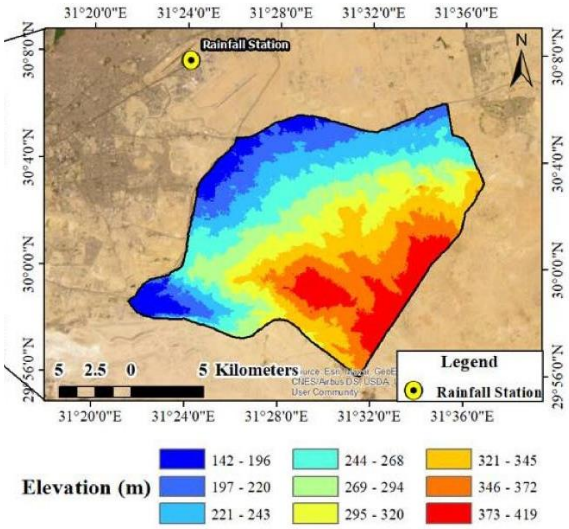


Fig 4: Topography of New Cairo. (USGS, 2017)

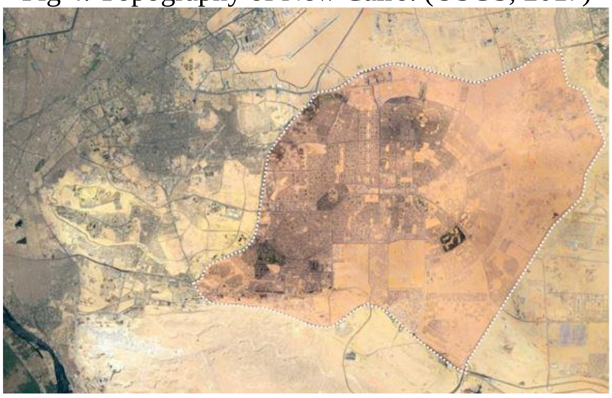

Fig 5: An overview of the urban fabric of the city of New Cairo shows that there are still large areas of extension and others that are incomplete. (Earth, 2023)

**3.2 Documentation of the study sample**

One of the neighborhoods of New Cairo (Jasmine 2, First Settlement, New Cairo) was chosen as a model for the application, as the general planning of the neighborhoods is very similar.

### 3.2.1 Sit Features

The population density is 513.3 people/km 2, and most of the buildings are of the same dimensions 16 m * 24 m, with a built-up area ranging from 384 m 2, and the number of floors, basement, ground level + 1.2 m, first floor, second floor, rooms on the roof with an area of 96 m 2, facades 50% balconies and 50 towers with an extension of 1.2 meters from the ground floor. Fig 6 The distances between buildings are 2.5m on both sides, 3m in front, and 4m in the back Land area within 600-650 sqm (20.5-21.5m * 30m). Fig 7. (Citypopulation, 2021)
The reason for choosing the study area is that the general planning of the buildings is directed towards the north according to the regulation of the Egyptian Urban Communities Authority without taking into account the proper environmental guidance for the buildings, (Fig 6).

Fig 6: A sample of building façade shapes showing unified building heights (Author, Field documentation of the study area, 2023)

Fig 7: Jasmine 2, First Settlement, New Cairo General site plan. (Earth, 2023)

### 3.2.2 Review of the prevailing climatic

New Cairo is considered to have a desert climate. There is virtually no rainfall during the year in New Cairo. Fig 8. According to the Köppen-Geiger classification, the prevailing climate in this region is categorized as BWh. The average annual temperature is 20.6 °C | 69.0 °F in New Cairo. About 23 mm | 0.9 inches of precipitation falls annually. Fig 9

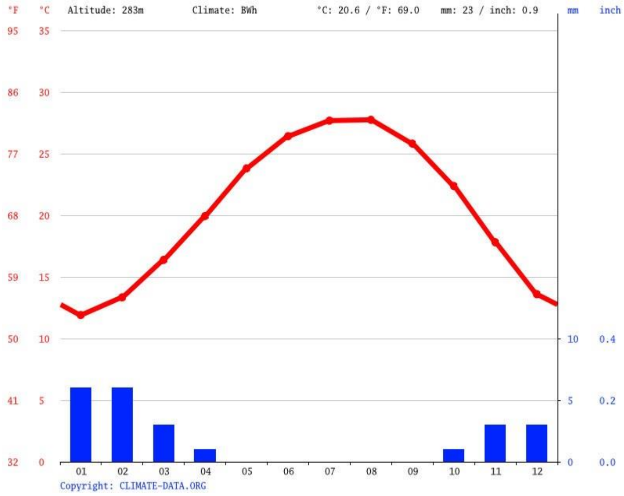


Fig 8: Least amount of rainfall in May. The average is 0 mm | 0.0 inch. Average of 6 mm | 0.2 inch, the most precipitation falls in January. (meteoblue, 2023)

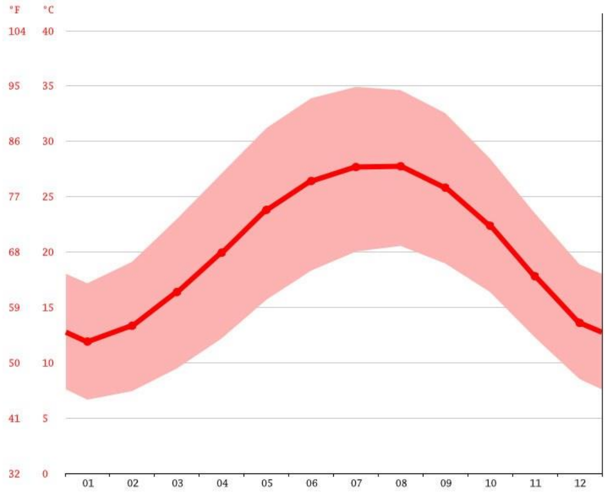


Fig 9: The temperatures are highest on average in August, at around 27.7°C | 81.9°F. January has the lowest average of the year. It is 11.9°C |53.4°F. (meteoblue, 2023)

New Cairo is in the northern hemisphere. It is situated in the upper half of the planet. The balmy days of summer commence at the end of June and conclude in September. This period encompasses the months: of June, July, August, and September.
Shadow Analysis is a useful plugin in the Sketchup program for evaluating daylight conditions especially solar radiation in Architecture. The study is shown with multicolored pictures. Dissimilar colors refer to diverse amounts of exposure to sunlight. Shadow Analysis plugin facilitates the analysis of daylight conditions in intense urban areas as well as the creation of designs efficiently for sustainable buildings and urban spaces, Fig 10

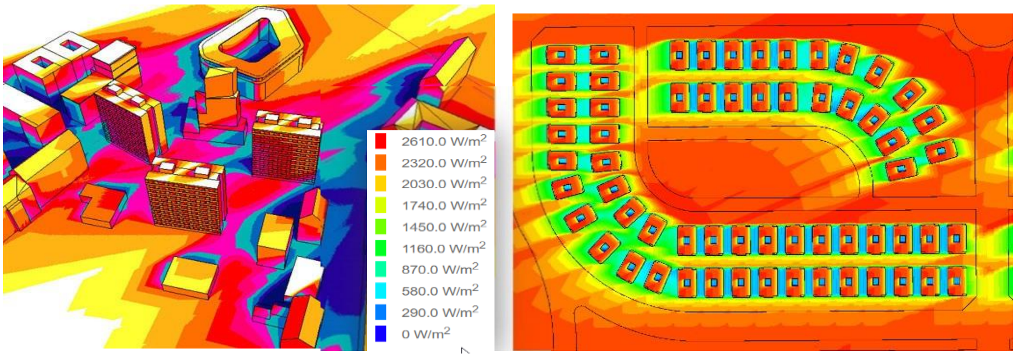


Fig 10: Shadow Analysis program interface and analysis of the current situation of the study area Layout and the analysis scale is Watt / m2 (Author, Analysis with programs(Autodesk Forma,Ecotect Software,Shadow Analysis Skp), 2023)

## 4. Orientation characteristics of the current urban fabric and the proposed model.

Architecture and its relationship with the surrounding environment play an important role in creating a comfortable and sustainable environment within buildings. Considering the local climate and conditions is essential to designing buildings that can adapt to changing weather patterns and temperature fluctuations. A passive solar design harnesses the sun's energy to naturally heat and cool the building. This can be achieved by orienting the building to the sun and prevailing winds, which is essential for energy efficiency and comfort. Where it is possible to increase the chances of increasing the timing of shading, reducing direct sunlight on the roofs of buildings, and exposing the surfaces of the facades to good ventilation while reducing heat gain or loss.

The compressed tapestry of buildings on Al-Muizz Street in Islamic Cairo is a great example of how architecture can adapt and thrive in a challenging desert environment. The harmonious coexistence of buildings, narrow winding streets, and traditional materials demonstrate the ingenuity of designing spaces that prioritize environmental adaptation and human comfort. It embodies a model of environmental adaptation and continuity in the face of changing climates.

Low heat island effect: Compression fabric reduces open spaces and exposed roof areas, helping to mitigate the urban heat island effect. Compared to sprawling modern cities, the dense arrangement of buildings in Islamic Cairo retains a lower temperature and maintains a more moderate microclimate.

To know the features of the climatic environment of the city of Cairo and its urban extensions, a weather history file approved by using environmental design and analytical programs such as “Ecotect”, and a climate advisory program, was used to monitor the climatic data of the city of Cairo.

### 4.1 An overview of the current building orientation and the proposed one

It is clear from the documentation of the study sample that there are multiple orientations of the buildings and their differences, but most of them are directed to the N/S axis by 55%, the E/W axis by 22.5%, and the northeast/southwest axis by 22.5%. These multiple orientations do not allow the buildings to take advantage of the largest periods of shade or in proportion to the preferred wind direction to reduce the thermal loads on the building. Fig. 11


Fig 11: Multiple orientations of the buildings (Earth, 2023)

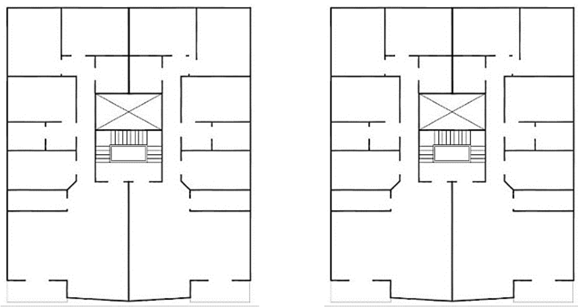

Fig 12: A model of an already existing residential building in the study sample (Author, Field documentation of the study area, 2023)

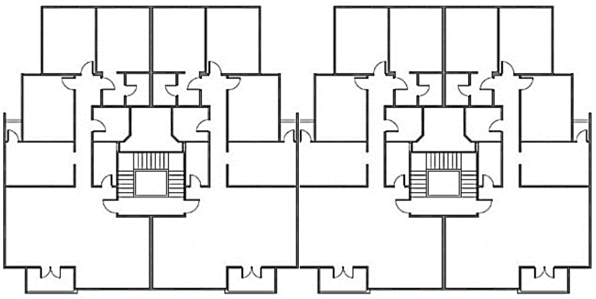

Fig 13: A suggested model for a residential building for analytical comparison (Author, Design model developed by author, 2023)

To show the comparison in detail, one of the residential buildings in the study sample was documented. Figure 12. A redesign proposal was submitted. Figure 13. But with adjacent buildings without lateral spaces, and uniform orientation in the front and back directions only, instead of the current site as separate buildings, surrounded by voids on all sides, which increases the area of exposure to sunlight and preferred wind directions. In addition, backyards were formed between the buildings with a width less than the height of the surrounding buildings, which formed a shading area similar to the internal courtyards in Islamic architecture, except that they are open on both sides to renew the air, Table 1. Thus forming a cold air area around the buildings, to achieve the best benefit from periods of shade and exposure to the preferred wind direction. As important factors in reducing thermal loads on the building, while allowing all buildings to be directed in the optimal direction, to suit the prevailing climatic conditions throughout the year. This reduces overall energy consumption. Fig 14


Fi 14: the suggested urban fabric of the study sample, allow all buildings to be directed in the optimal direction (Author, Design model developed by author, 2023)

**4.2 Analysis of the thermal performance of buildings in different directions from the north**

To determine the optimal direction, thus achieving a comfortable living environment inside the building, the study focused on two elements that represent the most important elements of influence on the internal environment of the building, namely the rate of heat gain through the exposure of the building's perimeter to direct sunlight and periods of shading, and the extent of exposure of the building's facades to appropriate winds to reduce natural temperatures and achieve proper ventilation. Therefore, a unit was chosen from the previous architectural model, Fig 14, and it consists of six adjacent residential blocks without side voids, it is characterized by the presence of backyards between buildings with a width of 8 m and around them buildings with a height of 12 m. As a result, it becomes a formation zone for cold air; With availability of shade for long periods, and thus by comparing the hours of building shading and wind speed, by changing the direction of the buildings from the north and ending in the south at a rate of every 15 °C in 12 samples. The optimal direction that achieves the best thermal environment surrounding the building can be determined.

By following up the shade rates according to the periods of sunshine over the Greater Cairo region, and through experiments it was found that experiment no. 6 is the most suitable urban solution for building orientation. That is, in the northeast/southwest axis, at an angle of inclination of 75° with the direction of the north. Fig 15, Fig 17. It achieves the best periods of shading, which reduces the effect of high temperature on the walls and external surfaces during the day in the summer. Table 1

One of the critical factors shaping the city's environment is the direction, intensity, and speed of the prevailing winds, which are among the factors affecting the rest of the climate averages. Understanding the patterns and impacts of these winds is essential for sustainable and resilient design, and we must take advantage of the favorable winds with many design and urban factors. (Halim, 2000). Cairo witnesses a unique meteorological phenomenon that is influenced by its geographical location. The city is located in the northern part of Egypt, near the Nile River and the Mediterranean Sea. Thus, Cairo's preferred prevailing winds flow from the north and northwest. But Cairo's proximity to the desert makes it vulnerable to sand storms and creeping dust. Especially the khamseen winds during the period between March and early May from the south and southwest, which are sandy winds with very hot air winds that raise the average temperature by an amount that may reach 14° C Celsius suddenly. Blowing from the southern side of the Western Desert to the north of Egypt. (Fajal, 2002)

Table 1: Documentation of a developed model using EPS (Author, Analysis with programs(Autodesk Forma,Ecotect Software,Shadow Analysis Skp), 2023)

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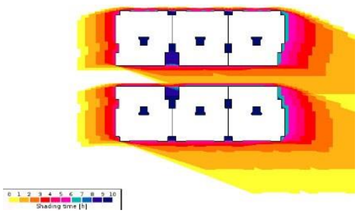
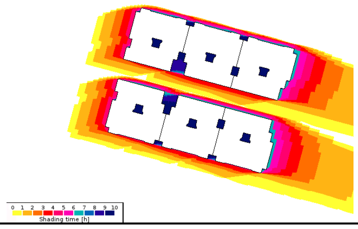
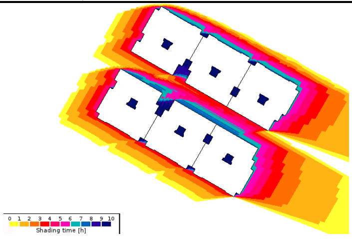
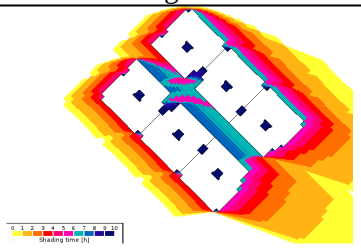
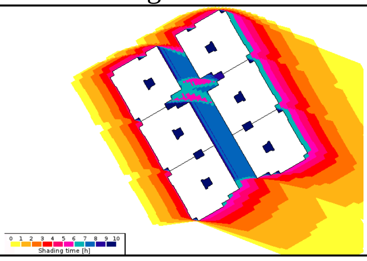
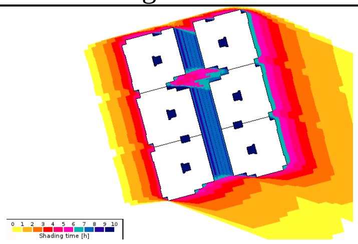
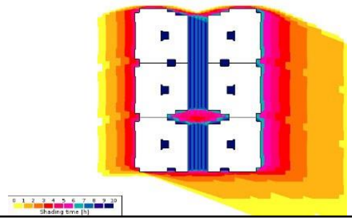
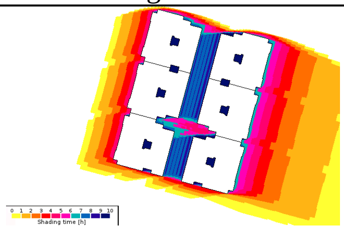
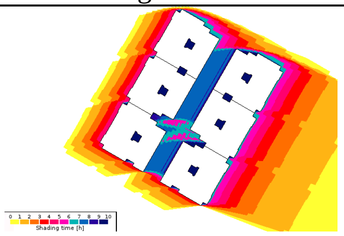
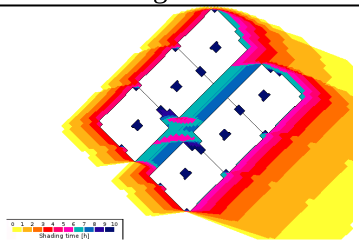
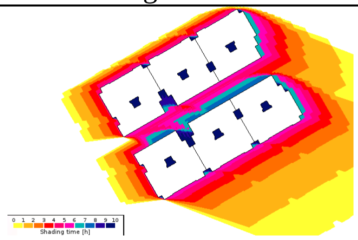
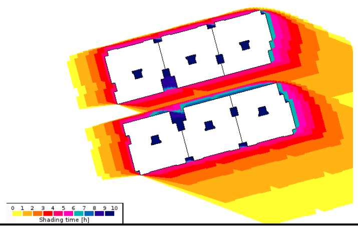
|---|---|---|
|  |  |  |
| Experiment:1<br>Orientation: 0˚<br>Shading Time: 2 | Experiment:2<br>Orientation: 15˚<br>Shading Time: 1.5 h | Experiment:3<br>Orientation: 30˚<br>Shading Time: 3.5 h |
|  |  |  |
| Experiment:4<br>Orientation:45˚<br>Shading Time: 6 h | Experiment:5<br>Orientation: 60˚<br>Shading Time: 8 h | Experiment:6<br>Orientation: 75˚<br>Shading Time: 10 h |
|  |  |  |
| Experiment:7<br>Orientation: 90˚<br>Shading Time: 9 h | Experiment:8<br>Orientation: 105˚<br>Shading Time: 7.5 h | Experiment:9<br>Orientation: 120˚<br>Shading Time: 7 h |
|  |  |  |
| Experiment:10<br>Orientation: 135˚<br>Shading Time: 6 h | Experiment:11<br>Orientation: 150˚<br>Shading Time: 3 h | Experiment:12<br>Orientation: 165˚<br>Shading Time: 2.5 h |

Table 2: Analysis of the direction of urban solutions with the prevailing wind direction between buildings in New Cairo (Author, Analysis with programs (Autodesk Forma, Ecotect Software, Shadow Analysis (Skp, 2023)

By changing the angles of the urban blocks to twelve different directions, and observing the airflow according to the speed and direction of the prevailing winds over the Greater Cairo region in the northwest and north directions, through experiments it was found that experiment No. 6 is the most suitable urban solutions for building orientation. That is, in the northeast/southwest axis at an angle of inclination of 75° with the direction of the north. Fig 16, where it achieves air flow between urban blocks, with no air vortices leading to high temperature of walls and external surfaces during the day in summer. It also provides the opportunity to achieve good ventilation in the interior spaces of buildings as in Table 2

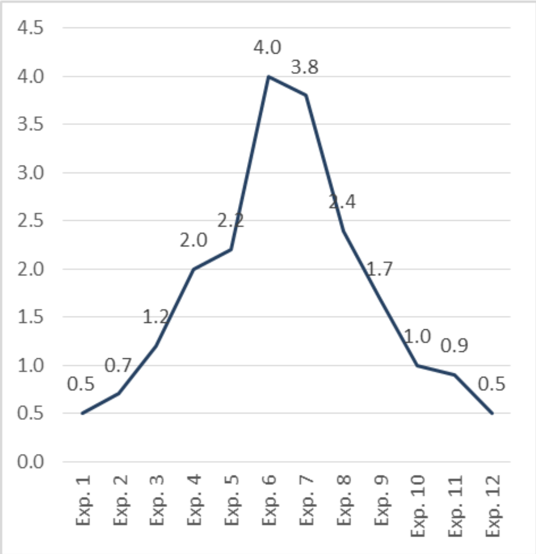



Fig 15: The intensity and direction of the prevailing and preferred winds throughout the year (Author, Analysis with programs(Autodesk Forma,Ecotect Software,Shadow Analysis Skp), 2023)

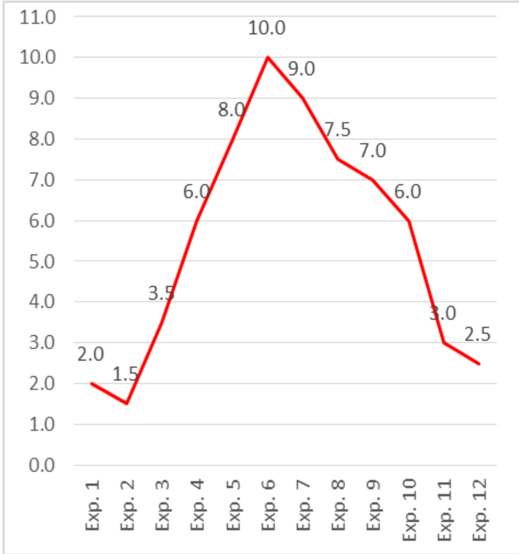



Fig 16: The intensity and direction of the prevailing and preferred winds throughout the year (Author, Analysis with programs (Autodesk Forma, Ecotect Software, Shadow Analysis (Skp, 2023)

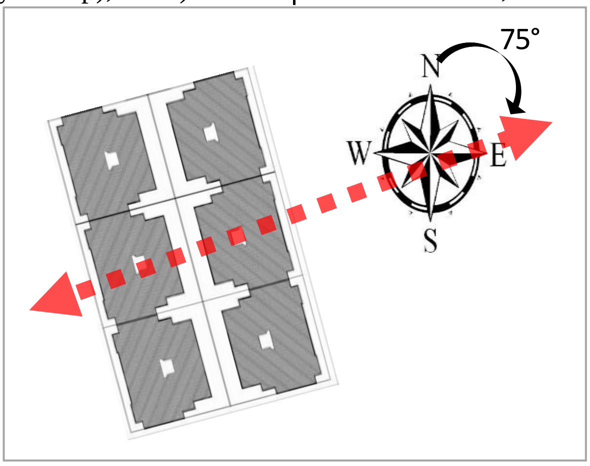
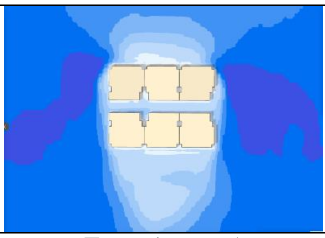
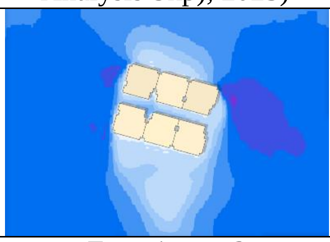
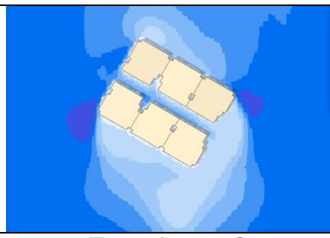
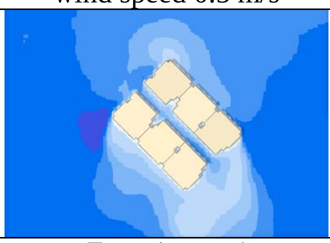
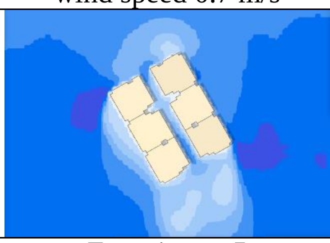
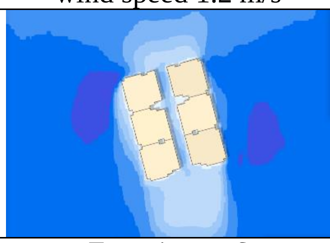
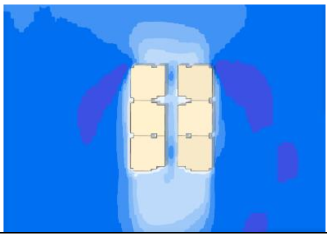
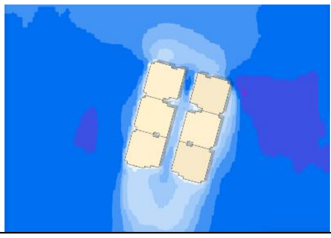
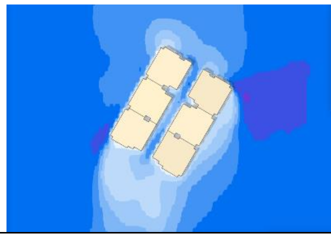
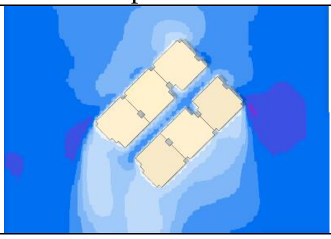
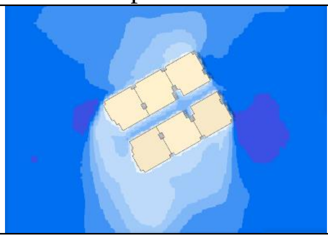
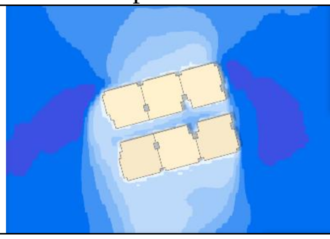


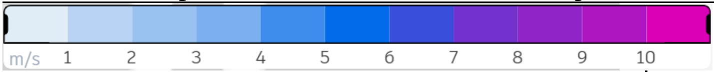

Fig 17: The intensity and direction of the prevailing and preferred winds throughout the year.

Table 2: Analysis of the direction of urban solutions with the prevailing wind direction between buildings in New Cairo (Author, Analysis with programs(Autodesk Forma,Ecotect Software,Shadow Analysis Skp), 2023)

| | | |
|---|---|---|
|  |  |  |
| Experiment:1<br>Orientation: 0˚<br>wind speed 0.5 m/s | Experiment:2<br>Orientation: 15˚<br>wind speed 0.7 m/s | Experiment:3<br>Orientation: 30˚<br>wind speed 1.2 m/s |
|  |  |  |
| Experiment:4<br>Orientation:45˚<br>wind speed 2 m/s | Experiment:5<br>Orientation: 60˚<br>wind speed 2.2 m/s | Experiment:6<br>Orientation: 75˚<br>wind speed 4 m/s |

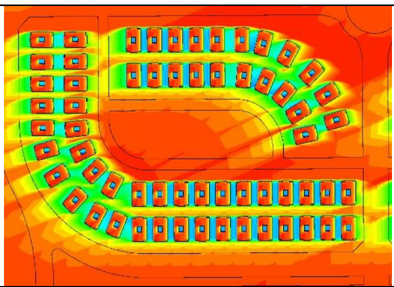
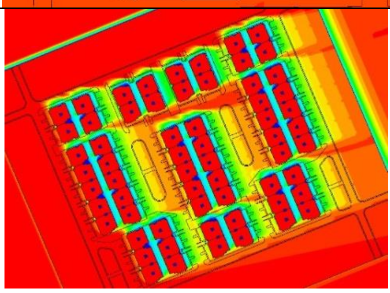
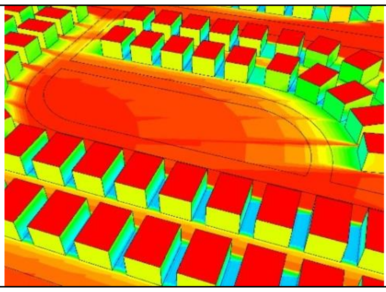
**Citation: Sherif Ahmed, Islam Hamed (2023), Impact of Urban Orientation on Environmental Comfort factors for Residential Buildings - A Comparative Analysis, International Design Journal, Vol. 13 No. 6 (November 2023) pp 447-459**

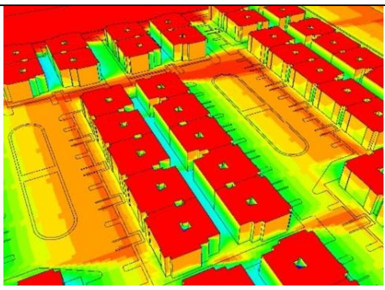
|  |  |  |
|---|---|---|
| Experiment:7<br>Orientation: 90˚<br>wind speed 3.8 m/s | Experiment:8<br>Orientation: 105˚<br>wind speed 2.4 m/s | Experiment:9<br>Orientation: 120˚<br>wind speed 1.7 m/s |
|  |  |  |
| Experiment:10<br>Orientation: 135˚<br>wind speed 1 m/s | Experiment:11<br>Orientation: 150˚<br>wind speed 0.9 m/s | Experiment:12<br>Orientation: 165˚<br>wind speed 0.5 m/s |




thermal comfort, the field of ventilation, and good wind speed are consistent throughout the year, in the north-southwest axis, at an angle of 75° with the north direction, so it is an optimal orientation for building; to take advantage of the maximum periods of shade and the best favorable wind speed; To cool the atmosphere around the building and contribute to achieving a comfortable living environment inside the building.

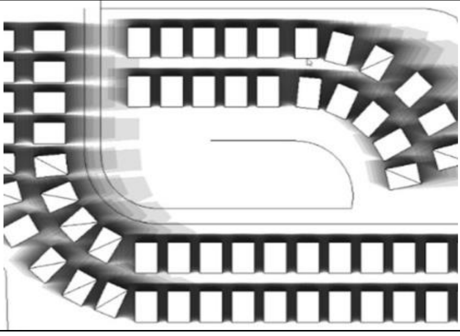
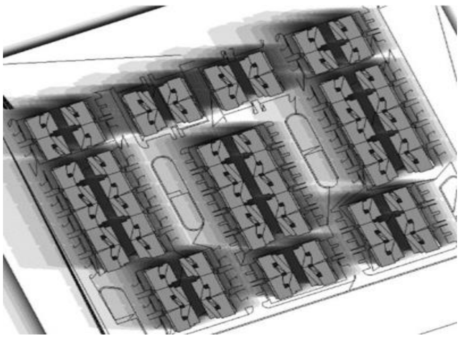
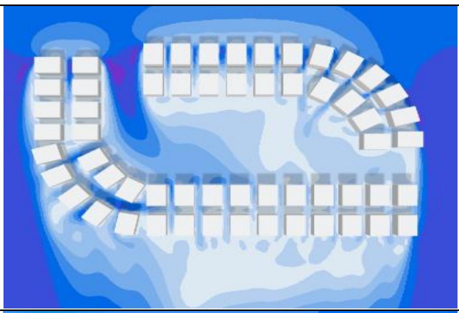
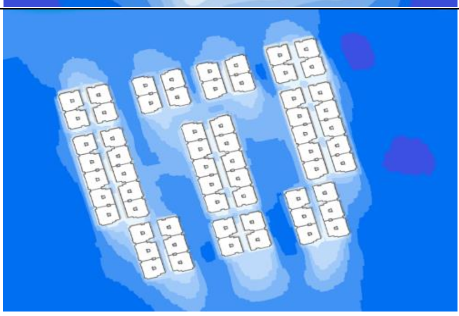
Table 2: Documentation of a developed model using EPS (Author, Analysis with programs) Autodesk Forma, Ecotect Software, Shadow Analysis (Skp, 2023)

| | | |
|---|---|---|
| | **Solar radiation rates (at the urban level)** | |
| **Current situation** |  | It is clear that the level of thermal radiation is high and reaches 5790 W / m2. As a direct result of the spacing between residential buildings on all sides, this increased building surfaces' exposure to direct and reflective sunlight and thermal radiation from surrounding surfaces, where improper orientation led to increased timings of direct sunlight exposure. This increases the temperature of the building environment and negatively affects the comfort thermal performance system. |
| **Proposed scheme -** |  | The level of thermal radiation decreases and reaches 2030 W / m2. As a direct result of the contiguousness between the buildings and not leaving the side spaces, where the direction of the building spaces is forward and backward only, this reduces the exposure of the surfaces to direct and reflective sunlight, thus reducing the thermal radiation from the surrounding surfaces, in addition to using the correct orientation. These factors reduced the temperature of the building environment and positively affected the performance of the thermal system of the building. |
| | **Solar radiation rates (at the southwest and southeast facades)** | |
| **Current situation** |  | It is evident that the southwest and southeast facades are exposed to large rates of solar radiation up to 4500 W/m2<br>As a direct consequence of improper orientation of the buildings, an increase in the timing of direct exposure to sunlight is noticed; Thus, the heat gain rates of the outer walls increased, which negatively affected the performance of the comfortable thermal system. This caused the need for mechanical cooling to reach appropriate thermal comfort levels within the building. |

| | | |
|---|---|---|
| **Proposed scheme** |  | The level of thermal radiation decreases and reaches 2000 W / m2.As a direct result of eliminating the lateral distances between buildings, and confining them to the front and back only, a reduction in the surfaces of the facades exposed to direct and reflective sunlight and thermal radiation, in addition to the appropriate orientation, which reduced the timing of direct exposure to sunlight. All these factors contributed to reducing the temperature gained in the building's internal environment and had a positive effect on energy savings. |

The most important results of the comparative analytical study and the advantages of taking into account the optimal orientation in mitigating the impact of the hot environment on buildings can be summarized in the following two tables: Table 1, Table 2

Table 3: Documentation of a developed model using EPS (Author, Analysis with programs(Autodesk Forma,Ecotect Software,Shadow Analysis Skp), 2023)

| | | |
|---|---|---|
| | **Shading rates throughout the year analysis** | |
| |  | The spacing of residential buildings from all sides, with the lack of a study of environmental standards for connecting buildings and their best orientation, was one of the most important reasons for the lack of mutual shade between buildings, especially in the hot periods of the year. This leads to increased exposure of surfaces to heat radiation, which increases the temperature of the building environment and negatively affects the comfort thermal performance system. |
| **Proposed scheme** |  | Studying the optimal orientation and connection between residential buildings, and their integration with open spaces, especially parking lots and open areas between buildings, that provide a general shading cover between buildings and on facades, reduces the rates of solar radiation directly acquired and reflected, especially during the hot periods of the year. It allows the formation of shading areas, contributing to the cooling of the air, thus leading to the formation of areas of high pressure for cold air, which moves through the buildings. This leads to a decrease in the ambient temperature of the building and provides a positively comfortable heating system. |
| | **wind speed rates** | |
| **Current situation** |  | The increase in wind speed rates around the residential blocks reaches an average of 34 m/s.<br>As a direct result of the spacing between residential buildings on all sides, and since the air is loaded with high thermal loads, the absence of an environmentally studied shade system and large areas exposed to direct solar radiation will lead to an increase in heating the external facades with hot air loaded with thermal radiation constantly growing, especially during the hot period of the year. |
| **Proposed scheme** |  | The optimal environmental orientation of the urban fabric according to the local environmental conditions, in addition to the closeness of the buildings, slowed the wind speed between them, to reach 4 m / s, especially in the backyards of the villas, which are thus similar to the courts in Islamic architecture and are a storehouse for cold air, during hot periods of the year, making suitable shading area around the buildings. This resulted in a relatively stable velocity with the cooling air while reducing its mixing with the heat-laden air coming from the desert area. |

## 5. Conclusion

The passive design harnesses the energy of the sun and periods of shade, as well as the appropriate wind speed, to naturally heat or cool the building. By orienting the building and allowing it to be adequately exposed to the sun and prevailing winds, the closely spaced formation of the buildings maintains a lower temperature and maintains a more moderate microclimate, which is essential for energy efficiency and environmental comfort in and around the building. It is possible to increase the opportunities for periods of shading, especially with the creation of backyards with an appropriate width, which contributes to reducing direct sunlight on the roofs of buildings, while providing an opportunity to expose the surfaces of the facades to good ventilation, which reduces heat gain. This was documented in the analytical study. Where it was found that orienting the building at an angle of 75° to the east with the direction of the north is the optimal direction, to achieve adaptation and continuity in the face of climate change, and helps to mitigate the effect of the urban heat island. Compared to the current situation in the study sample, where the building is exposed to the elements of the surrounding environment from all sides without a proper study.

In the proposed study model, the optimal direction was chosen according to the environmental conditions surrounding the building, and the use of the compact urban fabric, while providing shaded backyards between the buildings with a small width, similar to the inner courtyards. In a simulation treatment of planning residential areas in Islamic architecture. This provided a general shading cover between the buildings and the facades, which reduced the rates of solar radiation acquired and reflected. Especially during the hot periods of the year. This contributed to the cooling of the air surrounding the building, and the formation of areas of high pressure of cold air permeating the building and reducing the effect of the ambient temperature as follows:

- Provide a general shading cover between buildings and facades, which reduces the rates of solar radiation acquired and direct reflection. Especially during the hot periods of the year. It allows the formation of shading areas, which contributes to cooling the air, which leads to the formation of areas of high pressure of cold air
- At the urban level, heat radiation decreases and reaches 2030 W/m2. From 5790 W/m2.
- In the facades, the thermal radiation decreases and reaches 2000 W / m2. From 4500 W / m2.
- It achieves the best shading periods between buildings of up to 10 hours, which reduces the effect of high temperatures on walls and external surfaces during the summer day.
- At the urban level, it achieves air flow between urban blocks at a speed of 4 m/s, with no air vortices leading to overheating of walls and exterior surfaces during the day in summer.

This can be used as an indicator of one of the most important elements of building adaptation to the surrounding climatic conditions and benefiting from them, which opens the way for studying other factors such as wind movement inside the building and building materials and others, all of which are integrated in achieving harmony with the conditions of the surrounding environment to achieve a comfortable living environment inside buildings with less Industrial energy consumption rates and the use of natural energy.

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