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LOCAL AESTHETICS OF SUSTAINABILITY: THE CASE OF MULTI-STOREY HOUSING IN IRAQ

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Abstract

The environmental dimension is a crucial element in designing residential complexes, particularly in hot-dry climates that require effective thermal adaptations. This study seeks to identify and derive environmental aesthetic values for sustainability from residential examples in these regions and to assess contemporary complexes, such as those in Baghdad, using Envi-met 5.6.1 software to analyze variables including potential air temperature, relative humidity, predicted mean vote (PMV), and sky view factor (SVF). Results indicate that optimally oriented complexes, exemplified by the Iraq Gate residential complex, demonstrate superior thermal performance and comfort, emphasizing the significance of green spaces and environmental aesthetics in sustainable urban planning.

Keywords:

Envi-met5.6.1;
Global Aesthetics;
Hot-dry climate;
Predicted Mean Vote;
Sky View Factor.

1 Introduction

The German philosopher ‘Alexander Gottlieb Baumgarten ‘formulated the expression “aesthetics” during the 18th century, and the origin of this concept returns to the Greek word “Aesthetikos”. There are several meanings for the word aesthetics in antiquity such as the capacity to draw catalysts of physical sensations; whereas Baumgarten says that “aesthetics is a shape of obtained information of what is sensed from things”[1], [2]. Aesthetics is a branch of philosophy that deals with the nature of taste, nature, and beauty in addition to estimating and evaluating beauty. It is an enjoyable attachment that grants meaning to existence. Some of the most essential inquiries in aesthetics are: “Why does something look beautiful? “Does beauty have a form” or does it relate to personal emotional responses?”. The sense of beauty has perplexed many philosophers, writers, artists, and thinkers throughout human history. In addition, the classification of beauty has been doubled by the multiplication of critical, humanitarian, and philosophical features for it. The question: “what is beauty?”; refers to the core of aesthetics theories since the Greek days. Beauty is considered to be a delight and a happiness that considers an object's goodness. Freud pointed out that aesthetics is formulated by two components: The beauty of the essence: which refers to the beauty that is conducted from the safety of the practical interpretation. And the beauty of appearance: which refers to the beauty that is conducted from the integrity of sustainability [3].

The idea of the research is based on an attempt to find a framework of quantitative measurement for the concept of environmental aesthetics, and how to apply it in the design of the residential complexes, especially in the city of Baghdad which has a hot-dry climate. The quantitative measurement of the environmental aspects by using the programs of the environmental analysis and linking it with the concept of achieving environmental aesthetics is the new addition of this research, and through which new research avenues can be opened on how to deal quantitatively with some theoretical concepts especially the concept of aesthetics.

2 Sustainable developments

As stated at the World Commotion Sustainable Development (WCED), sustainable development is defined as the development which convenes with the demands of the current generations without coming to terms of the specific requirements of the subsequent descents. It is found that this notion includes social, economic and environmental sides which interchange with each other. For instance, environmental quality is connected with the fineness of society substances, since material and social circumstances constitute and effect each other [4] [5].

Sustainable development is a method of reflection from several aspects, or a direction rather than to be known as a concept. The notion of sustainability is deemed to be the first confirmed model that is changed in the history of humanity, that is permanently being altered and widened. The directions of thinking in the previous decades detect the changes in the model of sustainability which have gone behind the sustainable case quo towards an effective, essential, holistic and nonlongitudinal way [6] [7]. Sustainable development is observed as a sustainable shift in our realization of the relationship between the human beings and nature. Moreover, this matter contradicts the former notions which depend on the segregation of economic, environmental and social matters. It is a procedure that endeavour to obtain a human evolution as keeping the capacity of ecosystem to go on to supply them with naturalistic resources and ecosystem resources in which the society and the economy rely on. For the sake of achieving the aim, there must be an associated linking between three major parts: the environment, the society, and the economy. The environment has an effective role in the former procedures in achieving sustainability [8]. The notion of "sustainable" is overwhelmingly related with ecological, green, natural environmentally friendly constructions, environmentally aware, environmentally sensible, environmentally reliable, earth friendly constructions, high- prestation constructions, zero- energy construction, environmentally sensitive. Thus, the most important characteristics of sustainability are as follows: [9]

1) Environmental characteristics: includes (buildings that are designed with the viewpoint of the life's cycle, taking into consideration the minimization of the environmental effect (the best use of resources, decreasing releases and junk, the best use of articles), adaptation of the building through its life extension, environmentally friendly buildings).
2) Social characteristics: these features comprising: supplying social worths through time, supplying the feeling of place to the residents of the buildings, contemplating the specification of the place, sanitary buildings (internal fineness of the air, convent buildings (thermic, vocal, visible and olfactory comfort, safe buildings (integrity working provisions), obtainable to everyone, simplicity and easiness of use and psychologically acceptable.
3) Cultural characteristics: those features consist of: supplying cultural characteristics over time that is incorporated pertinent with the local worth and that are related with the encompassing environment and supplying aesthetic worth.
4) Economic characteristics: encompass: supplying economic worths over time, cost effective.
5) Political characteristics incorporate: incorporation with the local policies and infrastructure, interrelation to local servings and urban crisscrossed.
6) Philosophical characteristics: includes holistic process, cooperating process.

2.1 Aesthetics of Sustainability

The origin of aesthetics of sustainability is concerned with landscape ecology, daily aesthetics, design notion and more newly studied philosophical and urban aesthetics.
Lately, the vista and periscope of human aesthetic priorities have been discussed from the point of view of their role in developing sustainability in contemporaneous communities. The aesthetic of sustainability motif has lately been developed as a notion to clarify why specific thing, have crafts of aesthetic work only in terms of historic methods, orientation or relishes on the profound stratums of aesthetic estimation, cognitive worth and morals, since it is observed as a conceptual means that gives prudence into how the aesthetic predilection and options of the human being's work. Furthermore, it is suggested that the domain of aesthetics is an essential part of the capacity of human beings to visualize a more sustainable future [10]. Aesthetics of sustainability is a subgroup of aesthetics which depends on relation and methods and leans on the sensibility of models that connect many layers. It also refers to the complication and the spotlights of the beauty of the combination of contradictions. Arguments have distinguished a group of characteristics of sustainability of aesthetics, containing: [10]

- Emphasis on simplifying and communicating architectural relationships and design methodologies to a broader audience.
- Consideration of complexity as a deliberate design strategy rather than a flaw. Incorporation of contrasts.
- Use of contrast—material, form, or spatial—to enrich architectural expression and experience. Its utterance of the political and social complications of modern communities.
- Creation of spaces that evoke a sense of presence and reflect the dynamic, interconnected nature of urban and environmental systems.

The aesthetics of sustainability is requested for sensory and materialistic experiments of pass which call out a modern realization of the rhythms and circles that are important for the maintenance and renovation of life, the conceptual categorization makes clear standards like: equilibrium, encirclement, variety, etc., and presenting them as aesthetic precepts which are arranged into three groups: locative models, structural and visible purposes. Those categorizations depend on the visible characteristics of things [4]. It is found that the growing of the environmental awareness, design and performance requirements which are related with the implementation of sustainability goals have a direct impact on construction, architecture, urban design and the development of the environment in general. This influence is reflected in both the increasingly effective environmental performance of built structures and related technologies, and the aesthetic expression of environmentally conscious designs [6], see Table 1.

Table 1: Aesthetics of Sustainability.

Sustainable Development	Environmental characteristics	the best use of resources
		environmentally friendly buildings
	Social characteristics	residents' sense of place
		specification of the place
		sanitary and safe buildings
		simple and easiness of use
		psychologically acceptable
	Cultural characteristics	supplying cultural characteristics over time.
	Economic characteristics	supplying economic worths over time, cost-effective.
	political characteristics	incorporation into local policies and infrastructure.
	philosophical characteristics	holistic process, cooperating process.
Aesthetics of Sustainability	popularization of relations and methods	
	attention to complication	
	incorporation of contrasts	
	a sensation of appearance and complicated life networks of the environment.	
	equilibrium, encirclement, variety	
	visible characteristics of things (locative methods, structural and visible purposes).	
	environmental awareness, design and performance related to the implementation of sustainability on construction, architecture, and urban design.	
	environmental performance of built structures and related technologies.	
	environmentally conscious designs.	

2.2 Environmental Aesthetics

Sustainability has been posited recently as a status that is connected with the relations of human beings with the nature and the environment. This status depends on three standards: environmental, economic and social standards. The survey of the previous studies makes us able to find a shortage of particular aesthetic models which are related with sustainable modern spaces and just to treat them as environmental designs where the aesthetic sides are disregarded, and the result of this is the negligence of the aesthetic worths of landscapes and a separation from the surrounded environment which has influenced the essay "sustaining beauty". This essay has suggested a categorization of the aesthetic sides of sustainability by presenting three conceptual groups that are comprised by including other precepts of the environmental aesthetics and they are: eco-system impersonation geomechanically coherence, socio- biological context [8] . In the former definition of aesthetics, a group of standards which are including equilibrium feeling, identity, feeling of place, similarity and coherence are crossed major worth which can be interpreted into landscapes as: nominal, centric, similarity, continuousness, elasticity, and variety. Standards of aesthetics overtake not just materialistic and visible features but also perform visible realization and the experiment of a verified environment for monocular and correlative unit [10].

Aesthetics of sustainability origins can be traced as a conceptual means throughout its relationship with the theories of landscape ecology, daily aesthetics, design theory and it is related with the theories of applied and philosophical urban aesthetic assessment which link aesthetic, moral and cognitive worths together. Aesthetics of sustainability can be considered as a means of choice architecture of different kinds and pursuit from the philosophical aesthetic theory, green aesthetics and the notion of aesthetic footstep persistence for this, as both an improvement in a multidisciplinary circumstance by concentrating on sustainable design exercises as a premature try which blends design precepts which boost sustainability and the affirmative aesthetic goodness of the designed production.

Green aesthetics displays many ideas which are essential in the aesthetics of sustainability notion. In terms of concentrating on the choice of high- goodness objects which are longevity and thus, it is about conservation and look after the phases of the product's design. In addition to that, green aesthetics confirms the necessity to transact with the shapes of multi- sensory involvement which promote the materialistic and the spatial involvement with the incident in query [11].
Environmental aesthetics covers anything goes behind the arts to the naturalistic environment throughout the involvement and voluptuous inundation in the naturalistic world which distinguishes its aesthetic worth. Design aesthetics has the impact of redirection towards a more environmentally aware attitude. So that, the surveys pointed to the correspondence of seven characteristics which are connected with the aesthetics of sustainability are called: aesthetic continuation, easiness, reasoning and purpose, naturalistic shapes and objects, aesthetic identification and local culture, variety and authenticity [12].

Some investigators have differentiated the disconnected sets of environmental and humanistic standards in the structure of sustainability assessment system, and the anatomy makes clear the polarity of the used standards is two- dimensional and for instance, ecological and public proportion. According o [8] LEED and BREEM principles concentrate on ecological proportions, while the WELL system concentration public matters. Thus, a completely sustainable evolution can be visualized only if the proportions of ecological, public, economic and cultural sustainability are obtained [4].

As a result, the study [6] suggests firstly to distinguish styles which have the potential of evaluating three- or four-dimensional standards for determining sustainability and secondly to develop a special aesthetic term of sustainability including:

- Biophilic Design:
  The concept of biophilia stems from a comprehensive exploration of the interconnection between humans and the environment. It carries a moral imperative through the "greening of science," aiming to restore the lost connection between humans and the natural world. Furthermore, one of the principles of biological landscape aesthetics emphasizes our inherent affinity with nature, guiding aesthetic preferences toward natural environments. Six key components of biophilic design can be identified:
- Ecological characteristics
- Naturalistic forms
- Naturalistic patterns and styles
- Space and light
- Place-based relationships and the interaction between humans and natural development

- Regenerative design: refers to design practices derived from regenerative sustainability, which should be considered as a domain of application in architecture, landscape management, and agriculture. This approach promotes active engagement with the landscape through a cooperative and creative partnership with nature, emphasizing resilience, renewal, and adaptability. The resulting form should be environmentally responsible, minimally impactful, and integrated with local ecosystems and communities. Additionally, it supports the evolution of place toward its full potential, contributing to a more resilient, healthy, and enriched quality of life for society.
- The group of ownerships which locate visible term (for instance: colors).
- The group of features which influence the visible terms (for instance: style of attitude).
- The feature that locates the aesthetic reply (for instance: sentimental and mental link). see Table 2.

Genius Loci
One of the most pressing challenges in 21st-century design is capturing the "genius loci," or the spirit of place, which encompasses both the tangible and intangible elements that define the authenticity of a location. These elements can be categorized into three groups based on their relationship to aesthetic perception and experiential realization:
- A set of properties that define visible aspects (e.g., colors)
- A set of features that influence those visible aspects (e.g., behavioral styles or attitudes)

- A feature that triggers an aesthetic response (e.g., emotional or psychological connection) see Table 2.

2.3 Local Aesthetics of Traditional Residential Complexes

Sustainable aesthetics is a fundamental part of the organization and layout of residential complexes, especially in the hot-dry weather which demands designated solutions treatments to reach the most suitable design. The purpose of the current research is to elicit the aesthetic worths from the previous experiment of cities with hot- dry weather and to adopt them as a foundation for qualified anatomy and valuation of residential complexes in our modern cities. Both, the naturalistic and structured environment are an incorporated unity, and their elements are not rigid, but they are permanently interactive, affecting and effecting and the man himself is one of the elements of the environment interrelates with its elements, containing his human revival [13].

Since there is an increasing tendency to make the optimal potential use of obtainable sources to encounter the requirements of the inhabitancy, this symbolizes the growing stress on ecosystems; the aim turns to elicit environmental exponents from the previous urban environment of cities which can be utilized or controlled by them to control the design of multi-family residential complexes, especially in hot-dry areas and to use them in estimating the fineness of the present design from the point of view or their reply to the history of weather and the demands of sustainable environment. The conventional environment holds many ecological worths which are described by authenticity and have been continuously evolved throughout everyday exercise and deserves to be investigated and resolved to discover these worths and utilize them in contemporaneous design, comprising these ecological worths: [14]

- Inward looking.
- Correct orientation of residential complexes.
- Taking into consideration the proportion of the residential areas and in accordance with the dry-hot weather.
- Supply summer areas and profound balconies for residential units for the correct direction.
- Ensuring the existence of green areas and tent for the oncoming of residential complexes.
- Maintaining the water areas and the influx of water.

Regarding the aesthetic worths that are ingrained in the local conventual environments, the truth of materials relies on their visible form. While notice has a great role in determining the visible form, a deputation finds that despite the huge variations between the human beings in their relish and predications, it is potential to holdout the broad-based principles foe estimating beauty by depending on the analysis and a study of the human's passions in the shape of form, structure, installation, colour, shade, light, etc. Therefore, the most important lexicons of the aesthetic worths in the traditional residential ecology are: [15]

- Coherence & calmness of residential heights.
- The human scale of buildings.
- The incorporation of the urban formulation of buildings within their general urban ecology.
- Colour harmony of the heights of the buildings.
- The proportion of translucence to rigid heights.
- Incorporation of the lexicon of aesthetics in the height of the residential buildings.

Regarding the social side of sustainable ecology, it is found that obtaining a perfect social relationship is a requirement that cannot be separated from even the most advanced and urban communities, and any sanitary residential ecology should supply suitable weather since constructing social relations is connected with many non-physical elements, including: [16]

- Enclosing the non-honourable of the neighbourhoods.
- Enclosing the locative particularity of the neighbourhood.
- Enclosing the existence of locative social servings for the approaches of residential complexes.
- Supplying recreational and sports services to the approaches of residential complexes.
- Supplying the safety elements for residential complexes. see Table 2.

Table 2: Environmental aesthetics of sustainability.

Global Aesthetics	
sustaining beauty	eco-system impersonation, geometrically coherence, sociobiological context.
Biophilic Design	Ecological characteristics.
	Naturalistic shapes.
	Naturalistic styles and models.
	Space and Light.
	Place-based relations.
Regenerative Design	Lower influence on the environment.
	Local ecosystems and community.
	Elastic, sanitary, and goodness of life for the society.
Genius Loci	Colors, style of attitude, sentimental and mental link features.
local Aesthetics of Residential Complexes	
Environmental characteristics	Inward Looking
	optimum orientation of residential complexes.
	The proportion of outward walls to the overall size of residential areas.
	Supply summer areas and balconies for the residential units for the correct direction.
	Existence of green areas.
	Maintaining of water areas.
	Coherence and calmness of residential elevations.
	The human scale of buildings.
	The incorporation of the urban formulation of buildings within the general urban ecology.
	color harmony of building elevations.
	The proportion of translucence to rigid elevations.
	Incorporation of aesthetic lexicon in the elevations of the residential buildings

3 Simulation (Measurement) Method

Simulation modelling plays an important role in realizing and resolving the troubles in complicated environmental designs [17]. Envi-met is a computer program that can simulate the weather in urban environments and determine the impact of weather. This program is selected as an energizing means because of its capacity to spur the local weather on a materialistic basis. Many investigators have confirmed the accuracy of the outcomes of the program in several applications for thermic relief of cities, where they make clear that the knowledge wrapped in domestic metrological regions is harmonious with the energizing outcomes, [18]. Three of newly constructed residential complex projects within the city of Baghdad are selected as follows:

- Basmayah Residential Project

The Basmayah residential project is located in the southeast of Baghdad, approximately (10 kilometres) from the international highway that links Baghdad and Kut. It is spanning an area of around (1830hectaers). This development is planned to accommodate roughly (600,000) residents. The project is organized into eight sectors, and each sector is subdivided into multiple buildings and residential units. Each building comprises ten floors and each floor contains twelve apartments [19].see Fig.1.

- Iraq Gate Residential Investment Project

The Iraq Gate residential project is a comprehensive service complex in the Centre of Baghdad. It covers an area of approximately (12 dunams). The development contains (4750) housing units which are designed to accommodate around (28,500) residents. The project encompasses (49) residential buildings with heights ranging from (17-25). Furthermore, it includes a complete technical and social infrastructure, such as: schools, a commercial promenade, a mosque, a social entertainment club, a theatre and cinema, playgrounds and gardens, and green spaces [20].

- Al-Ayadi Residential Complex Project

The Al-Ayadi residential complex project is a comprehensive residential development that is located in the judas district of Baghdad. It covers an area of approximately (120,000 square meters). The project comprises (37) residential building; each one of them is combining a basement with a park, a ground floor and eight upper floors. Each floor contains eight apartments. This total (1,332) apartments within the complex. The project also includes integrated services such as: schools, commercial markets,

service buildings and green spaces, along with a gate that is serving as the main entrance of the complex [21].

3.1 Data entry for the model

The simulation model is initiated using weather data that is provided by the metrology and seismology authority [22] [23]. The characteristics of the local climate include: air temperature and relative humidity for the 15th of July 2023 which is classified as the hottest day of the year. The initial metrological settings are 5m/s for wind speed and 315 degrees for wind direction. The model incorporates the impacts of air, temperature and relative humidity over a single day, with a maximum temperature of 48 °C at 12:00 pm, the lowest relative humidity of 6% at 6:00am and the highest relative humidity of 23% at 6:00 pm. The area of the model is configured with a grid size of (X=50, y=50, z=40), where each grid cell measures (dx=2, dy=2, dz=2). The site orientation that is relative to the true north is 15 degrees.

3.2 Forming simulation model

The analysis of the three residential complexes focuses on the site plan of each residential complex and the horizontal plans (i.e. the general configuration of the residential buildings and their urban formation within the overall site of each complex). The indicators that are related with the facades of residential buildings are neutralized and they are not measured in this analysis. The selection of specific samples from each residential complex is based on the diversity of the mass- spatial configuration of the residential buildings and spaces within each complex and the variety in the orientation of the residential buildings within the general site of the complex, see Table 3.

Table 3: Indices of Local Environmental Aesthetics related to Envi-met indices.

Local Environmental Aesthetics	**Envi-met Indices**
Inward Looking	SVF, potential air temperature
optimum orientation of residential complexes.	potential air temperature, relative humidity, PMV
The proportion of outward walls to the overall size of residential areas.	Related to building's elevations
Existence of green areas.	potential air temperature, relative humidity, PMV
Maintaining of water areas.	potential air temperature, relative humidity, PMV
Coherence and calmness of residential elevations.	Related to building's elevations
The human scale of buildings.	Related to building's elevations
The incorporation of the urban formulation of buildings within the general urban ecology.	SVF
colour harmony of building elevations.	Related to building's elevations
The proportion of translucence to rigid elevations.	Related to building's elevations
Incorporation of aesthetic lexicon in the elevations of the residential buildings	Related to building's elevations

Several thermal receptors are placed in the selected areas for analysis. The total number of these receptors are (17) receptors across the three residential complexes. These receptors measure the potential air temperature in their designated locations for the sake of obtaining an objective comparison between the case studies.

In the Basmayah residential complex, three mass-spatial configurations (B1, B2, B3) are selected, as they are shown in Fig.1-A. In the Iraq Gate residential complex, two mass- spatial configuration (M1, M2) are chosen, as they are illustrated in Fig.1-B. Meanwhile, three configurations (D1, D2, D3) selected in the Al-Ayadi residential complex, as they are depicted in Fig.1-C.

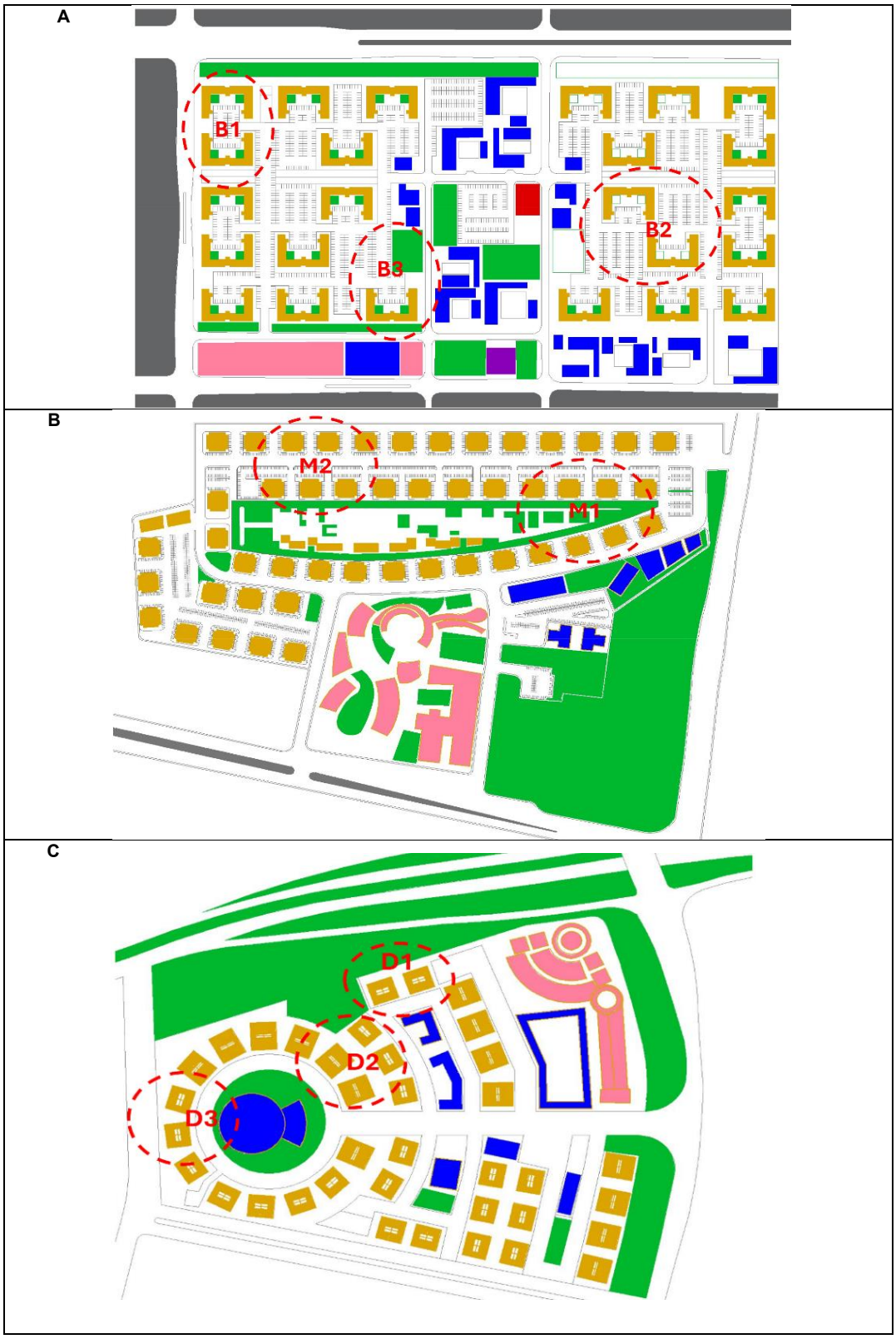


Fig. 1: Site plans of the three residential complexes and elected locations for simulation.

4 Results and discussion

Four indices from the Envi-met 5.6.1 program are measured (i.e. potential air temperature, relative humidity, predicted mean vote (PMV), and sky view factor (SVF). These indices align with the local environmental aesthetics of sustainability (i.e. internal looking), it is related with the indicators (SVF and potential air temperature) immediately. This indicator is found only in the urban design of the Basmayah residential complex, where the overall design of the buildings is in a U- shape, that is incorporating internal spaces between the various formations of the residential buildings. By comparing the results of the computer modelling for the (SVF) indicator among the three residential complexes, the Basmayah residential complex ranks the highest in the terms of the overall configuration of the residential buildings. These internal spaces provide shaded and comfortable areas for movement, as they have lower temperatures than the surrounding external environment. The Al-Ayadi residential complex records the highest (SVF) indicator value which indicates a need for covered areas and pathways with an appropriate roofing that are distributed among the residential blocks to protect the residents from the direct sunlight while they are moving in the complexes, see Fig. 2, Table 4.

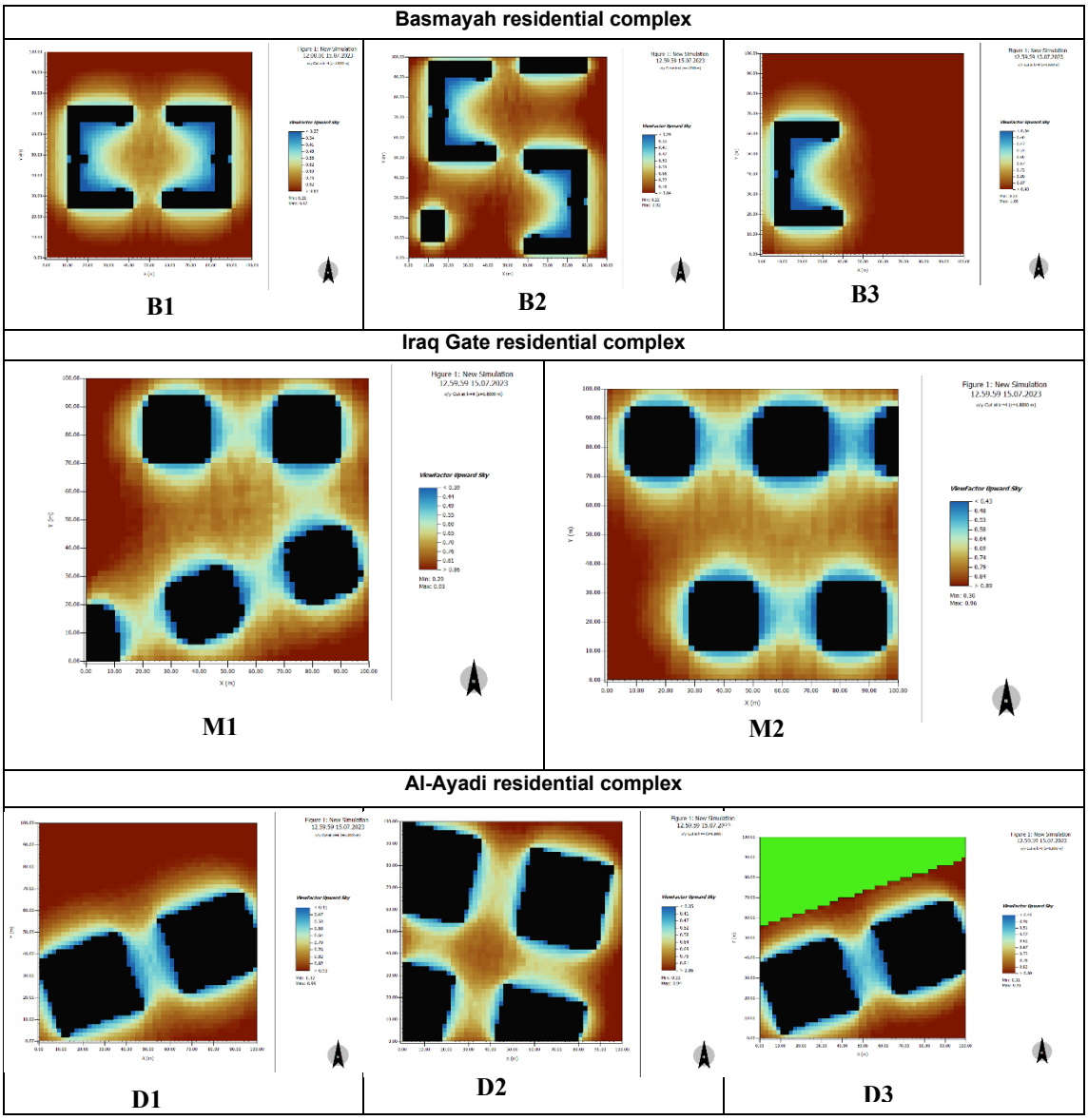
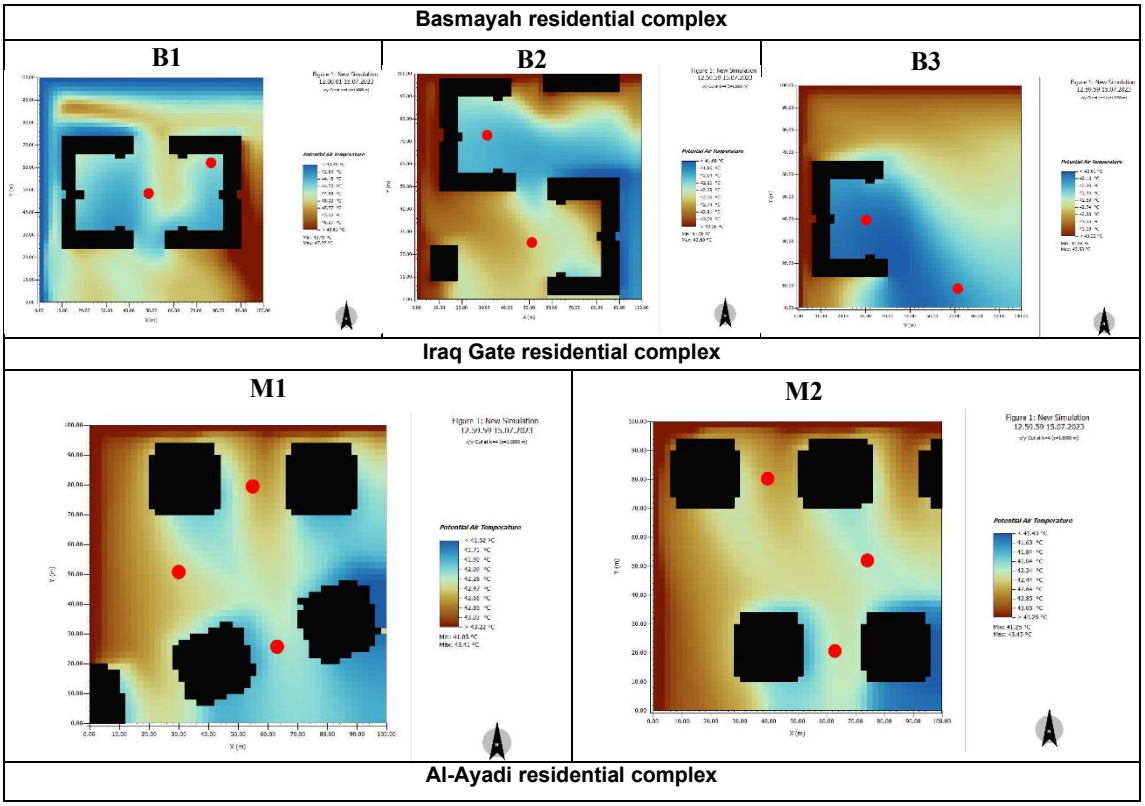


Fig. 2: SVF simulation results for the three residential complexes.

Table 4: Sky View Factor (SVF) related to: inward looking, the incorporation of the urban formation of buildings within the general urban ecology.

projects name		SVF (MIN %)	SVF (MAX %)
Basmayah	B1	0.21	0.97
	B2	0.22	0.92
	B3	0.23	1.00
Iraq Gate	M1	0.20	0.93
	M2	0.30	0.96
Al-Ayadi	D1	0.32	0.99
	D2	0.33	0.94
	D3	0.31	0.96

The second indicator of the environmental aesthetics of sustainability (i.e. optimum orientation of the residential buildings) is immediately related to the indicators of (potential air temperature, relative humidity, PMV). By comparing the temperature values that are obtained for the three residential complexes, the Iraq Gate residential complex is the best in terms of the recorded temperature averages. This is because of the mass formations and their orientation in the complex site which are directed towards the northwest, which is the preferred orientation in Iraq. Consequently, the Iraq Gate complex is the best in terms of the optimal orientation that is compared with the other two complexes. In contrast, the residential buildings of Basmayah complex are s oriented towards the east, which receives the higher solar exposure which results to longer durations of solar radiation in comparison with the other two complexes. See Fig.3, Table 5.



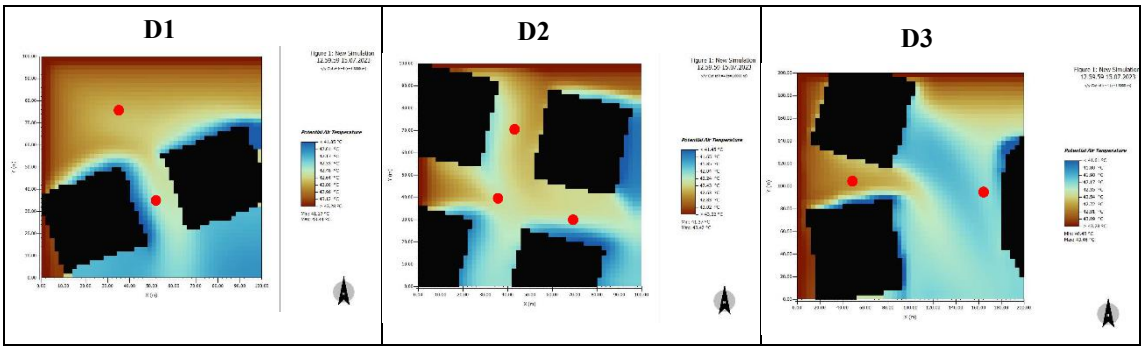
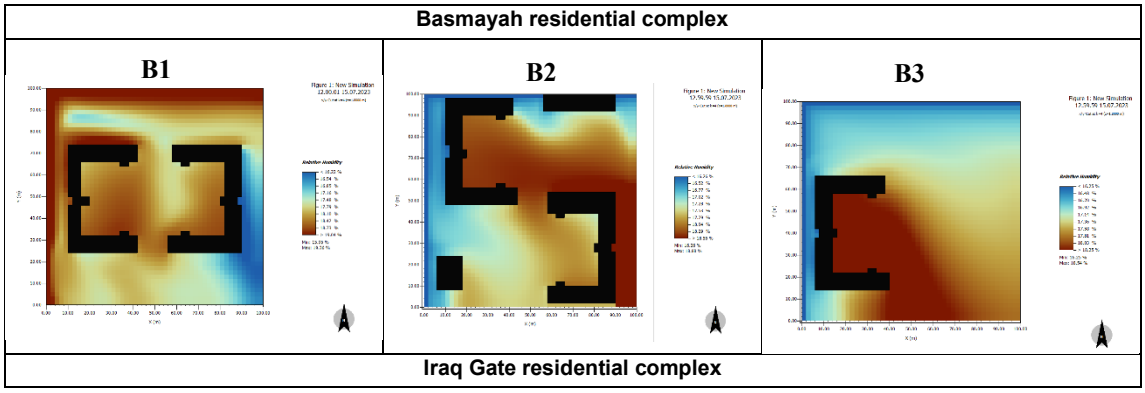


Fig. 3: Potential air temperature simulation results for the three residential complexes, and the locations of receptors.

Table 5: potential air temperature related to: optimum orientation of the residential complexes, existence of green areas, maintaining of water areas, inward looking.

projects name		potential air temperature (MIN %)	potential air temperature (MAX %)
Basmayah	B1	43.49 °C	47.27 °C
	B2	41.59 °C	43.60 °C
	B3	41.94 °C	43.53 °C
Iraq Gate	M1	41.05 °C	43.41 °C
	M2	41.25 °C	43.45 °C
Al-Ayadi	D1	41.17 °C	43.17 °C
	D2	41.37 °C	43.42 °C
	D3	40.40 °C	43.46 °C

Regarding the relationship between relative humidity and optimal orientation, the Al-Ayadi residential complex records the best average of relative humidity in comparison with the other two complexes. In contrast, the Basmayah residential complex has the highest level of relative humidity attributed to the limited area of vegetation and the absence of water bodies inside the site of the complex. See Fig.4, Table 6.



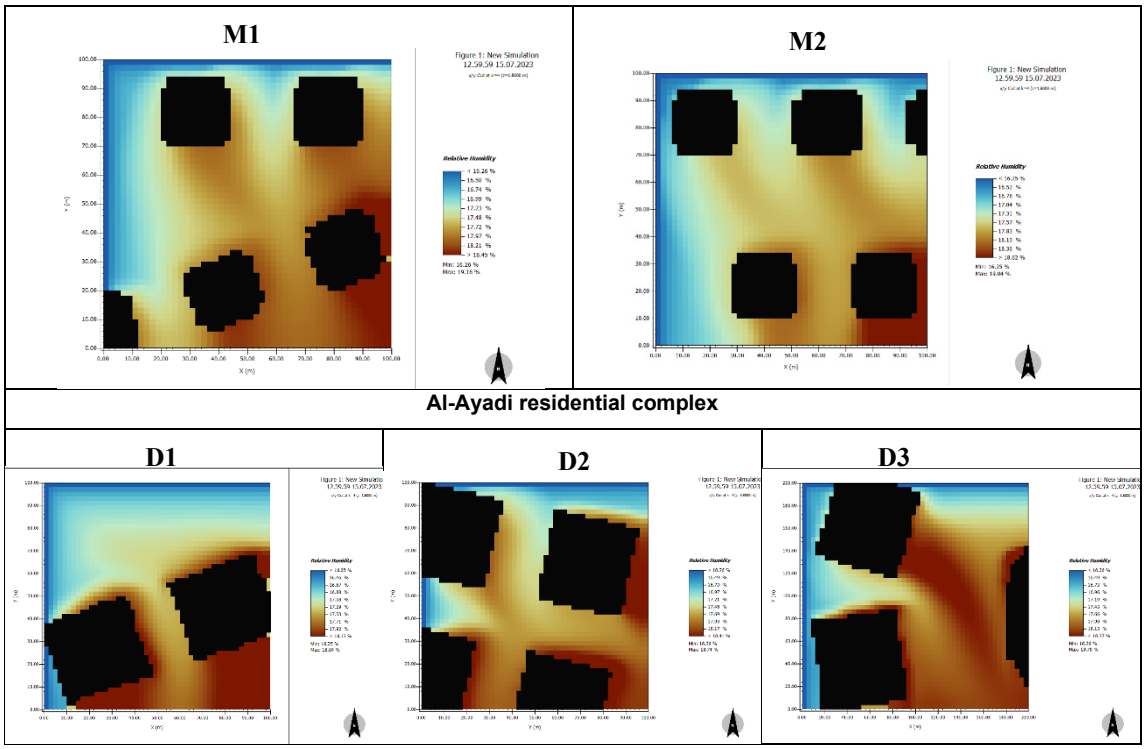


Fig. 4: Relative humidity simulation results for the three residential complexes.

Table 6: Relative humidity related to optimum orientation of the residential complexes, existence of green areas, maintaining of water areas.

projects name		Relative humidity (MIN %)	Relative humidity (MAX %)
Basmayah	B1	15.95%	19.36%
	B2	16.26%	18.88%
	B3	16.25%	18.54%
Iraq Gate	M1	16.26%	19.16%
	M2	16.25%	19.04%
Al-Ayadi	D1	16.25%	18.84%
	D2	16.26%	18.74%
	D3	16.26%	19.79%

Regarding the thermal comfort indicator (i.e. PMV), this indicator is immediately related to the temperature and relative humidity to assess the level of thermal comfort in the three complexes. By comparing the measured values for this indicator, the Iraq Gate residential complex records the lowest value, which indicates the highest level of thermal comfort. In contrast, the Basmayah complex records the highest value of this indicator. See Fig. 5.

Concerning the indicator of the availability of green spaces, the Iraq Gate residential complex scores the highest level because of the central open green space within the complex, towards which most of the residential buildings are oriented to. This is followed by the Al-Ayadi residential complex in terms of the size of the green area. The Basmayah residential complex ranks the lowest level, as the green spaces are very limited in comparison with the residential buildings and the overall site. The green spaces are confined to small grassy areas within the central space of each building. This limitation has led to higher temperatures, increased relative humidity and reduced thermal comfort. See Fig. 6.

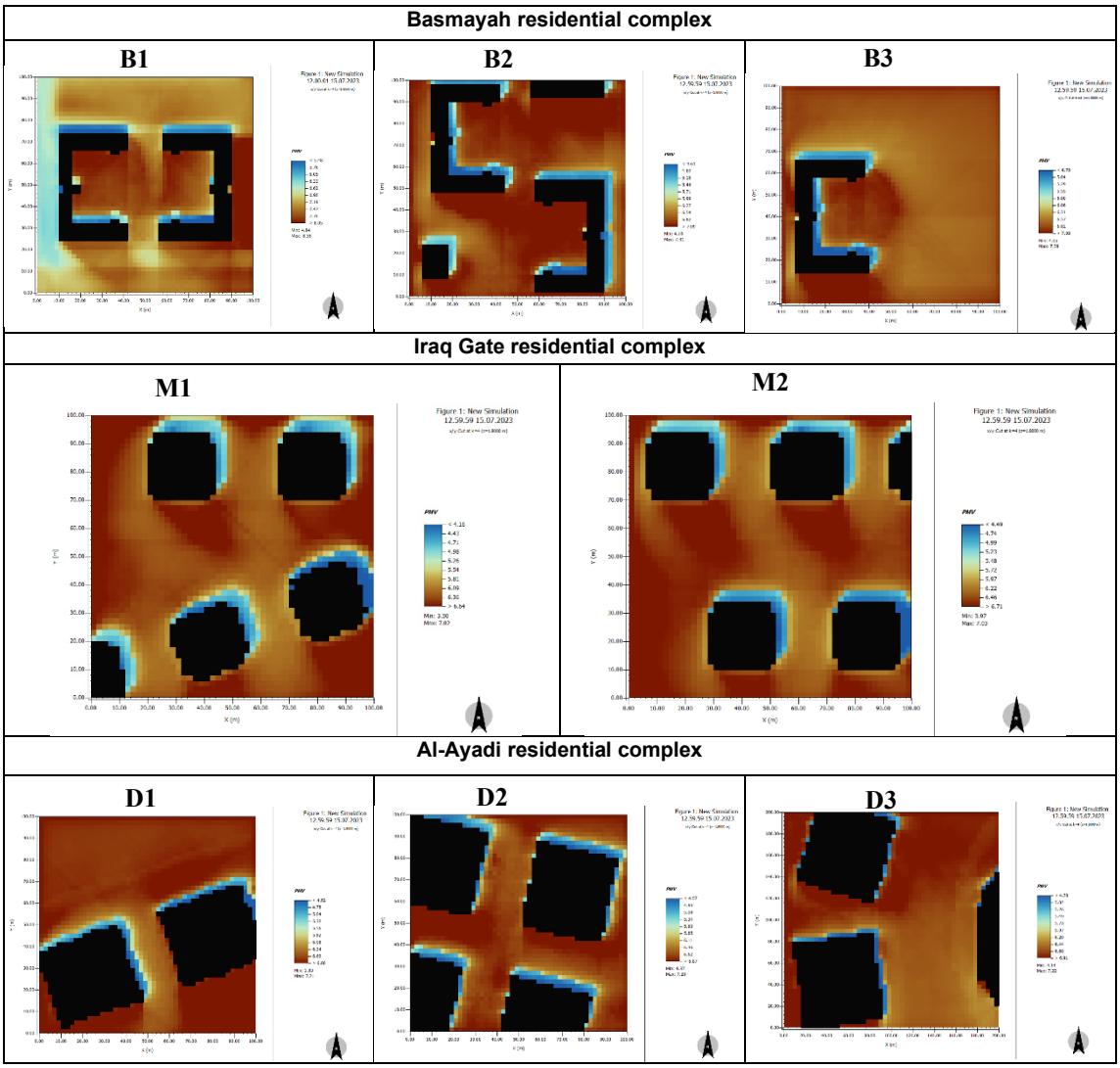


Fig. 5: PMV simulation results for the three residential complexes.

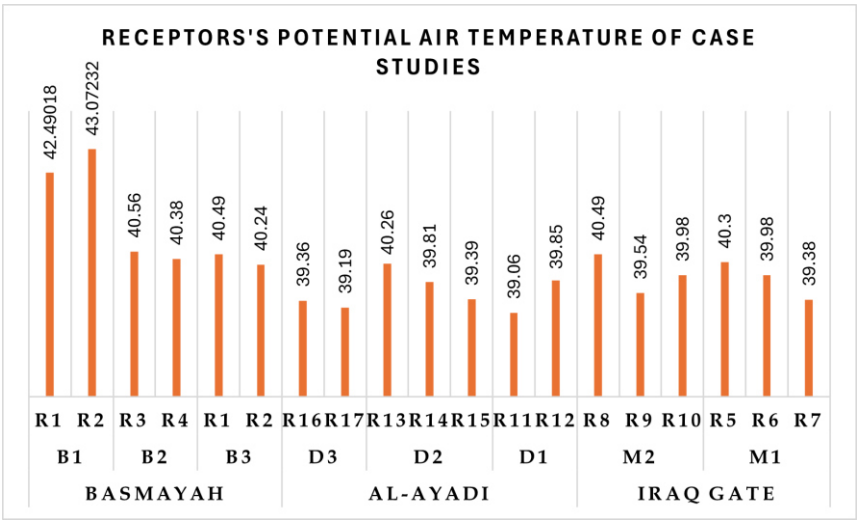


Fig. 6: Receptors temperatures for three case studies.

Integrating local aesthetics values with the quantitative environmental metrics such as potential air temperature, relative humidity, predicted mean vote, and sky view factor offers a complete realization of the quality of environmental the aesthetic appeal of residential complexes.
Northwest The Iraq Gate residential complex demonstrates the superior thermal performance due to its optimal northwest orientation which is ideal in Iraq for reducing the solar exposure and maximizing the thermal comfort. This orientation significantly affects the recorded temperature averages and enhances the overall thermal comfort of the complexes.

The presence and distribution of green spaces are crucial in enhancing the thermal comfort within the residential complexes. The Iraq Gate complex ranks the highest level in green spaces availability, which contributes to lower temperatures and an increment in thermal comfort. In contrast, the Basmayah residential complex with its limited green spaces, experiences higher temperatures and reduced thermal comfort.

The Al-Ayadi residential complex shows the best average of relative humidity due to its extensive green areas. Conversely, the Basmayah complex has the highest level of relative humidity because of the lack of vegetation and water bodies, high lightening the importance of greenery in regulating the levels of humidity and enhancing the environmental comfort.

The Iraq Gate residential complex records the lowest (PMV) value, which indicates the highest level of thermal comfort. This finding emphasizes the need to consider both the temperature and the relative humidity in the design of the residential complex to ensure the optimal thermal comfort for residents.

The urban design of residential complexes, especially the inclusion of internal spaces and the strategic configuration of the orientations of buildings, greatly affects the environmental aesthetics and the thermal comfort. The Basmayah complex, with its U-shaped design and the internal spaces provide shaded and comfortable areas for movement, despite its higher overall temperatures.

5 Conclusion

To enhance the values of the measured environmental indicators while designing the residential complexes, the following points should be taken into consideration:

- Enhancing the sky view factor (SVF) in residential areas can be achieved by incorporating more open spaces and reducing the height of the surrounding buildings. This strategy improves the natural ventilation and mitigates the urban heat island effect.
- Vegetation and green roofs implementing green roofs and increasing vegetation coverage effectively enhances the sky view factor.
- Reconfiguring building layouts to maximize sky visibility, such as using staggered building heights and varied spacing between buildings, can significantly improve sky view factor.
- Utilizing materials with high reflecting (high albedo) for pavements and the exteriors of buildings can reflect more solar radiation, thereby reducing ambient air temperature.
- Integrating cooling technologies like evaporative cooling systems and reflective surfaces in public areas can help manage and lower potential air temperature.
- Introducing water elements such as fountains and artificial lakes within the complexes can have a cooling effect on the local microclimate, thus reducing air temperature.
- Installing efficient irrigation systems to maintain green areas can help to regulate the level of relative humidity, especially during dry periods.
- Planting a variety of vegetation, including species with higher transpiration rates can increase the relative humidity and create a more comfortable environment.
- Implementing shading devices such as pergolas, canopies, and tree canopies can reduce direct solar radiation by improving thermal comfort and lowering predicted mean vote values.
- Enhancing the natural and mechanical ventilation systems in residential complexes can help in the dissipation of heat and the improvement of thermal comfort, for maintaining lower values of predicted mean.

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