

## Reviving the Hejazi Meccan Style to Achieve a Sustainable Saudi Housing - Case Study: Saudi Housing Units in Makkah

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**Abstract:** The Ministry of Municipal Rural Affairs and Housing implemented many housing projects within the framework of the Kingdom's Vision 2030; however, this implementation appears to not fully absorb the impacts and concepts of sustainability within the framework of preserving heritage identity in the Kingdom, particularly in the Makkah region, distinguished by its Hijazi style. This resulted in the loss of the Hijazi-Mecca character, posing a problem that must be addressed. The study suggests modifying the recommended design samples. It proposes comparative and simulation studies on housing sustainability and energy-saving criteria, natural lighting, and thermal wall transfer. It uses the Sefaira web application to conduct applied analytical studies on three study case designs: villa, duplex, and apartment (ASHRAE 90.1.2013) to compare energy consumption rates before and after modification. The study makes use of the software program Autodesk Insight 360 to demonstrate the benefit of using solar energy in saving nonrenewable energy resources. The study demonstrates how to use the Hejazi style of revival applied to models presented by Holly Makkah Municipality to achieve sustainable Saudi housing. The study recommended employing the architectural elements and items of eco-friendly architecture of Hejazi style in Sustainable Saudi housing future plans.

**Keywords:** Revival– Meccan Hejazi Style – Sustainable heritage housing– Saudi Housing- simulation - Sefaira web application.

### 1. Introduction

The ongoing sustainable development process is a debatable pan-Arab discrepancy in general and Saudi Arabia in particular. The ferocious globalization contest has wiped out the conception of identity and style, especially in housing units. Lamentably, the Hejaz region in Holly Makkah Municipality has been vulnerable to identity mutilation and style deformation due to the simultaneous climatic changes and recent thermal variation. Thus, the research elucidates the compatibility of the in-progress ministerial projects conforming to the 2030 Saudi vision of sustainability validation and heritage preservation,

specifically in the realm of housing and the Hejazi heritage identity of Makkah consequences of these projects on the urban style.

The population of the Kingdom of Saudi Arabia in 2017 was about 32552336, compared to the 2016 census of 31742308, with a population growth rate of about 2.52%. 57.48% are males, and 42.52% are females. The Population Characteristics Survey for 2017 states that this number is geographically distributed among 13 administrative regions approximately. The municipality of Holy Makkah came first with about 26.29% of the populace in 2017. The General Authority for Statistics survey states that the percentage of houses of Saudi tenants and landlords is approximately 49.91%.

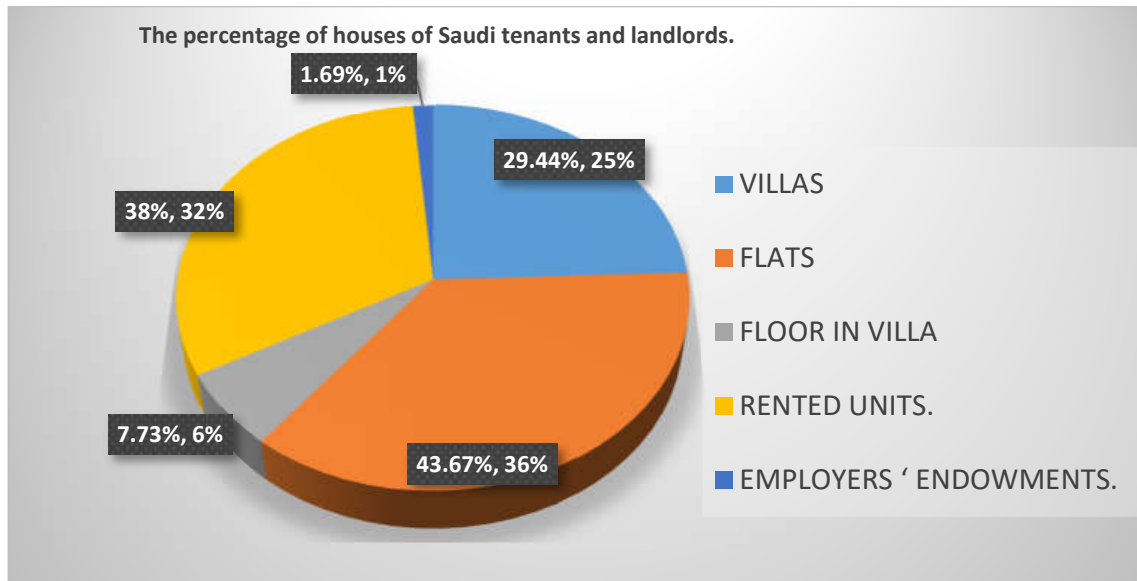


Figure (1). The categorical housing distribution according to the Population Characteristics Survey for 2017.

Fig. (1) shows The categorical housing distribution of this percentage according to the Population Characteristics Survey for 2017.

Due to the unique Islamic sanctity of Makkah, there has been a housing supply incompetence, after the real-estate investments increment of visitor-oriented housing units, by the uncurbed flow of pilgrims, which grants financial profit superfluity, refraining from the costly maintenance processes. This incompetence resulted in a wide gap between the demand of Saudi families and the supply of housing units. Adding insult to injury, the holy capital, Makkah, suffers from the truancy of housing units supply and the accelerating extermination of its Hejazi heritage and identity traces amongst the architectural edifices and urban pattern, despite the stipulations and motifs provided by the Holy Capital Secretariat.

The research question is, do the Ministry of Municipal and Rural Affairs and Housing 2030 project plans consider the variant environmental and climatic conditions while keeping up the Hejazi heritage preservation in Makkah or not? The research presents a modified version of those projects to preserve and revive the threatened Hejazi style of holy Makkah while defying environmental and climatic change.

## 2.Literature

- **Revival**

This encompasses revitalizing the style and identity of a named region or even a building to its former posture. It may extend to retain a dormant performance or ameliorate a bygone purpose, on which this heritage foundation has embarked to realize. This process may involve installing some changes to keep pace with the latest upgrades of this activity in the contemporary age (R.F.A. Cuijpers 2018), (Jakle 1983).

- **Style**

The prolific professor Dr. Yahiya Wazeery states it as “innateness”. In other words, it is the inherent divine instinct since creation ruling out any humane interference. It is spontaneous coursework without fabrication or dictation. This hypothesis postulates that the urban and architectural styles are applied disciplines that cope with the natural environmental conditions; innateness. Therefore, the urban style of a particular region is a vivid incarnation of the environmental and societal development phases, which are mirrored in the variant urban types and architectural formations (Wazeery 2003).

On the other side, Dr. Ali Ra'fat asserts that style is "the definitive urban traits of certain geographical parameters or humane context". This named context encloses the formation regulations, urban codes, and spatial characteristics. Style is the pillar of deciphering the urban fabric of an area and the interweaving of its forms and spaces. That is to say; style is the compound resultant of form and fabric (Ra'fat 1986).

In brief, style interacts with the given environmental features, social circumstances, and economic conditions, resulting in proportionally variant urban profiles or styles. These givens reign supreme on the urban profile; rural, urban, etc. The vastness of the kingdom has been influenced by numerous human traits and geographical features, which are apparent in its inauguration, development, and characterization throughout successive eras. This has fruited multifarious profiles amongst the Saudi municipalities. However, Makkah has been a cosmopolitan port, the attraction pole of all Muslims worldwide (Abou Leila 2011).

- **Identity**

Some scholars believe that identity is the consolidated core of human beings. Others denote that it is the ultimate embodiment of the surrounding cultural and social setup. Other intellectuals refer to a certain context's sovereign norms, costumes, and traditions. They demonstrate that their continuity entails their authority over the ages, unaltered by the ongoing environmental contextual transformations (Abou Leila 2010). This uniqueness stands out. Architecture is the window to its social characteristics, where it delegates its urban survival success. Thence, architecture is the innovative manipulation of several factors to eternalize the identity of each society among its counterparts (Muhammad 2002).

### **3. The Urban and Architectural Style of Vernacular Buildings in Makkah.**

#### **3.1 The Factors Affecting the Style of the Façades.**

Façades are the outer crust of the building and the disclosed factor to the public within the urban environment. Not only, it reflects the culture

of its community, but also it is the lord bearer of the respective urban style of each region. Several influential factors affect the façade ideological representations (AL Saeidy).

#### **3.2 Vernacular Hejazi Building Formation in Makkah.**

The region is home to three prominent cities; the holy Capital of Makkah, Medina, and Jeddah. Hejazi housing formation varies by the variation of each town. Holy Makkah is known for its attached outer courtyards to houses, yet the atrium is circumscribed with chambers in Medina. Jeddah is marked for the elimination of enclosures altogether (Faresi 1984).

#### **3.3 Elements of the Vernacular Hejazi Building plans**

##### **3.3.1 Ground Floor Constituents:**

The entrance leads to a passage ending up by the Roshan reception; to receive guests. The specifically designed reception hall is attached to many bedrooms, majlis, a warehouse, and a water closet. This closet is close to the lobby and entrance. While seeking privacy, this floor is connected to the first floor by either stone or wooden staircase, desolated from the reception and chamber by a transitional section or corridor (Al-Suwaiyan 2000). Beneath the first floor of the stairs, there is a basement warehouse formed according to the style of building the stairs.

Medina is distinguished for its spacious inner courtyard or atrium. This style is scarcely found in Jeddah, after the shrinkage of building-appropriated lands, due to its surrounding fence. No wonder the city's humid climate stood beyond the presence of courtyards.

##### **3.3.2 First Floor Constituents:**

- It encloses the utmost ventilated spaces within the Hejazi house, for it is the private residential section of the family. No mention, it consists of the seating majlis and living room, to be aligned by the central façade of the house. It is attached to the living room, where the food preparations and hand washing take place, a bathroom, and

a warehouse. Conjointly, it consists of the second spacious room in the house, called Mo'akhar, by any side of the living room. It hosts a morning feminine guest room, living, and bedrooms, in addition to a warehouse, food preparation room, and a water closet.

- The first floor embraces a dormitory room adjoined to the bathrooms and terraces, whereas its warehouse can be used for food

preparation instead of storage purposes.

### 3.3.3 The components of Vernacular Hejazi Building Façades.

It is acknowledged that Roshans are the most dear-priced and crucial factor on the main façade. It is a stereotypical social stratum marker. Functionally speaking, it is a triadic breeze

Table (1). The factors affecting the façade style

Environmental Factors	Historical Factors	Cultural Factors	Social Factors	Technical Factors	Aesthetic Factors
The mountainous geological nature and the tough hot climate in Makkah have added a vertical urban annexation circumscribing Al-Haram mosque to accommodate the inhabitants and pilgrims. Hence, some vernacular Meccan buildings have been five-floored, contrary to the urban setup of Makkah, where distinguished environmental elements have treated the façades. Moreover, the narrowness of the horizontal spaces has obliterated the atrium's inner courtyard, inspired by its environmental compulsion. This way, Roshans were added for privacy concerns all over widely opened windows, abiding by the Meccan traditions. Roshans are renowned Hejazi factors to provide ventilation and illumination in part and reduce saturation and solar beam refraction in the other.	Historically speaking, the Hejaz region consisted of three cities. First, Muzdalifah is the central municipality of Makkah. The Second and the third are Medina and Taif, respectively, lying on the incense trade road from the Levant to Yemen. Hence, Makkah has flourished as the most ancient trade link between the near West and Northern empires. The agoras have been the host of countless merchants, especially in the early Islamic caliphate and the Umayyad caliphate. Therefore, it has been a cosmopolitan port, showing its variable urban styles.	The cultural factor has been affected by mingling with other cultures after being in desolation, thanks to the desperate backgrounds of pilgrims. The culture has affected its urban style after being a worldwide hosting platform.	Due to the ancient trading and timeless pilgrimage, the Hejazi community kept clinging to their former privacy norms in their exterior and interior vernacular architecture despite the civilization's revelation. It is worth noting that most of the Meccan façades are similar, yet not identical. This lasted even after the birth and spread of Islam, which signifies the citizens' intimacy to their Hejazi origin; since each citizen is the owner, designer, and founder of their building.	The Hejazi vernacular architecture is distinguished for its local materials. These materials are bad heat conductors. Bricks and stones were used in walls. Silt, wood, and timber were used in ceilings. Roshans were optimum facilities for ventilation and illumination. Besides, it safeguards the right to domestic privacy. These givens have resulted in a homogenous ambiance between the vernacular architecture and the natural environment.	There are some advantages the horizontal façades: <ul style="list-style-type: none"> <li>• The gradual horizontal minimization of form; the higher, the smaller the fifth floor.</li> <li>• The extravagant ornamentation of the frontiers; façades, and doors; the Roshan, which embraces a luxurious number of artistic engravings, and fine detailing</li> <li>• The terminal of each building is topped with sky dames or cachets. They might be built with multicolored bricks as in the shutters. These shutters are built-in enchanting geometrical shapes to increase the aesthetic appeal of the façades and highlight the size of the Roshan (AL Saedy).</li> </ul>

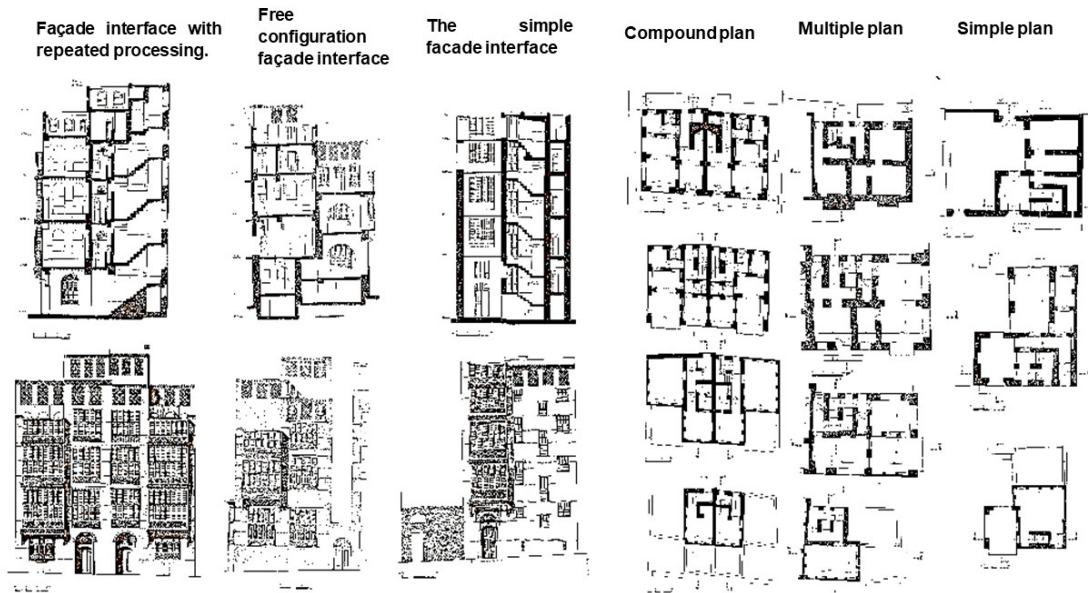


Figure (2). Plan and façades categorical illustration (Center 1411 AH).

penetrator to the house. Yet, lower social classes go for an affordable alternative named Shish. It is a sum of movable wooden slides fixed to the window to block the interior view, yet it does not lease a seating space like its posh counterpart (Al-Suwaiyan 2000). Roshan is a fancy teak façade protrusion, supported by Iron rails and stuffed with engraved and surface inscriptions and openings.

#### 4.Sustainable Housing and Sustainable Environmental House Design Basics.

Since sustainability implies eternity, green architecture is a newfangled eco-friendly trend. It works on meeting contemporary needs and securing futuristic ones. It opts to cut down the negative environmental impacts and the foundation, operation, and maintenance financial drawbacks. It is ideal to deal with our environment for a better life and a safe future.

A house is termed sustainable when it proves qualitative confidentiality of energy, water, and material consumption. Besides, it must manifest coherent interweaving with the vernacular design, and environmental, natural, artificial, and sociable factors. Last but not least, it must achieve

functional and environmental credentialed quality, which is measured by the satisfaction rates of the users, ecological protection, and public sanitation standards (Howard 2003).

Accordingly, sustainable houses are indispensable means to complement the energy and environmental discrepancies in an acceptable socio-economic framework. This complementation is prioritized throughout the developmental phases of a building; design, operation, and maintenance. Consequently, sustainability is the common denominator among proceeding housing projects and qualitative evaluators.

Housing sustainability has been the artery of global sustainability, which causes the anxiety of all scholars and intellectuals, especially those who stand on the horns of the environmental balance protection dilemma.

House design depends on a quadrilateral equation; site allocation, climate conditions, technological advances, and the cultural mindset of a community. Hereto, each design must be competent to handle these givens, bearing in mind its locality and criticality. This is to realize

a sustainable housing and balanced environment by adapting the integrated spaces within; motion paths, building formation, mechanical systems, and building technologies. Furthermore, it must convey a symbolic representation of the history, spiritual norms, costumes, and traditions that signalize the named region. These factors will result in the building's feasibility, sustainability, and aesthetic appeal.

In brief, sustainable housing caters to public health and the environment in the first place, where a building survives its life span efficiently. Undoubtedly, these houses have surpassed their virtual life span out of their qualitative proficiency. This housing reduced its unaffordable operation and maintenance costs, meeting the users' expectations compared to their neighborhood (Abou Liela 2018).

The harsh climate of these deserts necessitates a knowledgeable background of their local nature. Additionally, a designer must sort out the contrast between the shaded spaces and lighted surfaces. The entire sum of these obstructions grounded for the region's witnessed extraordinary house formation techniques.

Designing houses in such hot and dry regions is far from being simplistic. It relies on the direction and formation of the building, building materials selection, sufficient ventilation, and natural illumination. As for ventilation, the wind poles have been manipulated by the distribution of the openings. The size, direction, and ratio of wall openings must be considered. Thermal insulation and color scheme are equally significant. Likewise, the allocation of courtyards and atriums serves the same purpose, where water vaporization may be advantageous for interior cooling. As for illumination, some protrusions are added to the façades seeking a shading effect. Similarly, sunlight breakers are used to avoid internal refraction.

Housing units conform to several urban and architectural criteria to realize the optimum environmental design of each unit. These criteria are branched into two categories (Abou Leila 2011):

#### **4.1 Environmental Criteria**

This category indicates all the natural authoritative factors of a named site. It jets off

from the topographical formation of the region; mountains, hills, and valleys moving forward to the climatic conditions; heat, humidity, wind speed, and rainfall capacity. The kingdom lies between (16-46) latitude, north 29-34), east (40-55), and north-mid (23-30) longitudes. Therefore, the climate is not constant all over the country, yet it is continental. It is scorching in summer and extremely cold in winter, with little rainfall capacity in winter and spring. However, the southern mountainous regions are exclusively rainy in summer. The weather is generally humid on the western coasts and mountains and decreases inwards.

#### **4.2 Humane Criteria:**

It is correlated to the consecutive phases of the design processes, starting from its urban planning and design, passing by the environmental design of the project forms, and reaching the final stage of the architectural and technical innovations. This succession grants the utmost advantage of the mined natural resources within the respective site.

On the Urban Plan Level, Planners must select an easily reached site and develop its urban context. This step warrants the validity of its socio-economic and environmental fruition in the local community of the project. The topographical and morphological limitations and determinants of the site must be considered. Equally, the site's climate must domineer the form direction and allocation of spaces to achieve a meaningful visual presentation and climatic project orientation (Abo Al Ainen 2002).

On the Urban Design Level, Designers must conduct geological and topographical studies to detect their influence on the region's status and the architectural formation right there. On the same thread, they must dissect the public spaces and outdoors and the impact of plant composition on the landform. Visual studies and street networks must be delineated. Most importantly, designers must devote their effort to profiling the housing units' prototypes, connected and semi-connected, to actualize a flawless direction plan (AL Wakil 2007).

On the Environmental Design of Project Forms Level, the environmental, visual, and climate determinants are a must-study scope. These compulsory prerequisites would dictate the treatment strategy of the form shaping and opening directing. This orientation facilitates ventilation and illumination of the opening spaces. The finishing materials must be of a long-life span or affordably maintained local materialized ones to preserve the natural resources. On the other hand, designers are to opt for following the vernacular architectural style and its attribute character. Therein, the identity and sanctity of holy Makkah would grant their everlasting eternity in the Muslim world.

On the Architectural Design Level, Designers must dedicate their concern to the interrelation between pedestrian paths around the building itself and public means of transportation and private ones. Assertedly, they must study the interrelation between the private spaces within the building and the public ones. The outer crust of the building must meet the users' audio, visual, and thermal satisfaction within the houses. Colors, fences, surfaces, openings, and complimentary greeneries play a crucial role in realizing this effect.

On the Technical Design Level, it is all about making the utmost advantage of natural resources and renewable energy sources, rather than the obsolete normative ones, to operate the interior and exterior project elements sustainably. For instance, solar energy is a perfect electric network dynamo. It may also warm the spaces and heat the water streams for the quotidian routine. As for water resource protection, water could be saved and recycled. As for the pollution issue, the propagation of pollutants can be subdued by raising public awareness. The term environmental operation sums it up, where the essential natural resources are saved, and fundamental factors are manipulated within the project (water, petroleum, and electricity).

## 5. Materials and Methods:

5.1 Deductive, analytical, and descriptive methodologies of the Features of historic Vernacular Hijazi houses were analyzed in terms of plan

formation and facade analysis and used as models for sustainability and environmental analysis in the comparative analytical study.

5.2 Comparative analytical study on housing samples of the Ministry of municipal Rural Affairs and housing in the Holly Makkah Municipality after adding these models as models of sustainability and environmental analysis using:

- Sefaira web application (ASHARE.1.2013): to generate virtual utmost energy-saving scenarios during the daylight period
- Autodesk insight 360: to illustrate the power of solar energy usage to reduce the excessive consumption of non-renewable energy sources (Abou Liela 2017)

The housing samples are categorized by the Ministry of municipal Rural Affairs and housing as follows:

- Category (1) Duplex
- Category (2) Villa
- Category (3) Apartment (1) Flats

## 6. Results and Discussion.

The results section presents two key conclusions: feature of historical Vernacular Hijazi house plans and facades were identified. In the applied study, samples of urban and architectural style of traditional buildings in Makkah - categorized by the Ministry of Municipal Rural Affairs and housing - were reviewed before and after Modifications made by the research to revive the Hijazi character of the traditional buildings in Makkah Using simulation software.

### 6.1 Feature of historic Vernacular Hijazi houses plans and Façade

#### Findings of the Analysis of the Urban and Architectural Style of Vernacular Buildings in Makkah.

Like any cosmopolitan city, its distinct residents' cultures, norms, costumes, and traditions mingle and create a unique character from all its neighbors. Therefore, this hybridity has bestowed Meccan architecture with a distinguished style. This style is the fruition of the variant experiences

Table (2). Findings of the Vernacular Hejazi Houses Plan Analytical Studies.

Comparison point		Plans	
Type of the Plans	Simple Plans	Compound Plans	Multiple Plans
Popularity	Wide	Limited	Scarce
Size	small	Medium	Big.
Number of interior spaces	small	Moderate	Numerous.
Functionality	Multi-functional in a single space.	Exceeding one function in a single space.	Each space is for a function.
Number of Family Members	small	Moderate	big
Economic status of the family	poor	Moderate	wealthy
Space rental possibility rates	weak	Weak	Strong.

Table (3). Findings of the Vernacular Hejazi Houses Façade Formation Analytical Studies

Comparison Point		Façades	
Type of the Façade.	Plain Façade	Multi-treatment Façade	Free Form Façade
Popularity	Wide	Limited	Scarce
Size	Small	Medium	Big
Economic status of the family.	poor	Moderate	Wealthy
Inscribed engravings and details.	Modest	Moderate	Luxurious
Workforce category	Local	.Local yet skilled	.Imported professionals

(Abou Liela 2018)

and demands of the multinational fusion of Muslim citizens. The harsh environmental conditions in Makkah have affected its vernacular architecture beyond all bounds. The expansive vastness of vacant lands, where these houses are built, is nothing but the valley grooves between its mountains; that is why the novice architecture that has settled in Makkah is of a foreign attire and void of any sense of consolidation. The Haram has the upper hand in the Meccan vernacular architecture. This influence may be branched as follows:

**Positive Effect:** There, all buildings rally around it. Streets and routes are designed to look upon it. Most surprisingly, landlords were used

to renting specific chambers in their houses for pilgrims, as there were no hotels to serve this purpose long ago.

**Negative Impact:** Each annexation process of the Haram necessitates the elimination of the authentic vernacular houses lying within the project parameters. Since its downtown allocation, all the nearby housing units became unaffordable. Worse, the profit-motivated investors swept all the vernacular apartments to substitute them with gold-digging skyscrapers. The table below pinpoints the deducted analytical results of the urban and architectural vernacular style in Makkah.



**Table (3). Findings of the Vernacular Hejazi Houses Façade Formation Analytical Studies**

Style and Façades.	Openings	Windows	They are wooden frames with narrow openings for privacy concerns and swings to control light and air penetration.
		Roshan	It is extravagantly and artistically inscribed. It may differ in size, and some could be attached to seats.
		Entrances	They are of various sizes and manifestations and are ornamented with stone and gypsum.
		Braces	They were either circular, semi-circular, or pointed, where the latter is most prevalent.
	Aesthetic Elements.	Inscriptions	They are either gypsum or stone or wooden engravings. They may be even iron. They are always of botanical inspiration.
		Ornaments	They are a variety of decorations from gypsum, wood, stone, and even iron, and they have Arab, Indian, Asian, and other botanical styles.
		Accessories	The shutters in the cachet of the roof bestowed it with a unique beauty and elegance. They may be iron crafts, and they were known as Sky dames.
	General façade formation.	Skyline	Its enchanting grading all over the building, or the whole city has resulted from the earthly graded surface.
		Form and Vacuum	The vacant vastness exceeds that of the form, yet it is blocked by Roshans for privacy concerns, illumination, and ventilation.
		Sectors borders	It adds a minute protrusion on each higher floor.
Expressive elements of vernacular architecture in Makkah,	Physical factors.	Building materials	Local stones have been favored in this epoch to attain vernacular architectural style.
		Texture	Meccan buildings were distinguished for their roughness due to using natural building materials and leaving them barely covered. Then, this toughness has been gradually changed, after using wood instead of stone, buildings became bright white.
		Color scheme	At first, black was dominant due to using natural materials; opaque Chebiki stone. Afterward, other colors came to the surface; wooden shades and multi-pigment shutters. Then, pastel pigments started to flourish.
	Constructional factors	Exterior walls	The harsh weather conditions and bygone constructional strategies enforced adapting thick interior walls.
		Columns and crowns	They were not prevalent in traditional buildings, but they became stuffed with engravings and details when they did.
		Ceilings	The used wooden boards flattened the ceilings for roofing. The wood veins were left uncoated, and sometimes they were decorated and painted with various colors and patterns.
Building Textures of vernacular architecture in Mecca,	Exterior encasements.	Stone	It has many types: Chebiki stone is used in building basic walls, and Chamesi stone is used in construction for its leniency in sculpture. Other classes have multiple sources used to construct buildings, roads, and viaducts.
		Concrete	It is either a fastener concrete or cement-like to stick the stones altogether.
		Inflorescence	It is either a priming powder or a blended one with Sarooj to firm a compound bleaching clay.
		Ajour	It is multicolored. It is mainly used to cover higher openings, roofs, and curved windows.
		Wood	It is either local timber or imported, teak, Javanese wood, sandalwood, and beech, for Roshans, windows, and doors.
		Iron	It is often imported and used for ironworks.
	Interior encasements.	Floors	It is a three-phase process, soiling, battering, and slabbing.
		Walls	They are whitened, and wooden decorated; afterward, they had been painted for portrayals.
		Ceilings	They are either bare wooden boards or textured shingles
The colonial architectural profiles vernacular architecture in Mecca,	Ottoman	The caliphate proved its supremacy by introducing the ottoman style to Hejazi architecture.	
	Mamluks	It bloomed in the first Saudi Haram annexation. It has been cloned in the second annexation process seeking a unified pattern.	
	Indian	It is most prominent in Roshan's designs, ancient and modern buildings.	
	The Renaissance (Classic European)	It is a token of high social stratum, as it is applied to villa façades, using the cornices, entrances, and openings used in that era in sheer negligence to the Meccan norms and identity.	
	Historic revival style	It is a neoclassic orientation.	

## 6.2 Applied Studies on the Analysis of the Urban and Architectural Style of Traditional Buildings in Makkah.

The researchers have undergone a questionnaire on a large number of Saudi residents in Makkah. The results of this questionnaire are crystal clear in another research by the same researchers. The cited study discovers that the identity crisis can be sorted out using modern architectural techniques but keep on the traditional visual attributes of the Meccan housing units. The research recommended launching an initiative to unify the vernacular architectural style of each respective region. The recommendation suggests imposing housing design criteria and codes to meet the Saudi community's demands and social norms and conditions. This

does not infringe on the rigid design stipulations of hot environments by using appropriate architectural elements, either by adding atriums and courtyards or treating the façades to cope with the heat and vernacular style (Abou Leila 2021). These samples are categorized by the Ministry of municipal Rural Affairs and housing (Housing 2020) as follows.

- Category (1) Duplex
- Category (2) Villa
- Category (3) Apartment (1) Flats

The plans of Categories are presented by the Ministry of municipal Rural Affairs and housing were reviewed before and after Modifications made by the research to revive the Hijazi character of the traditional buildings in Makkah. Using simulation programs to study lighting, ventilation openings, internal courtyards, the treatment of external walls,

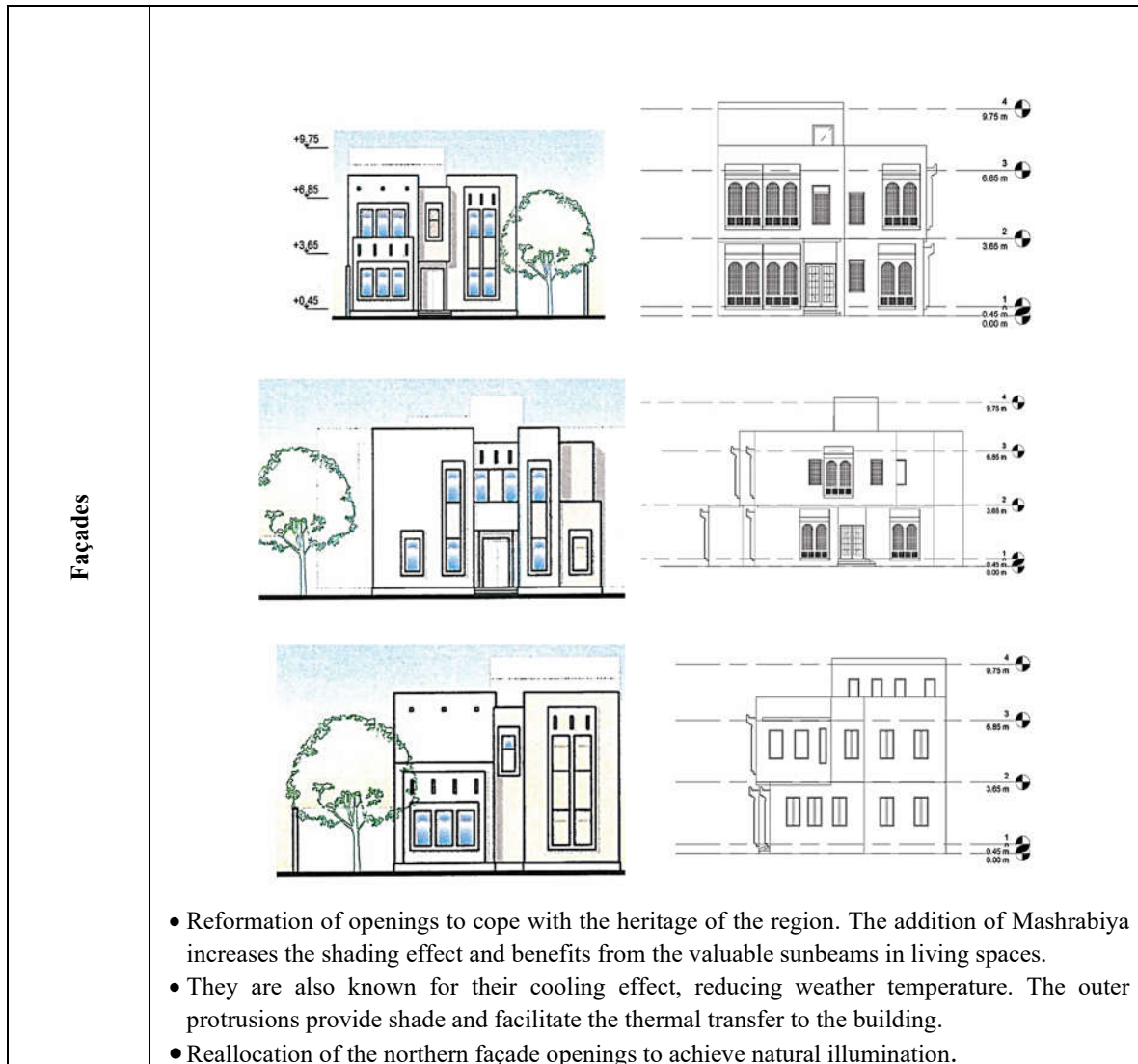
### Category (1) Duplex (1)

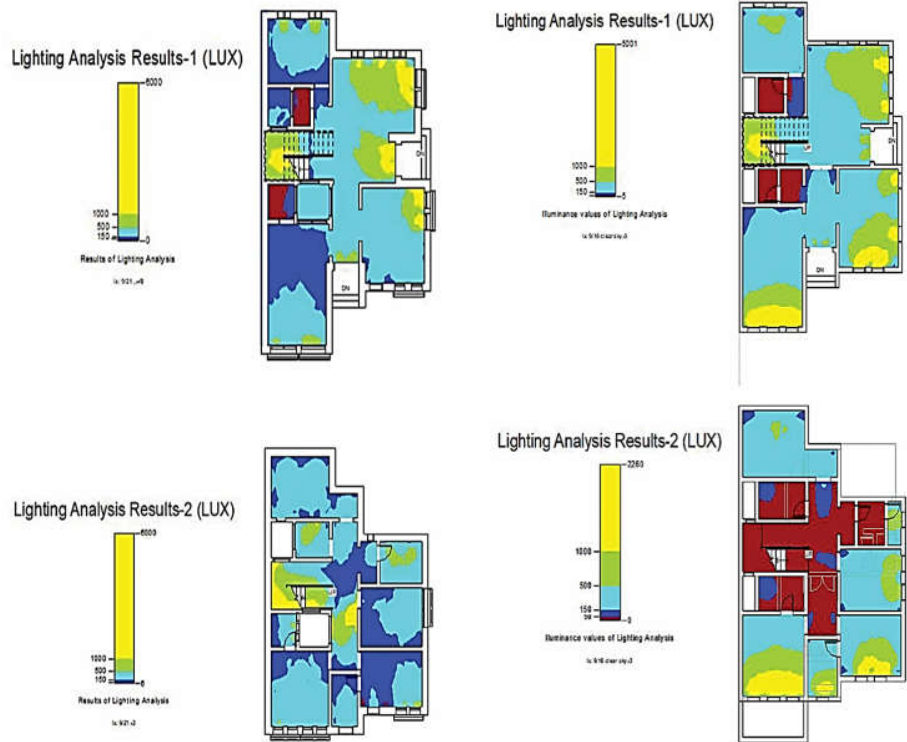


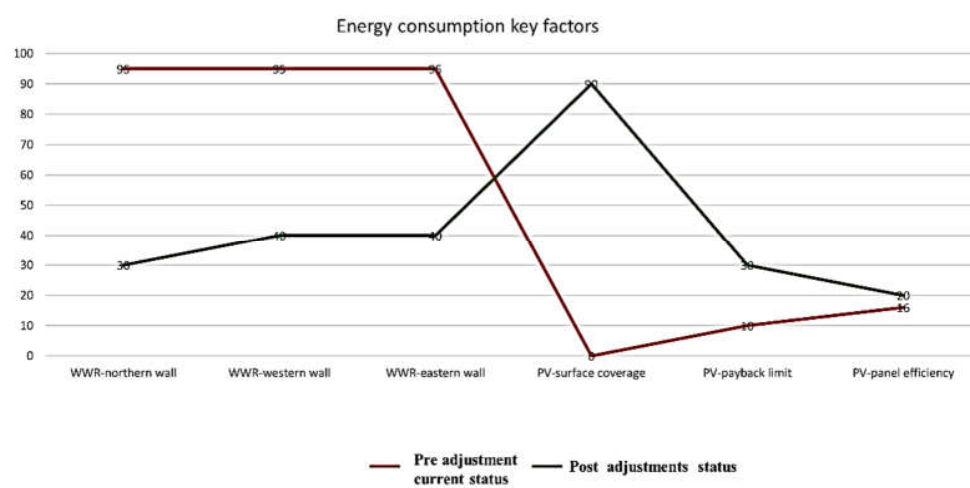
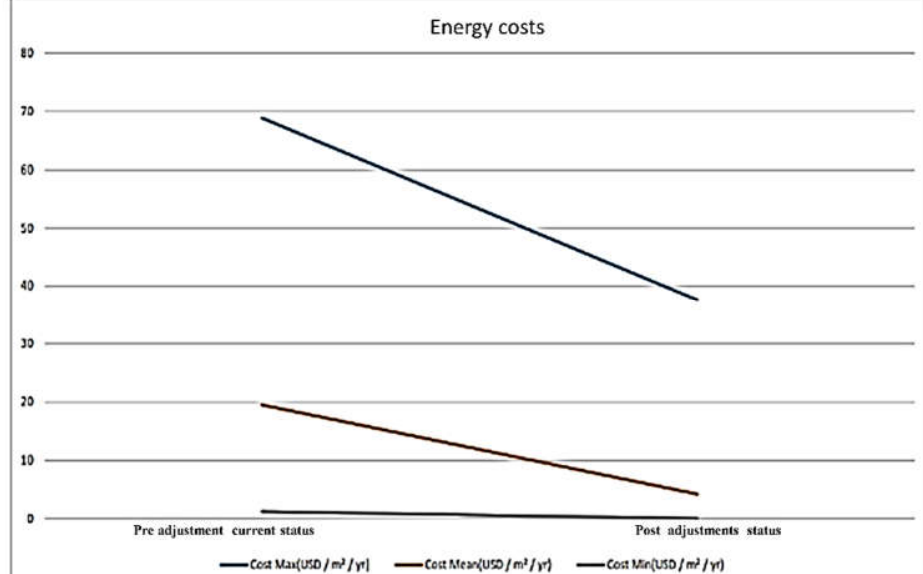
and some internal openings to achieve the concepts of sustainability and preserve the Hijazi Meccan character. This was used as a way of converting these buildings into sustainable buildings by studying the natural lighting in the current situation and presenting the measures taken to increase the proportions of natural lighting to reduce the energy consumed. The main elements controlling the

determination of the amount of energy consumed and reducing it, after the simulation process, then the heat transfer rates of the walls in their different directions were reviewed, in the current situation before and after the modification, and finally, the cost of the energy rates before and after the simulation was calculated.

Plans	<p style="text-align: center;"><b>Executed procedure</b></p> 
	<ul style="list-style-type: none"> <li>• Reallocation of openings along with the plan for a coherent illumination distribution.</li> <li>• Expanding the courtyard modified the plan to embrace a water element for natural ventilation and cooling.</li> <li>• A profusion of the southern and eastern wall thickness for less thermal transfer.</li> <li>• Addition of an upper window in the door, for illumination, where the different air pressure is efficient for ventilation.</li> </ul>



<p><b>Natural illumination</b></p>	 <ul style="list-style-type: none"> <li>• Increasing the percentage of illumination to the current situation by using openings directed towards the north to penetrate the sunlight beams, not heat.</li> <li>• Depending on the courtyard to increase the illumination, address the current status deficit.</li> </ul>
<p><b>Energy consumption.</b></p>	<ul style="list-style-type: none"> <li>• Autodesk Insight360 detects the critical sources of energy consumption and reduction strategies to analyze the database of energy consumption rates.</li> <li>• Applying thermal insulation materials to the façade quadrilaterals and the ceiling.</li> <li>• Adding Mashrabiya, to insulate the window's glass as in their post-adjustment illustration.</li> <li>• Controlling the quantitative and qualitative renewable productivity of solar panels.</li> </ul>
<p><b>Ventilation and technical facilities.</b></p>	<ul style="list-style-type: none"> <li>• A bilateral comparison between the current and post-adjustment status in ventilation, technical facilities, and electric energy consumption.</li> <li>• In the post-adjustment phase, the broadening and treatment of the openings provide ventilation and thermal comfort. The photovoltaic cells substitute the consumed electric energy in the building.</li> </ul>

<p>Energy consumption key factors</p>	 <p style="text-align: center;">Energy consumption key factors</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Factor</th> <th>Pre adjustment current status</th> <th>Post adjustments status</th> </tr> </thead> <tbody> <tr> <td>WWR-northern wall</td> <td>98</td> <td>30</td> </tr> <tr> <td>WWR-western wall</td> <td>95</td> <td>40</td> </tr> <tr> <td>WWR-eastern wall</td> <td>96</td> <td>40</td> </tr> <tr> <td>PV-surface coverage</td> <td>0</td> <td>90</td> </tr> <tr> <td>PV-payback limit</td> <td>10</td> <td>30</td> </tr> <tr> <td>PV-panel efficiency</td> <td>16</td> <td>20</td> </tr> </tbody> </table> <ul style="list-style-type: none"> <li>• The rates of wall thermal transfer in different directions</li> <li>• Red reflects the status quo, pre-adjustment.</li> <li>• Green reflects the post-adjustment status by shading or profusion of the wall thickness.</li> </ul>	Factor	Pre adjustment current status	Post adjustments status	WWR-northern wall	98	30	WWR-western wall	95	40	WWR-eastern wall	96	40	PV-surface coverage	0	90	PV-payback limit	10	30	PV-panel efficiency	16	20
Factor	Pre adjustment current status	Post adjustments status																				
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<p>Costs</p>	 <p style="text-align: center;">Energy costs</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Cost Type</th> <th>Pre adjustment current status</th> <th>Post adjustments status</th> </tr> </thead> <tbody> <tr> <td>Cost Max (USD / m<sup>2</sup> / yr)</td> <td>70</td> <td>38</td> </tr> <tr> <td>Cost Mean (USD / m<sup>2</sup> / yr)</td> <td>20</td> <td>5</td> </tr> <tr> <td>Cost Min (USD / m<sup>2</sup> / yr)</td> <td>1</td> <td>1</td> </tr> </tbody> </table> <ul style="list-style-type: none"> <li>• Energy costs are marked in red as the status quo pre-adjustment and in green post-adjustment status.</li> </ul>	Cost Type	Pre adjustment current status	Post adjustments status	Cost Max (USD / m <sup>2</sup> / yr)	70	38	Cost Mean (USD / m <sup>2</sup> / yr)	20	5	Cost Min (USD / m <sup>2</sup> / yr)	1	1									
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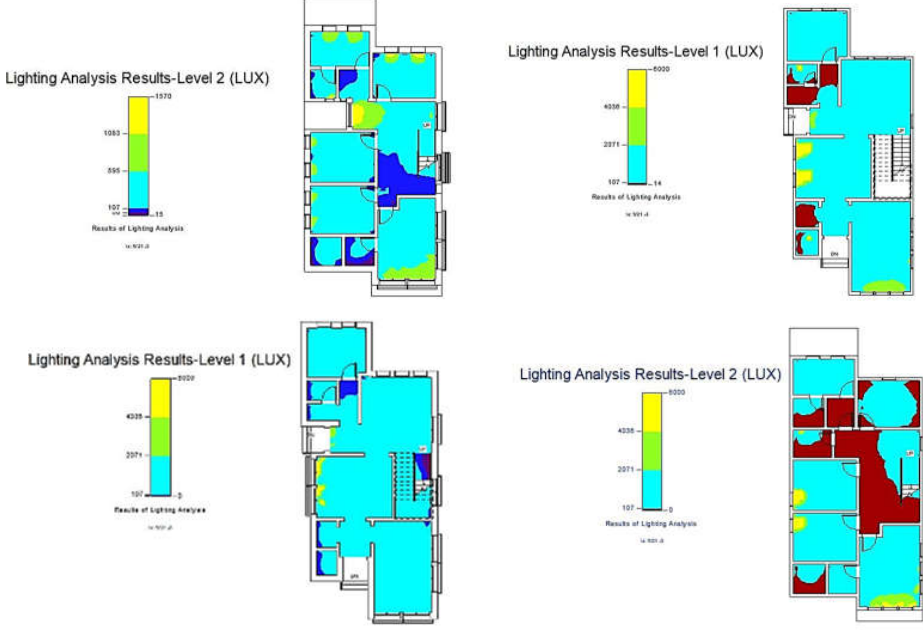
Category (2) Villa

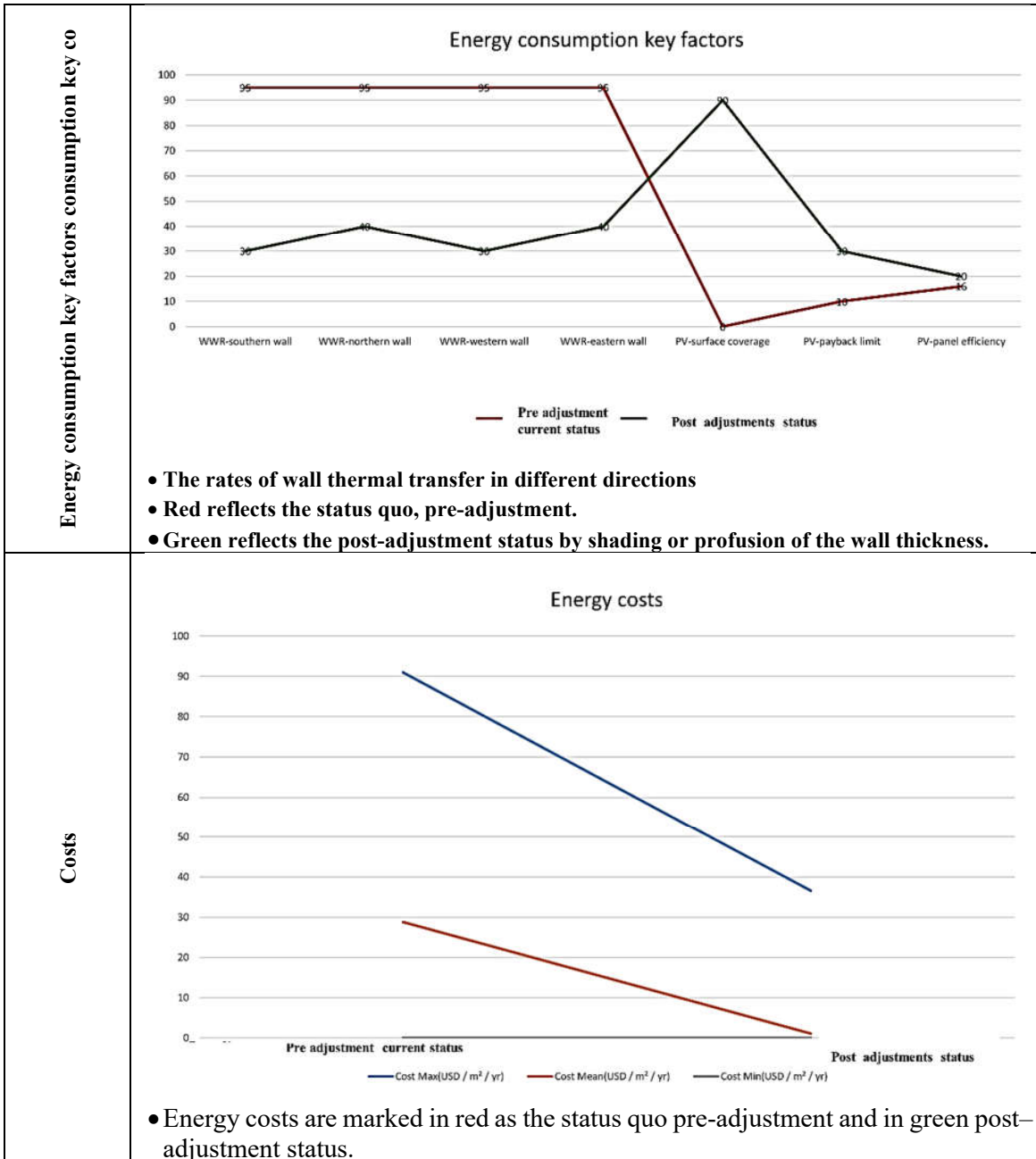
		Sample Data		
Villa				
				
				
		<p>Land dimensions = 25 x 15 meters                      Total land area = 375 square meters                      Built-up area 135 square meters                      The height is two floors and an extension</p>		

Plans	<p style="text-align: center;"><b>Executed procedures.</b></p> 
	<ul style="list-style-type: none"> <li>• Reallocation of openings along with the plan for a coherent illumination distribution.</li> <li>• Modification of the plan by expanding the courtyard to embrace a water element for natural ventilation and cooling.</li> <li>• A profusion of the southern and eastern wall thickness for less thermal transfer.</li> <li>• Addition of an upper window in the door, for illumination, where the different air pressure is efficient for ventilation.</li> </ul>

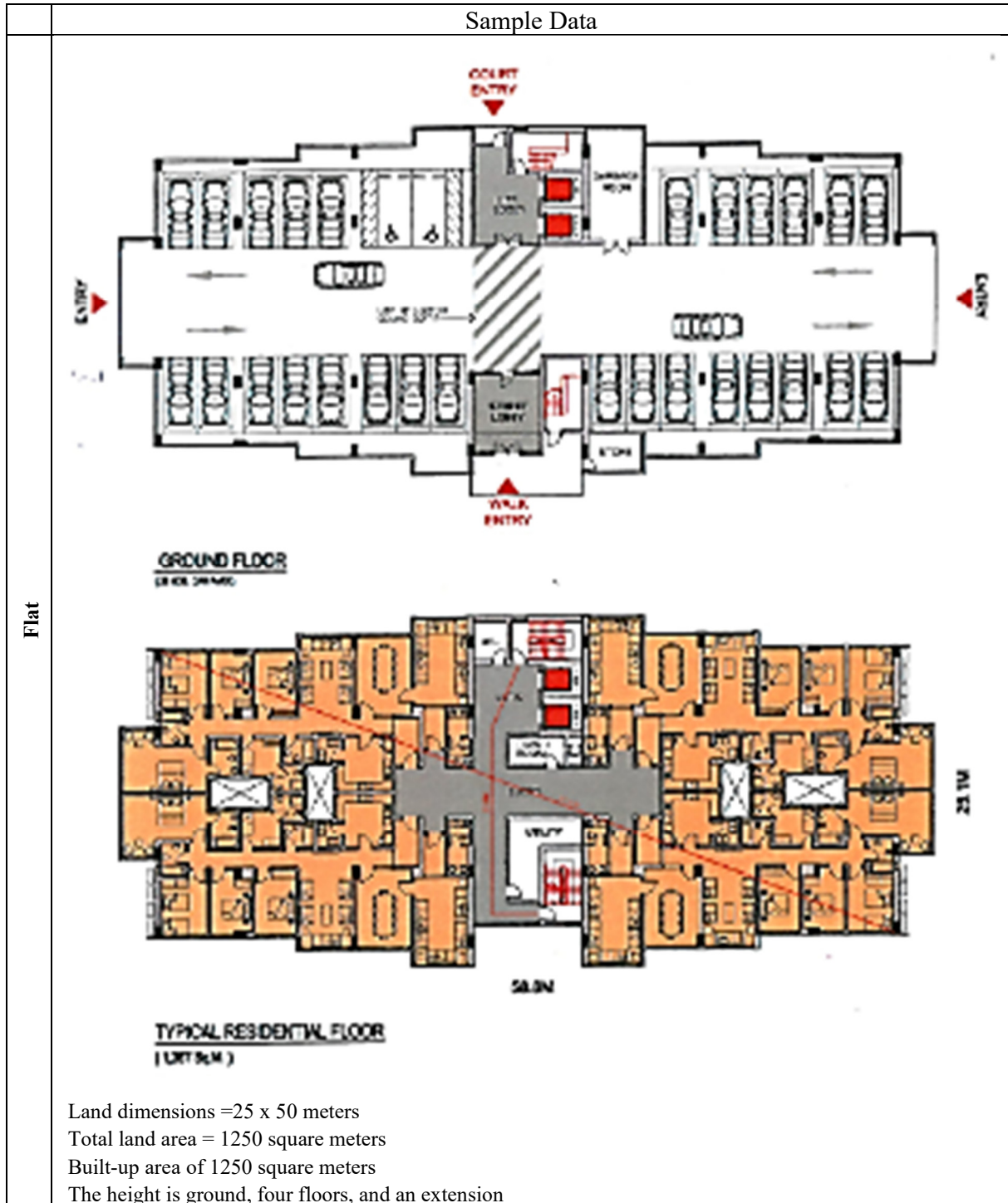


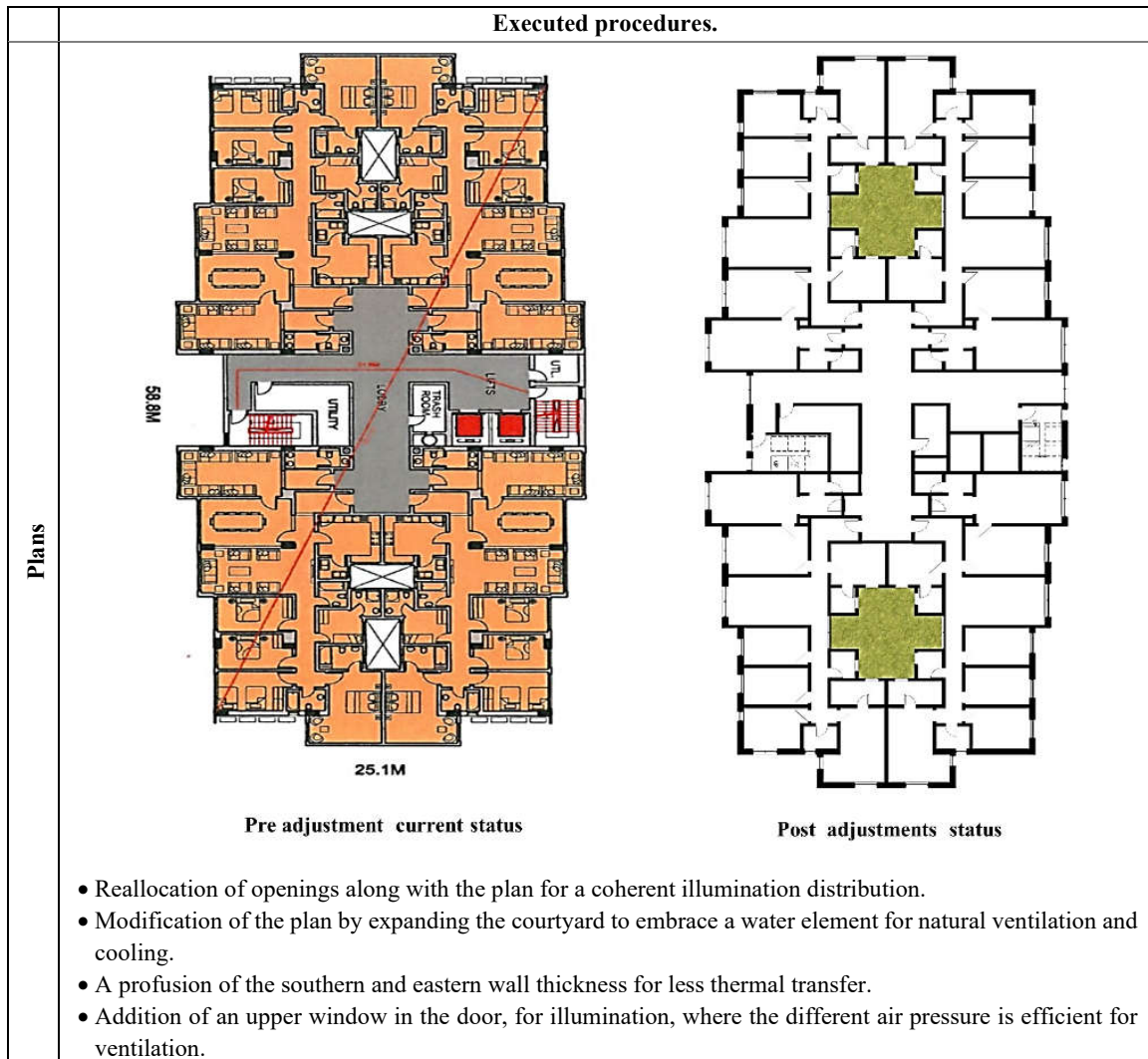


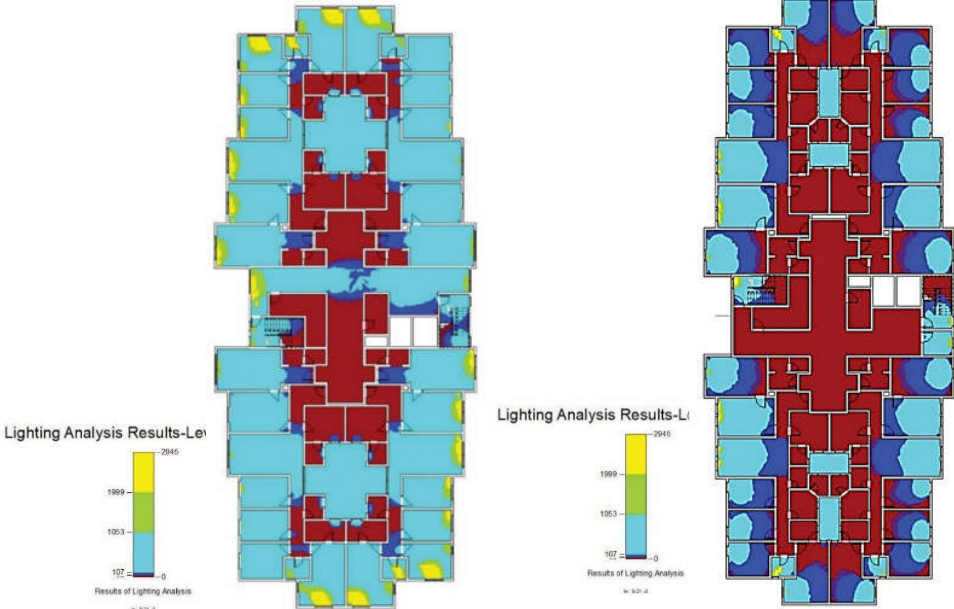
<p><b>Natural illumination</b></p>	 <ul style="list-style-type: none"> <li>• Increasing the percentage of illumination to the current situation by using openings directed towards the north to penetrate the sunlight beams, not heat.</li> <li>• Depending on the courtyard to increase the illumination, address the current status deficit.</li> </ul>
<p><b>Energy consumption</b></p>	<ul style="list-style-type: none"> <li>• Autodesk Insight360 detects the critical sources of energy consumption and reduction strategies to analyze the database of energy consumption rates.</li> <li>• Applying thermal insulation materials to the façade quadrilaterals and the ceiling.</li> <li>• Adding Mashrabiya to insulate the window's glass, as in their post-adjustment illustration.</li> <li>• Controlling the quantitative and qualitative renewable productivity of solar panels.</li> </ul>
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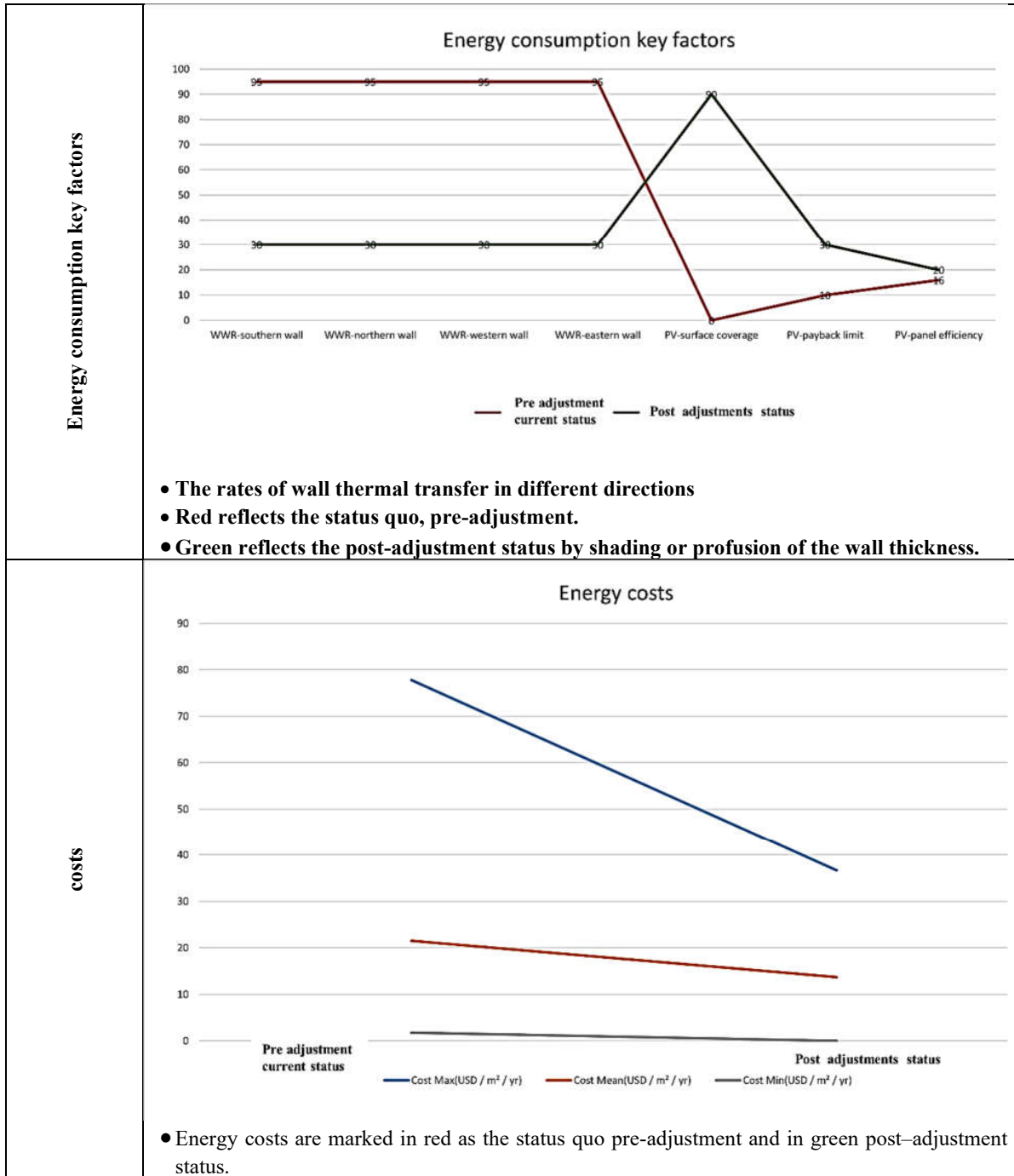


Category (3) Apartment (1) Flats





<p style="text-align: center;"><b>Natural illumination</b></p>	<div style="display: flex; justify-content: space-around; align-items: center;">  </div> <ul style="list-style-type: none"> <li>• <b>Increasing the percentage of illumination to the current situation by using openings directed towards the north to penetrate the sunlight beams, not heat.</b></li> <li>• <b>Depending on the courtyard to increase the illumination to address the deficit in the current status.</b></li> </ul>
<p style="text-align: center;"><b>Energy consumption</b></p>	<ul style="list-style-type: none"> <li>• Autodesk Insight360 detects the critical sources of energy consumption and reduction strategies to analyze the database of energy consumption rates.</li> <li>• Applying thermal insulation materials to the façade quadrilaterals and the ceiling.</li> <li>• Adding Mashrabiya to insulate the window's glass is their post-adjustment illustration.</li> <li>• Controlling the quantitative and qualitative renewable productivity of solar panels.</li> </ul>
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## 7. Conclusions

The research provides a vivid demonstration of the discipline of the Hejazi style revival process in Holly Makkah Municipality to achieve sustainable Saudi housing. The researchers display a decent variety of the offered study cases by the Ministry of Housing. No question, the research hypotheses have verified that Saudi houses in general and Meccan ones are directly inflected with the climate conditions and their subsequent changes. In this event, the environmental conditions of the Meccan parameters have proven to be authoritative in the coursework of the analytical and applied studies of the researchers, who spared no effort to realize sustainability and Hejazi's genuine identity. Theoretically speaking, the research has underlined many theoretical definitions and conceptions; revival, originality, and style. It further encapsulated the cardinal reasons that usurped the façades and vernacular Hejazi style formation in Makkah. This results from thorough deductive and analytical multifarious urban-architectural Hejazi style studies on the façades and plan facets. Afterward, it postulates the main stakes of sustainable housing design in hot desert regions, exfoliating the environmental housing design criteria. This perspective has been grounded on three genres of executed projects under the patronage of the Ministry of Housing; duplex, villa, and apartment. The research offers some modification recommendations to adjust the sustainability rates, by data analyzing the illumination capacity and energy recession, due to the dire need to reduce energy consumption. The comparative simulation points out the key factors of energy-saving techniques; wall thermal transfer conductivity and energy consumption affordability.

The research explores the urgency of:

1. Consolidating the theoretical conception of revival, style. Identity and sustainable housing.
2. Comprehending that the style of the façade in Makkah is affected by environmental, cultural, social, historical, and aesthetic criteria, which is blunt in the variation of the vernacular plan in accordance with its context in Makkah.
3. Valuing Roshan and Shish's aesthetic, functional, and environmental role as the milestone of the Hejazi façade vernacular constituents.

4. Using the mentioned software programs, recognize the importance of the recommended modifications after simulation.

### First: Plans

- As for natural illumination: Spacious courtyards are optimum to increase illumination and make up for the recent shortages. Direct the openings to the north, penetrate the sunlight, yet avoid its fatal thermal beams. This step required the reallocation of spaces in a consistent pattern.
- As for natural Ventilation: Spacious courtyards are still there to embrace water elements for ventilation and cooling. By adding a sliding upper window with a different air pressure standard, doors have been modified to endow the house with natural illumination and ventilation.

### Second: Façades and outer crust

- The modification of the opening's forms, and introduction of glass insulation techniques, integrating them with Roshan and Mashrabiyyah in respect of heritage have increased the shading effect. Moreover, the living chambers made advantage of the useful sunlight beams, blocking out the harmful ones. Also, protrusions have been beneficial all over the façades, reducing the façade thermal transfer probabilities.
- The reallocation of openings on the northern façade achieves the utmost illumination and ventilation effect.
- The profusion of the southern and eastern façades thickness reduced the thermal transfer conductivity towards the inner spaces.
- The addition of insulation materials on the quadrilateral façades and ceilings of the building controlled the penetrating heat to the interior chambers.
- The utilization of solar energy panels and its precedent renewable energy production rates with its photovoltaic cells substituted most of the electric energy consumption rates in the building.

## 8. Recommendations

The problem of preserving the local character and identity of the residential buildings in the city of Makkah Al-Mukarramah remains one of the urgent and necessary points in light of the city's



cosmopolitanism and the rush of all Muslims from all over the world. It is thus essential to preserve the urban and architectural character of Makkah, and the research came out with some recommendations as follows:

#### **Recommendations related to the policies of the Ministry of Municipal and Rural Affairs and Housing**

- Staying updated about the environmental, economic, social, political, and cultural changes that affect housing strategies, which necessitates finding channels and paths to collect information related to these areas from their sources, constantly updating them with developments and changes, evaluating them and determining their impact on housing strategies, and then developing or amending these strategies. In line with all developments.
- The need to work on establishing an initiative to authenticate the local character in the various regions of the Kingdom.
- Providing a set of regulations, legislation, and incentives that enable and motivate citizens to preserve the spatial identity of the different cities of the Kingdom, each according to its region.
- Providing a set of advanced housing models in design and specifications in line with the requirements of citizens and the conditions and customs of Saudi society, which at the same time works to preserve the spatial identity of the cities of the Kingdom of Saudi Arabia.
- Municipalities' engineers and specialists in municipalities of cities and local councils must be provided with a mechanism for applying the principles of building design and treating the hot environment by developing and codifying the use of architectural elements suitable for each region through the use of internal courtyards, for example, if they are suitable for those areas or not, or in Treatment and design of facades to suit the local character and climate condition.

#### **Recommendations related to achieving Sustainable Housing in Makkah.**

Preserving the use of architectural elements, units, and items of eco-friendly architecture, such as air hooks and lofts, must be maintained; as local characteristics that achieve sustainable development in modern buildings and the use of the

system of openings Mashrabiyyah that enrich the architectural structure.

- Establishing a specialized auditing bureau to monitor the new construction processes and provide eligibility licenses, to abide by the modern architecture code, yet not infringe the Hejazi vernacular style and the hot environment techniques.
- Enforcing the façade treatment techniques, protrusions, upper lofts for ventilation, windshields, and vertical and horizontal sunlight breakers in buildings could be very effective to protect from sunbeams and intensify the shadows on the building facades.

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## إعادة إحياء الطابع الحجازي المكي .. نحو تحقيق مسكن سعودي مستدام دراسة حالة نماذج من المسكن السعودي بمدينة مكة المكرمة

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قدم للنشر في ٢٢ / ٣ / ١٤٤٤ هـ؛ وقبل للنشر في ٨ / ٨ / ١٤٤٤ هـ.

ملخص البحث. يعدُّ عدم استيعاب مشروعات الإسكان التي تنفذها وزارة الشؤون البلدية والقروية والإسكان السعودية والتي تتم في إطار رؤية المملكة ٢٠٣٠، لتأثيرات ومفهوم الاستدامة في إطار من الحفاظ على الهوية التراثية في المملكة بعامة، وفي منطقة مكة التي تتميز بطرازها الحجازي ومدينة مكة المكرمة بخاصة، مؤثراً على ضياع الطابع الحجازي المكي. ويهدف البحث إلى محاولة إحياء الطابع الحجازي المكي من خلال تطوير عدد من النماذج التصميمية للمساكن المختلفة المطروحة من قبل وزارة الإسكان السعودية؛ مراعاة للخصائص البيئية والطابع العمراني والهوية التراثية الخاصة بمنطقة الدراسة، وذلك من خلال عمل دراسة تحليلية وتطبيقية على ٣ نماذج سكنية (دوبلكس، وفلا سكنية، وعمارة سكنية) من المشروعات التصميمية المقترحة من قبل وزارة الإسكان السعودية، من خلال استخدام تطبيق (ASHRAE Sefaira web application 90.1.2013) لمقارنة خصائص وتحليل بعض نماذج الإسكان، وعمل محاكاة لدراسة بعض العناصر التي تؤثر على استدامة المساكن، وعمل عدد من السيناريوهات الافتراضية لاستخدام الحد الأدنى من الطاقة في وضح النهار؛ بدراسة عنصر الإضاءة الطبيعية، ومعدلات الانتقال الحراري بالحوائط، وتكلفة الطاقة قبل وبعد عمل المقترحات والتعديلات على تلك النماذج وعمل محاكاة على الحالتين، كما تم استخدام (Autodesk insight 360) لإظهار أهمية استخدام الطاقة الشمسية، وعُملت محاولات لأفضل استفادة منها لإدخال أكبر قدر منها لتقليل الطاقة المستهلكة غير المتجددة، حيث توضح الدراسة كيفية استخدام أسلوب الإحياء الحجازي المطبق على النماذج التي قدمتها أمانة مكة المكرمة لتحقيق سكن سعودي مستدام، كما أوصت الدراسة بتوظيف العناصر المعمارية وبنود العمارة الصديقة للبيئة من الطراز الحجازي في الخطط المستقبلية للإسكان السعودي المستدام.

الكلمات المفتاحية: إعادة الإحياء، الطابع الحجازي المكي، المسكن التراثي المستدام، المسكن السعودي.