

## **Islamic architectural ecological philosophy in contemporary Egyptian residence**

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### **Abstract**

The research discusses the relation between the modern ecological design trends and the preservation of the identity taking advantage of the ecological Islamic design in contemporary Egyptian residence, where the research aims to avoid interior designs that help to drain energy and resources, polluting the environment and adverse impact on human health, also it aims to philosophy preservation of Islamic content in interior design re-using Islamic vocabulary environmental substances in the contemporary Egyptian residence. Finding the formulation of the contemporary Egyptian residence design by Islamic heritage vocabulary with its environmental content.

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### **Keywords**

*Islamic architectural; Ecological design; Egyptian residence; Identity*

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### **1. Introduction**

The modern trend towards ecological buildings is the inevitable future entrance to harmonize between the functional and physical requirements of mankind and the balance of nature surrounding him as a kind of peace with it. It is the process of designing buildings in a manner that preserves the environment, reducing energy and resources depletion and reducing the negative impacts on the environment and human beings. The Islamic architectural heritage is governed by fixed rules and architectural philosophy that achieves most of the objectives of ecological design through design functionality that suits the needs of the user taking into consideration the surrounding environment, this philosophy is reflected in Islamic buildings, especially residential buildings.

Thus, we can take benefits of the Islamic ecological design philosophy to the contemporary Egyptian residence to develop designs that achieve modern trends in buildings, which urges us to connect with the surrounding environment, using the philosophy and vocabulary of Islamic heritage to confirm identity within the control of modern thought.

#### **1.1. Research problem:**

1. Spread of designs that help to drain energy, pollute environment and have negative impact on human health in the inner space.
2. Separation between the trends of modern interior design such as ecological design, and the preservation of the Arab Islamic identity.

### 1.2. Research objectives:

1. Importance of interior design functionality, to suit the needs of the user taking into consideration the environment, and avoid designs that help to drain energy and resources, polluting the environment and adverse impact on human health.
2. Preserving the Islamic content in the interior design by reusing the Islamic vocabulary environmental substances in the contemporary Egyptian residence.
3. Finding the formulation of the contemporary Egyptian residence design by Islamic heritage vocabulary with its environmental content.

### 1.3. Research Methodology:

Research pursues the historical approach, and descriptive analytical approach. The historical approach demonstrates the historical relationship between ecological design and Islamic architecture in its different eras. The descriptive analytical approach in order to describe and analyze the modern ecological design trends in the inner space and its relation to the philosophy of Islamic architecture and how to formulate it in contemporary Egyptian housing.

## 2. Principles of ecological design in buildings:

Understanding the environment, ecosystem and the impacts of the buildings on it is one of the most important approaches to understand the ideas and principles of ecological buildings and the best way to apply them. The principles of ecological buildings are ideas capable of overcoming Drain of energy and resources, pollution of the environment, negative impact on the health of building users (Hayles 2015), (Waziri 2002), they are summarized in the following table:

Table 1. The principles of ecological buildings

<b>Natural energies use:</b>
<ul style="list-style-type: none"> <li>- Use of natural and renewable energies</li> <li>- Use of building materials with a large thermal capacity.</li> <li>- Openings Design that helps flow of lighting and natural ventilation</li> </ul>
<b>Eco building materials</b>
<ul style="list-style-type: none"> <li>- Local and high probability materials</li> <li>- Low energy consumption materials</li> <li>- nonpolluting Materials</li> </ul>
<b>Saving Water</b>
<ul style="list-style-type: none"> <li>- Rationing water use</li> <li>- Reuse of wastewater</li> <li>- Use of rainwater</li> </ul>
<b>Indoor air quality</b>
<ul style="list-style-type: none"> <li>- Avoid using materials pollute or help concentrate pollutants in the air</li> <li>- Use of natural ventilation systems</li> <li>- Porous materials to Control moisture.</li> </ul>

**Table 1 Continued**

<b>Lighting quality</b>	
Rationing industrial light energy: - Use types of lighting closer to natural light - Selection of energy saving types	Provide natural lighting: - The presence and distribution of openings to obtain natural light - Open spaces - Building heights for non-blocking of natural light
<b>Sound design</b>	
- Efficiency of walls to prevent transmission of sound - Floors with a noise absorption degree - Plant trees on the noise side.	
<b>Safe design of the building</b>	
- Region Study to avoid natural hazards - Avoid hazards that threaten the safety of the building or its occupants - Alternative materials for inflammable materials	
<b>Harmonious Architectural Style to surrounding environment</b>	
- The architectural Style & form must correspond to the surrounding environment historically and socially. - Study the cultural heritage throughout the ages to inspire the appropriate style for surrounding environment and contemporary society.	

### 3. International Systems for Environmental Design:

With the increase of the world's interest to the environment and hence the idea of environmental buildings, they began to develop assessment systems of ecological buildings, including:

#### 3.1. BREEAM (Building Research Establishment Environmental Assessment Methodology):

BREEAM was developed in the United Kingdom. It is the oldest system for assessment and environmental classification of buildings. Buildings are rated and certified on a scale of Pass that achieves 36%, Good 48%, Very Good 57%, Excellent 68% and Outstanding ([www.Breeam.org](http://www.Breeam.org)).

Table 2. BREEAM Points of evaluation and standards

<b>BREEAM Points of evaluation and standards</b>	
<b>Standards</b>	<b>Evaluation</b>
<b>Energy and carbon dioxide emissions</b>	19%
* The rate of emission in the house * Effect of building material on energy	* Environment-friendly classified goods. * Low power source consumption
<b>Water</b>	6%
* Water consumption inside the house	* water use outside the house

**Table 2 Continued**

<b>Materials</b>	12.5%
* Environmental impact of materials * Sources of materials for secondary elements	* Sources of materials for basic
<b>Waste</b>	7.5%
* Warehouse for recyclable waste	* Management of waste generated by construction
<b>Pollution</b>	10%
* Influence in global warming	* Nitrogen oxide emissions
<b>Health &amp; Wellbeing</b>	15%
* Daylighting * Special space	* Sound insulation * Age of the house
<b>Management</b>	12%
* Home User Guide * Effects of construction	* Security * Consider the plans of contractors
<b>Ecology</b>	10%
* The environmental value of the site * Protection of environmental features	* Effects of construction on the environment * Additions and environmental improvements
<b>Transport</b>	8%
* Connected to public transport network * Maximum parking space	* Convenient transportation

**3.2. LEED (Leadership in Energy and Environmental Design):**

LEED is the most widely used green building rating system. Aims to help owners and operators of buildings to take environmental responsibility and use resources efficiently. Buildings are rated and certified on a scale of four levels, Certified that achieves 40–49 points, Silver 50-59 points, Gold 60-79 points, Platinum 80 points and above (Reeder 2010).

Table 3. LEED Points of evaluation and standards

<b>LEED Points of evaluation and standards (V4 edition):</b>	
<b>Standards</b>	<b>Evaluation points</b>
<b>Transportation means &amp; location</b>	<b>16</b>
Non- polluting means of transport and protection of land	
<b>Sustainable Sites</b>	<b>10</b>
Ecological Sites & design strategies	

**Table 3 Continued**

<b>Water Efficiency</b>	<b>11</b>
Water use reduction	
<b>Energy and Atmosphere</b>	<b>33</b>
Improve energy efficiency for entire building	
<b>Materials and Resources</b>	<b>13</b>
Waste management & ecological materials	
<b>Indoor Environmental Quality</b>	<b>16</b>
Management of and improvements to indoor air quality, Low-emitting materials, sunlight benefit	
<b>Innovation in Design</b>	<b>6</b>
Creativity in design, Cultural awareness; impacts and challenges; historical or heritage awareness.	
<b>Regional Priority</b>	<b>4</b>
Total points	110 points

### 3.3. GPRS (Green Pyramid Rating System Levels):

The Green Pyramid Evaluation System was established in 2009 by the Egyptian Council for Green Building. Global systems that could contribute to the development of the Egyptian Green Pyramid, such as the LEED system, were used. The system was developed according to the Egyptian laws of construction and the integration of methodologies and techniques that have proven successful in using the programs of the United States, Europe, Asia and the Middle East (The Egyptian Green Building Council 2011).

There are levels of green building certification according to the Egyptian classification system for green architecture, Certified that achieves 40% to 49%, Silver pyramid 50 to 59%, Golden pyramid 60 to 79%, and Green pyramid 80% or higher assessment points.

Table 4. GPRS certification category points

<b>GPRS certification category points</b>		
<b>Categories</b>	<b>points</b>	<b>credits</b>
<b>Sustainable Site, Accessibility, Ecology</b>	<b>10</b>	<b>15%</b>
<ul style="list-style-type: none"> <li>- Desert area development</li> <li>- Informal area redevelopment</li> <li>- Brownfield site redevelopment</li> <li>- Compatibility with National Development Plan</li> </ul>	<ul style="list-style-type: none"> <li>- Transport infrastructure connection</li> <li>- Catering for remote sites</li> <li>- Alternative methods of transport</li> </ul>	<ul style="list-style-type: none"> <li>- Protection of habitat</li> <li>- Respect for sites of historic or cultural interest</li> <li>- Minimizing Pollution during construction</li> </ul>

**Table 4 Continued**

<b>Energy efficiency</b>		<b>50</b>	<b>25%</b>
- Energy Efficiency Improvement - Passive External Heat Gain Reduction - Energy Efficient Appliances - Vertical Transportation Systems	- Peak Load Reduction - Renewable Energy Sources - Environmental Impact - Operation and Maintenance	- Optimized balance of Energy and Performance - Energy and Carbon Inventories	
<b>Water efficiency</b>		<b>50</b>	<b>30%</b>
- Indoor Water Efficiency Improvement - Outdoor Water Efficiency Improvement	- Water Feature Efficiency - Water Leakage Detection - Efficient water use during construction	- Waste water management - Sanitary Used Pip - Efficiency of Water-based Cooling	
<b>Materials and Resources</b>		<b>20</b>	<b>10%</b>
- Regionally procured materials - Materials fabricated on site - Use of readily renewable materials	- Use of salvaged materials - Use of recycled materials	- Use of lightweight materials - Use of higher durability materials - Use of prefabricated elements	
<b>Indoor Environmental quality</b>		<b>20</b>	<b>10%</b>
- Optimized Ventilation - Visual Comfort	- Thermal Comfort - Acoustic Comfort	- Controlling emissions from building materials	
<b>Management</b>		<b>20</b>	<b>10%</b>
- Containers for site materials waste - Employing waste recycling workers on site - Access for lorries, plant and equipment - Identified and separated storage areas	- Project Waste Management Plan - Engaging a company specialized in recycling - Protecting water sources from pollution - Waste from mixing equipment	- Control of emissions and pollutants - Providing a Building User Guide - Providing a Periodic Maintenance Schedule	
<b>Innovation and Added Value</b>		<b>10</b>	<b>Extra</b>
- Cultural Heritage	- Exceeding Benchmarks	- Innovation	

#### **4. Ecological Interior Design Standards:**

Ecological interior design standards are an extension of green and sustainable design principles, and as part of a comprehensive environmental system, Ecological interior design works to achieve the physical and psychological health of humans in enclosed environments. Through taking into account the systems and materials used in the design process to have a positive impact on the ecosystem and work to reduce the negative effects on the environment and human health (Todd and Todd 1994).

By studying principles of ecological design in buildings, systems and codes of environmental design for buildings and internal spaces, we can have inference of aspects of interest to achieve ecological design in the interior spaces and divide them into three aspects as shown in the table below:

Table 5. Ecological aspects in interior design:

<b>Environmental side</b>	<b>Functional side</b>	<b>Aesthetic side</b>
<b>Save energy and reduce resource depletion</b>	<b>Visual and Acoustic comfort</b>	<b>Innovation and Design</b>
<ul style="list-style-type: none"> <li>- Natural and renewable energy sources.</li> <li>- Building materials with large thermal capacity for thermal insulation.</li> <li>- Use water to adjust moisture and purify and cool the air.</li> <li>- Reuse of wastewater and rainwater.</li> </ul>	<ul style="list-style-type: none"> <li>- Efficiency of walls to prevent transmission of sound.</li> <li>- Floors with a noise absorption degree.</li> <li>- Plant trees on the noise side.</li> <li>- Openings design for visual privacy.</li> </ul>	<ul style="list-style-type: none"> <li>- The architectural Style &amp; form must correspond to the surrounding environment historically and socially.</li> <li>- Study the cultural heritage throughout the ages to inspire the appropriate style for surrounding environment and contemporary society.</li> </ul>
<b>Ecological materials</b>	<b>Secure design</b>	
<ul style="list-style-type: none"> <li>- Regional, higher durability materials</li> <li>- Non-polluting materials.</li> <li>- Energy efficient materials and raw materials.</li> <li>- Porous materials to control moisture.</li> </ul>	<ul style="list-style-type: none"> <li>- Study the region to avoid natural hazards.</li> <li>- Avoid hazards that threaten the safety of the building or its occupants.</li> <li>- Avoid inflammable materials.</li> <li>- Protection against harmful atmosphere.</li> </ul>	
<b>Ventilation quality</b>		
<ul style="list-style-type: none"> <li>- Openings design that help flow of natural ventilation.</li> <li>- Use of natural ventilation and heating systems.</li> </ul>		
<b>Lighting quality</b>		
<ul style="list-style-type: none"> <li>- Openings design that help flow of daylight.</li> <li>- Opened spaces.</li> <li>- Energy-saving industrial lighting types.</li> </ul>		

## 5. Components of Ecological Interior structure:

The aim is to create interior environment that works as Natural ecosystems and as living machines, and the adoption of principles and concepts that help the interior components to sustain themselves. Main components of interior are responsible for losing or gaining heat, and by design treatments they became environmental mediators that have vital functions in the interior space (Todd and Todd 1994).

### 5.1. Walls, Ceiling, Floor:

- Distribution and height of walls and their positions to openings encourage the flow of air and light.
- Finishing materials must be eco materials, whether they are paints, wallpaper or tiles.
- Floors must be covered with materials that absorbs noise, like wood panels, cork or recycled rubber

- Ceiling is preferred to be sloped and as high as possible, to help flow of natural ventilation and daylight (Hayles 2015).

## 5.2. Doors and Windows:

- Windows Glazing systems that allow a specific range of solar radiation to flow within the air, reducing solar thermal gain.
- Internal shading systems should work to reduce light glow, provide privacy, and prevent indoor air leakage. The southern, eastern and western openings need internal shade and the northern openings do not need to be shaded except for privacy or designing purposes.
- Doors and windows materials must be eco materials.
- Make sure there is no air leakage that reduces the function of systems of heating and cooling of the vacuum.
- Adjust the size and position of the door in return with windows and openings to help flow of natural ventilation (Ibrahim 2006).

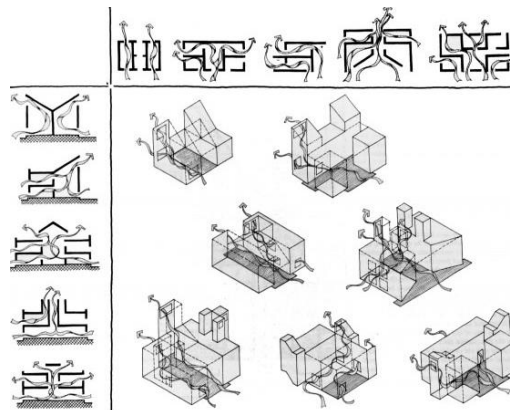


Figure 1: Role of openings in air flow

## 5.3. Ventilation and Lighting:

### 5.3.1. To improve the flow of natural ventilation design should include both ventilation systems; wind ventilation and buoyancy ventilation; design must take into considerations the following points:

- Improving the function of ventilation openings, ensure the absence of external constraints (plants or nearby buildings) or internal (furniture and domestic items).
- Entry openings for air and exit openings inside the space, this could include openings on the wall facing the wind, others on the opposite wall or in the ceiling.
- Air entry openings preferred to be low, and air outlet openings to be at a higher level, to larger air permeates the space.
- Use of courts and skylights to provide thermal comfort in internal space, especially at night.
- Presence of external shading for southern openings (Theweny 2008).

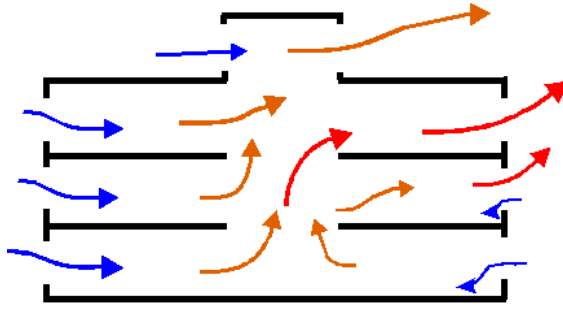


Figure 2: wind ventilation

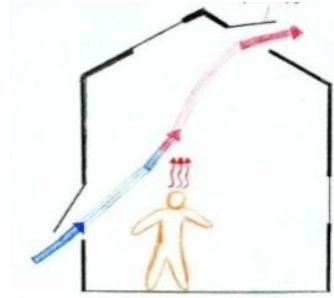


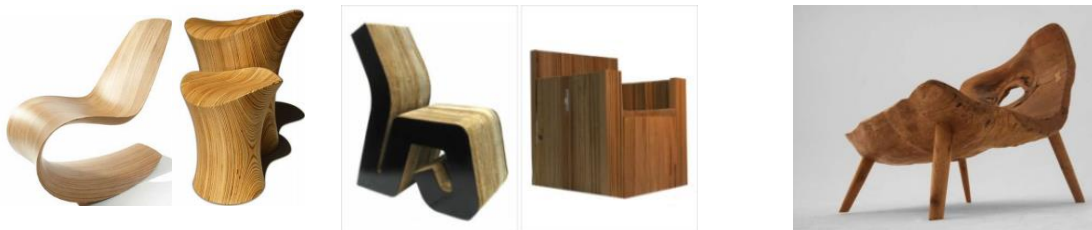
Figure 3: buoyancy ventilation

**5.3.2. To improve the flow of natural light, the design must be integrated with artificial light. There are two strategies of natural lighting:**

- Side lighting: wall openings, it is preferred to be high, openings on western and eastern walls works to gain as much light without glow or gaining heat.
- Top lighting: roof openings, good distribution of openings provide good distribution of light in internal space. This type of lighting is used in one story building or in the upper floor of multi stories building.

**5.4. Furnishing:**

- Eco furnishing must be made by eco standards, like: (Vicente et al., 2009)
- Materials of furnishing preferred to be raw local materials, recycled, or renewable.
- Provide as much benefits to the user as possible like Multifunctional, and durable furniture.
- Textile and manufacturing process free of harmful chemicals.



a) Hand sculptured chairs,durable and had no harm impact on environment

b) Furniture made of falling leaves, and tree peels

c) Natural fusing to install tree units together using wooden nails and organic adhesives

Figure 4: Eco Furniture

**6. Ecological vocabulary and processors in Islamic Residence:**

Islamic architect used ecological methods and vocabulary in buildings adapting to climate data, where the environment of Islamic communities in the Arabic region characterized by desert climate and high solar temperature through using some vocabularies and processors in Islamic architecture, including:

**6.1. Building shape & orientation:**

Building in Islamic city is characterized by not being long, which yields largest amount of interior spaces away from the external climatic conditions to achieve internal thermal stability. Building forms is complicated blocks to provide shadows. Best building orientation and openings was north, then the south

Where the shading process was as easy as possible. Islamic buildings fluttered openings to the west as much as possible. Using solar energy in winter rooms and energy stored in walls and ceilings (Waziri 2003).

## 6.2. Building materials:

Using Light-colored local materials with high thermal insulation properties helped to decrease temperature and increase humidity as:

The **mud-brick**, natural substance that can provide thermal insulation of the building **Brick** and red bricks, helps to provide good thermal insulation in interior spaces **Stone**, provides good thermal insulation, limestone helps to keep the interior spaces cold most daily hours. **Wood**, provides a porous property and reduce convection and construction on the building and spaces underneath (Waziri 2004).

## 6.3. Refracted Entrance:

Indirect entrance Provides visual privacy, also it protect interior space from dust and external noise (Waziri 2004).

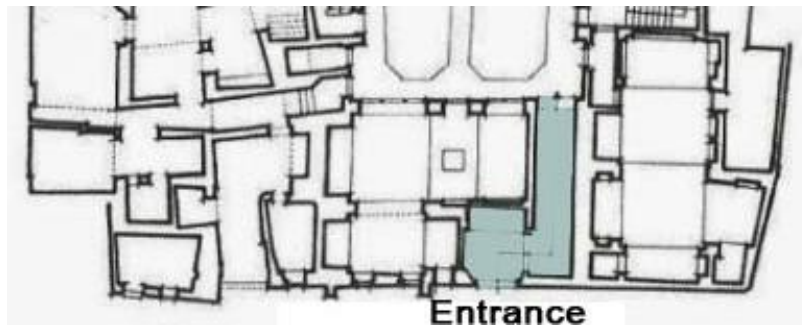


Figure 5: Refracted entrance

## 6.4. Inner courtyard:

The internal courtyard is the constant element in the various Islamic buildings, whether religious or a civil, in mosques and religious building is an open area surrounded by arcades, and in houses surrounded by walls. Is an opened space of the building to achieve environmental and social objectives? The roofing of the courtyard provides the possibility of maintaining the coolness required at night. It is possible to roof most or part of the yard, for the protection from sandstorms and extreme heat (Theweny 2008).

In residences, the courtyard is the center of the house, main rooms face it, most of openings overlook the courtyard, and also most of house activities are held in or around it.

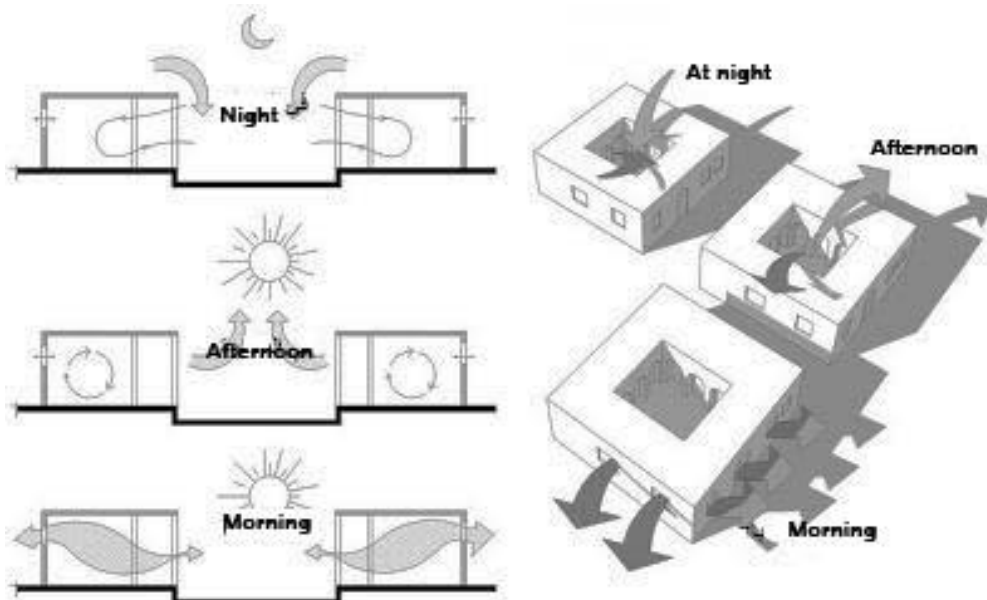


Figure 6: Flow of air in courtyard through the daytime

### 6.5. Shokhshekah:

Is a difference in the level of the ceiling of the architectural space having small openings, that allow the exit of hot air rising up. It is used to cover the main halls and help to provide ventilation and indirect lighting to the room. It is either in the shape of a wooden dome, circular or polygonal form.

### 6.6. Malqaf (wind catcher):

'Malqaf' is one of the distinctive elements in the Islamic buildings especially in the hot areas. It is defined as entrances that ventilate the building in the presence of air exits. It is a wooden roof above the building in a sloped way with an entire open side facing the direction of the desired wind and directed to the inside of the house to temper the atmosphere the hall. (Okasha 1994)

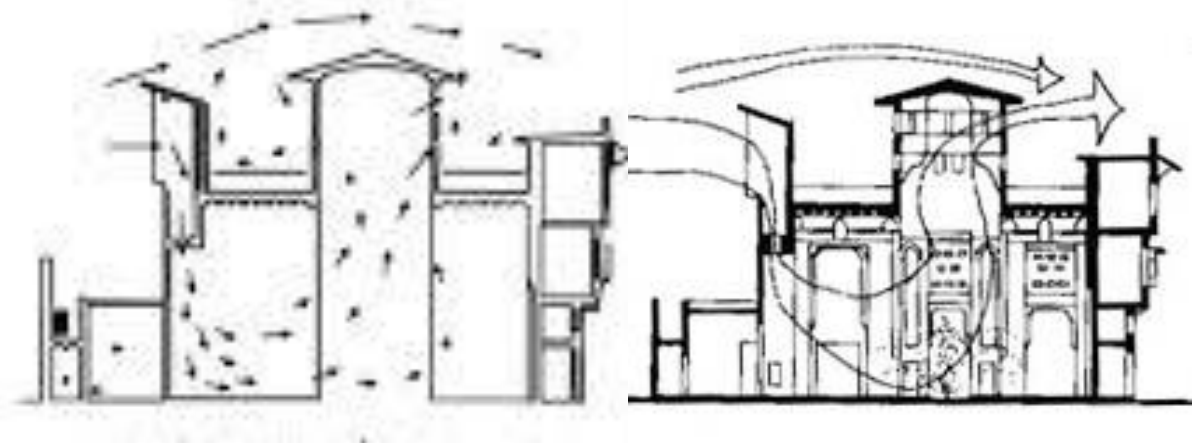


Figure 7: Movement of air inside building in presence of Malqaf & shokhshekah

### 6.7. Windows and openings:

The window is the opening that penetrates a wall and may be narrow from the inside and wide from the outside to expand the viewing angle and prevent direct rays from entering. The windows were made of plaster and were engraved by geometric or floral motifs, filling the gaps with colored glass, known as 'shamsiat', and windows with smaller volumes called 'kamriat'. (Waziri 2004)

### 6.8. Mashrabiah:

A wooden window, is made of geometric, square or triangular shapes with decorative elements and inscriptions. It allows gentle air to enter easily because of the rotation of its parts. It helps absorb some of the humidity in air as it is made of wood that absorbs moisture and does not allow direct sunlight, and usually exist in the external interfaces to provide privacy. It is provided with internal glass to protect from coolness in winter and dust. (Theweny 2008)

### 6.9. Ceiling treatments:

Some insulating materials, such as fiberglass and light bricks, were used to isolate the heat absorbed by the ceiling. The sloping and gable ceilings were used. These included the elevation of part of the interior area, allowing the hot air to move upward. The increase in roof area reduces roof heat average. Part of the ceiling is shaded most of the day, acts as a heat radiator absorbs heat from the exposed part of the sun and from the internal air and then radiates to the outside air (Ali 2007).

### 6.10. Plants & water:

To add beauty feature in addition to the role played in the mitigation of temperature and increasing humidity. Water was used in various forms like fountains and salsabil. Plants has many health and climatic benefits. It is effective in reducing noise, absorbing heat and reducing speed of harm air currents and dust storms (Waziri 2002).

Table 6. Ecological aspects that Islamic residence achieves:

<b>Environmental side</b>			
<b>Save energy and reduce resource depletion</b>	<b>Ecological materials</b>	<b>Ventilation quality</b>	<b>Lighting quality</b>
<ul style="list-style-type: none"> <li>- Natural and renewable energy sources.</li> <li>- Building materials with large thermal capacity for thermal insulation.</li> <li>- Use water to adjust moisture and purify and cool the air.</li> </ul>	<ul style="list-style-type: none"> <li>- Regional, higher durability materials</li> <li>- Non-polluting materials.</li> <li>- Energy efficient materials and raw materials.</li> <li>- Porous materials to control moisture.</li> </ul>	<ul style="list-style-type: none"> <li>- Openings design that help flow of natural ventilation.</li> <li>- Use of natural ventilation and heating systems</li> </ul>	<ul style="list-style-type: none"> <li>- Openings design that help flow of daylight.</li> <li>- Opened spaces.</li> </ul>
<b>Functional side</b>			
<b>Visual and Acoustic comfort</b>		<b>Secure design</b>	
<ul style="list-style-type: none"> <li>- Efficiency of walls to prevent transmission of sound.</li> <li>- Openings design for visual privacy.</li> </ul>		<ul style="list-style-type: none"> <li>- Protection against harmful atmosphere.</li> </ul>	
<b>Aesthetic side</b>			
<b>Innovation and Design</b>			
<ul style="list-style-type: none"> <li>- The architectural Style &amp; form correspond to the surrounding environment historically and socially.</li> </ul>			

## 7. Results:

1. Ecological design can be achieved in interior design, avoiding interior designs that help to drain energy and resources, polluting the environment and adverse impact on human health.
2. The possibility of connecting between the modern ecological design trends and preservation of identity.

## 8. Conclusions:

1. Recommending interior and architectural designer to control and reduce designs that help to drain energy and resources and pollution of the environment and negative impact on human health in the internal space.
2. Public awareness and dissemination of the importance of ecological design and concerning the environment to reconcile the functional and physical requirements of the human and the balance of nature surrounding it.
3. The role of the state in finding solutions to reduce pollution of the environment, and the establishment of ecological buildings and housing without losing identity, especially in new cities and youth hostels, to spread this concept among the community.
4. The interior designer's interest in heritage and cultural heritage and awareness of the ecological, cultural and social content of Islamic heritage architecture.
5. Importance of producing and using ecological raw materials in various fields of life, especially in interior design and furniture.

## References

- Ali, S. (2007 April). Impact of environmental dimension on Urban planning and Islamic architecture, *AlAzhar ninth international engineering conference*, Egypt.

- Azab, K. (2003). *The cultural and architectural heritage of the Islamic cities*. The House of Scientific Books for publication and distribution.
- BREEAM. (2020). Retrieved from <https://www.breeam.com/>.
- Hayles, C. S. (2015). Environmentally sustainable interior design: A snapshot of current supply of and demand for green, sustainable or Fair Trade products for interior design practice. *International Journal of Sustainable Built Environment*, 4(1), 100-108.
- Here's How to Practice Sustainability With Your Furniture. (n.d.). Retrieved from <http://furniture.about.com/od/furnitureterms/qt/su22409le.htm>
- Ibrahim, M. (2006). *The New Environmental Structure in Internal Architecture* [PhD Thesis]. Alexandria University.
- Kibert, C. J. (2016). *Sustainable construction: green building design and delivery*. John Wiley & Sons.
- Okasha, T. (1994). *Aesthetic values in Islamic architecture*. Dar Shorouk first.
- Reeder, L. (2010). *Guide to green building rating systems: understanding LEED, Green Globes, Energy Star, the National Green Building Standard, and more (Vol. 12)*. John Wiley & Sons.
- The Egyptian Green Building Council (2011). *The Green Pyramid Rating System publication*, First Edition.
- Theweny, A. (2008) *Environmental orientation in Islamic architecture*. Alnoor (Independent cultural media center).
- Todd, N. J., & Todd, J. (1994). *From eco-cities to living machines: principles of ecological design*. North Atlantic Books.
- Vicente, J., da Silva, F. M., & Frazão, R. (2009). Sustainable Design: A furniture focused approach. In *IN CORTE-REAL, E., COUTO, A. & DUARTE, C.(Eds.) IADE 5Th International Conference. Lisbon, IADE*.
- Walker, A. (2010). Natural Ventilation: National Renewable Energy Laboratory. Retrieved from: <https://www.wbdg.org/resources/naturalventilation.php>
- Waziri, Y. (2002). *Applications on Environmental Architecture, solar design of the inner courtyard*. Matbouly library.
- Waziri, Y. (2003). *Environmentally Friendly Architecture Design Towards Green Building*. Arab Printing and Publishing.
- Waziri, Y. (2004). *Islamic Architecture and Environment, The Tributaries that Formed Islamic Reconstruction*. Knowledge World, Kuwait.