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Water Sustainability in Islamic Architecture as a Guide-line for Contemporary Architecture

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ABSTRACT

The principles of water sustainability are not exclusive to one civilization without the other this make led the research problem to emerge as a question: "What is the methodology of water sustainability in Islamic architecture and how it can be used as a guide-line for achieving water sustainability in contemporary architecture?". To answer this question the research in its theoretical study demonstrated three points, begun with presenting the functions of water in Islamic architecture, then it explained how Islamic architecture depended on water as a design tool in the process of place making, and it ended with determining the principles and criteria of water sustainability in Islamic architecture. The research determined the methodology of achieving water sustainability in Islamic architecture. Depending on this methodology the research analyzed two case study projects: Alhambra palace in Spain and Al-Ghuri Sabil in Egypt, and then the research applied this methodology in one of contemporary housing projects in Egypt, and this led the research to emphasize its main hypothesis which state "the principles and criteria of water sustainability which preexists in Islamic architecture can be used as a guide-line for achieving water sustainability in contemporary architecture".

Keywords: Contemporary Architecture, Islamic Architecture, Water Sustainability.

1 RESEARCH INTRODUCTION

Water has a great importance not only for human but also for all living things as the source of life. Quran mentioned "We made from water every living thing" that God created water before He created the heavens and the earth "And his Throne was upon water" [1]. In Quran to render God's generosity three types of water mentioned: the rain, fountains and river. From architectural point of view Quran mentioned water as a main component of the space in the Paradise, Quran mentioned that water flows in all of its parts to soothing thirst and brings coolness, " In it are rivers of pure water, and rivers of milk forever fresh…" [1]. Water is used in architecture for three functions: environmental functions, aesthetical functions and symbolical functions.

1.1 The Research Problem

From shading light on water in Islamic architecture the research observed three points:

- Water has been studied in term of its architectural and artistic qualities, while its sustainability criteria among the scholars at the field of Islamic architecture had not gained considerable attention.
- There is no study dedicated to explain how Islamic architecture depended on water as a design tool in the process of place making.
- There is no methodology determined the principles and criteria of water sustainability in Islamic architecture and also there is no one formulated them in a guide-line formula for achieving water sustainability in contemporary architecture.

The research problem can be formulated on a question this research tried to answer: **"What is the methodology of water sustainability in Islamic architecture and how it can be used as a guide-line for achieving water sustainability in contemporary architecture?"**

1.2 The Research Hypotheses

The research based on two hypotheses they are:

- In generating the design of the buildings Islamic architecture depended on a design generative technique, this technique used water as a design generator factor
- The principles and criteria of water sustainability in Islamic architecture can be used as a guide-line for achieving water sustainability in contemporary architecture.

1.3 The Research Structure

In light of understanding water sustainability in Islamic architecture this study is divided into five parts as shown in figure (1): The first part is the research introduction, which presented the research problem and hypothesises. The second part is the theoretical study which demonstrated three points, begun with presenting the functions of water in Islamic architecture, then it demonstrated how Islamic architecture depended on water as a design tool in the process of place making, and it ended with determining the principles and criteria of water sustainability in Islamic architecture. The third part presented the methodology of water sustainability in Islamic architecture, which contains a corpus of principles and procedures for achieving water sustainability at the level of the urban design and at the level of the architectural design of the building. Then the research reached to the fourth part in which analyzed the criteria and principles of water sustainability in two of case studies, Alhambra Palace in Spain and Al Ghuri Sabil in Egypt. The fifth part is the applied study; it utilized the methodology of water sustainability in a model of contemporary housing projects in Egypt. Finally the research reached to formulate its main results

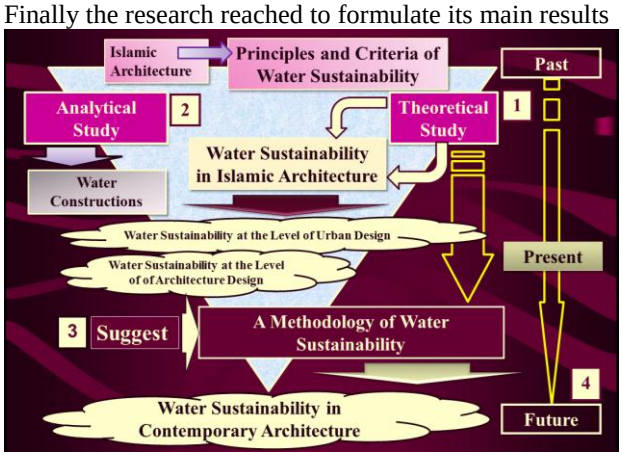


Figure 1: The research idea and research method [Author]

1.4 Definitions

1.4.1 Water Architecture

It is the architecture which depended on water as a design tool and a design element regardless of its position in the building. It is architecture directed by water sustainability criteria which extracted from Islamic teachings and doctrine and its form expresses the spirit of Islam [Omar,2000]. From contemporary architecture point of view the water architecture is the architecture which depended on the dynamic and fluid nature of water to make life in harmony with nature and and from water building and landscaping design gets its form not only at the level of urban design but also at the level of architectural design.

1.4.2 Water Cities

Water cities are urban communities that overlap water bodies and water forms the urban and environmental pattern of the community [2]. Water communities are widely distributed in Egypt, such as some fishermen's villages in the northern lakes, and the city of El Gouna. The research determined four main types of water cities, as follows:

1- Canal Cities: It is cities that were formed intertwined with water bodies through a large number of water channels which used as transportation means and divide the city into a group of islands connected to each other by bridges, as Venice – Italy in figure (2).

2- Artificial Islands City: it is a man-made island, as Dubai's Palm Jumeirah

3- Floating Cities: They are pools that are built floating on the surface of the water without foundations, as Water buurt West – Amsterdam.

4- Stilt Cities: it built over a body of water on stilts or columns fixed at the bottom that separate the building from the water, as Kampong Ayer – Bronaay

(a) (b)

Figure 2: Water City a)Venice-Italy, b)The Pearl Qatar [3]

1.4.3 Water Sustainability

Water sustainability concerns with the ethical/environmental/social dimensions of human welfare and the equity between generations. Brain Edward in his book "Sustainable architecture" concluded that the criteria of water sustainability can be seen in three aspects, as follows:

- Water supply for a variety of uses done in a safe matter.
- conserving, managing and preserving water as an economic resources, for example recycling rain water to be reused in irrigation, car-washing and paths.
- Controlling storm-water in streets to avoid damage.

It must also be clear that all secrets and the overall vision of water sustainability in Islamic architecture are uncovered at the moment and will be so for decades.

1.4.4 Sustainable Architecture

Architecture: In his "Muqaddimah" the historian Ibn Khaldun observed that building is a basis of civilization, and is of the most indispensable crafts which man ought to gain knowledge of: "This (architecture) is the first and

oldest craft of sedentary civilization. It is the knowledge of how to go about using houses and mansions for cover and shelter. He start thinking on how to avert the harm arising from heat and cold by using houses which have walls and roofs to intervene between him and those things on all sides, and this is architecture in its simplest definitions[6]. Sinan the chief architect of the Ottoman eras said: "It is obvious that building with water and clay being an auspicious art, the Children of Adam felt an aversion to mountains and caves and from the beginning were inclined to cities and villages. And because human beings are by nature civilized, they invented day-by-day many types of buildings [7].

Sustainable Architecture:

The word sustainability used for the first time in a book "Sylvicultura oeconomica" by a German scientist Hans Carl in 1713[4], and the first definition of sustainability is set out in the Brundtland Report in 1987 "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"[5].

Sustainable architecture has three integrated and not separated aspects: environmental, economic and social aspects. It makes environmental, economic and social elements as close to perfection as possible, for example it concerns with minimizing environmental harm, preserving historic sites, and utilizing in buildings locally renewable/recyclable resources [9].

1.4.5 Islamic Architecture

Researchers differed in defining Islamic architecture. Is it architecture that was built by Muslim hands, architecture that was built in Islamic societies, or is it architecture that follows the teachings, principles, values, beliefs and spirit of the Islamic religion?. Islamic architecture is a style of architecture has two sides, One is apparent which is the architectural forms/functions, the second is hidden which is the identity of Islamic culture and civilization. The both sides has been translated into reality by the hands of Muslims regardless of time or place. Alfred Frazer said about the nature of Islamic architecture: "The architecture of Islam is the expression of a religion and its view of the world rather than that of a particular people or political or economic system" [10].

2 THEORETICAL STUDY

To understand how Islamic architecture achieved water sustainability at the level of urban design and at the level of architectural design this part focuses on four points: it begun with demonstrated the functions of water in Islamic architecture, then presented how Islamic architecture depended on water as a design tool in the process of place making, then presented water constructions and ornamental water in Islamic architecture, then determined the principles and criteria of water sustainability in Islamic architecture

2.1 The Functions of Water in Islamic Architecture

The Holy Quran mentioned water several times (59 times) as an important element in the creation of heavens and lands that's why architect in Islamic architecture depended on water as a tool delivered his religious beliefs into reality in the design of different buildings.

Water is used in Islamic architecture for three basic functions. The first is environmental function to a void the wilderness of nature in hot, dry climates through providing thermal comfortable inside spaces. The second is aesthetical functions to emphasize visual axes and to reflect the adjacent architecture. The third is symbolical functions to present the life-giving, and purifying.

In mosques, gardens and houses water placed at the center of them for the following reasons:

- To symbol the spiritual purity of Muslim's inside.
- In Islamic architecture mosques considered as a real entrance to the high world, and from the spiritual symbolism point of view the fountains in the middle of the courtyards is a door to the other world [11].
- Water in the design of buildings employed as a visual continuity element throughout leading the user's eyes in a long, straight vision axis connecting different architectural functions.

2.2 Water As A Design Tool In The Process Of Place Making In Islamic Architecture

Although Islamic architecture has undergone several studies over different periods, a majority of mainstream researchers still omit water from their developmental theories on architectural designs. Most of the available literature on Islamic architecture is mainly from historical point of view rather than understanding water as a design tool. To understand how Islamic architecture based on water as a design tool in the process of place making this section starts with explains the role of water in the concept of space then shades light on the methodology of using water as a design generator in Islamic architecture.

2.2.1 Water in the concept of space

The research defined the architectural water-space as a functional space designed by water, a space in it water is a basic component of the architectural function, a space in it water adds geometric characteristic and aesthetic values to it, a space in it water fulfill the social requirements and physical needs of the users. Water in the concept of space differs in the urban space from the architectural space as follows:

2.2.1.1 Water in the concept of urban space

The most important effect of water in the concept of urban space is making visual continuity to the space character, this seen clear in Islamic architecture in three positions. The first is in each building independent and the visual continuity in this case occurs between the courtyard as internal urban space and the functions

around it. The second is in the urban space between the building and its urban context. The third is between the internal space and the external landmarks as in the mutual relationship between the fountain in Muayied Shiekh courtyard and the Minarets of Bab Zwaylla.

2.2.1.2 Water in the concept of the architectural space

The research determined three characteristics of water by which the water affects the concept of the architectural space, as follows in table (1) and figure (3):

Table 1. Types of characteristics by which water affects the concept of the architectural space [Author]

characteristics	Water composition
Movement	Static water as pools, it spread static feelings on the users of space
	Dynamic water as fountain, it impose dynamism on space
Depth	Deep water: used to reflect surroundings
	Shallow water: it illuminate its intricately-patterned, tiled basin
Form	Water linear form: to make axis
	Water compact form: to make points

(a) (b)

Figure 3: Water in the concept of urban and architectural spaces: (a) Visual continuity in the courtyard by water, (b) Water linear form to make linear visual axis [Author]

2.2.2 The Methodology of Using Water as a Design Generator

To the processes of design in different eras of Islamic architecture Islam drawings were not seen as essential [12], from this notion and by depending on the research hypothesise which is "In generating the design of the buildings Islamic architecture depended on a design generative technique, this technique used water as a design generator factor" this section illustrates how the automatic derivation of Mamluk madrasa plans have been reached by depending on the water element which control the process of "designing" as a backbone of it.

The methodology of using water as a generator of design in Islamic architecture outlined a design generative technique in which the design process divided into a fixed sequential steps and cumulative stages, this is being essential to uncover some secrets of design methods in Islamic architecture.

2.2.2.1 The Steps Of The Generative Technique

The technique of using water as a design generator for the plan design formulated in five steps as follow:

Step 1: pre design step (site analysis)

In which the designer determines the qibla direction and the site boundry.

Step 2: placing the water spaces

In which the designer determines the Sabil position and the courtyard' fountain position

Step 3: placing the visual element which connect the water spaces with the urban context

In which the designer determines the position of the entrance, the minaret and the dome.

Step 4: completing the architectural functions

In which the designer completse the design of the entrance, courtyard, the iwans and the mausoleum.

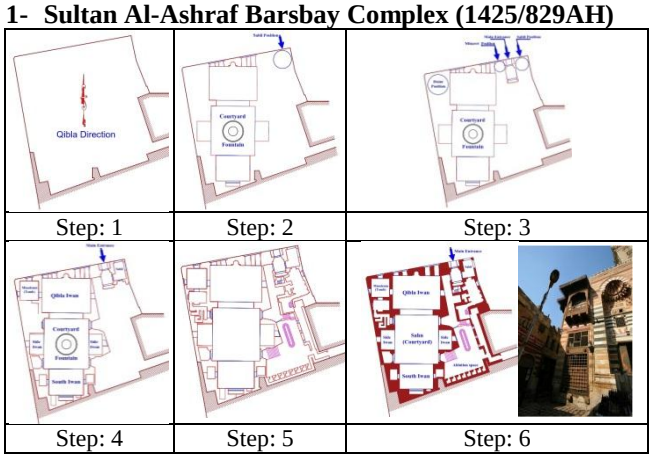
Step 5: completing the rest of the attached spaces

Step 6: completing the final form of the water elements and the final design of the building.

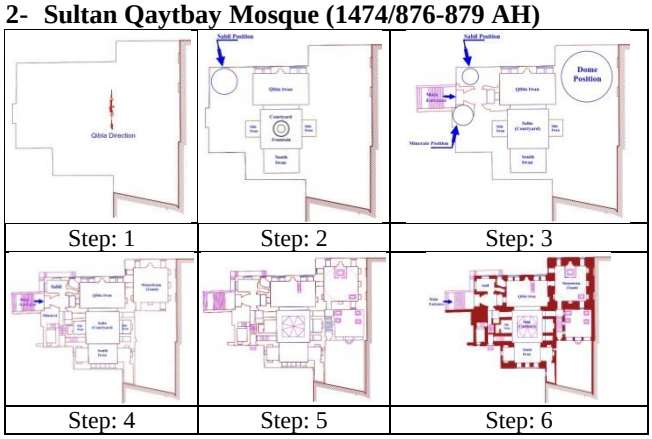
2.2.2.2 Applying The Generative Technique

The research selected three of Madrasa buildings in Cairo from Mamluk period to apply on them the suggested methodology of using water as a design generator, the selection of them done without any exception and this demonstrates the validity of the proposed methodology for application.

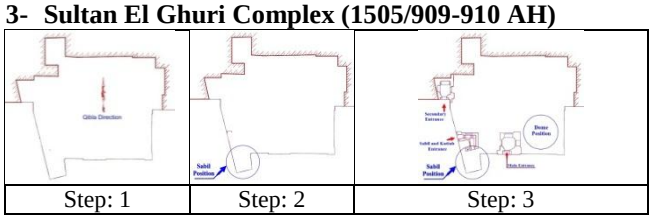
1- Sultan Al-Ashraf Barsbay Complex (1425/829AH)

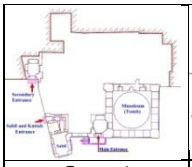
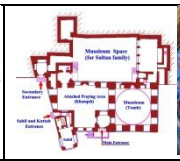
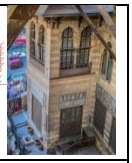


2- Sultan Qaytbay Mosque (1474/876-879 AH)



3- Sultan El Ghuri Complex (1505/909-910 AH)



		 
Step: 4	Step: 5	Step: 6

2.2.2.4 Remarks about using water as a design generator factor

- Water helped designer in Islamic architecture to create a third type of space: inside-outside space [13], the research name this place "**In-between space**". It is a "place" for transition between outside and inside, this dynamic space provide some facilities for short-time rest as a "pause moment", it is more openness to outside; more enclosure to inside and more dependence to both.
- Designer in Islamic architecture depended on 6 criteria of water in the process of place making they are: calm, illusion, communication (function connection or visual connection), hearing (the sound of waterfall), reflection (the reflection of the sky and the sun on the water) and dramatic panorama (viewing the image of the surrounded buildings in the water).
- Water enhances the suitability between the space and its architectural functions through giving the opportunity for visual wandering in spaces. Islamic architecture philosophy of using water in the visual design of the place based on two criteria: the first is breaking all the space into long axis of water sights, the second is using water as a spatial configuration factor affecting the user behavior and the serial visions of the space.

2.3 Water Constructions and Ornamental Water In Islamic Architecture

2.3.1 Water constructions

Water constructions are the constructions which mainly depended on water to introduce its function. Islamic architecture created many of these constructions as water measurements, canals, fountains, pools, Sabils (buildings for drinking) and Hamamas (public paths). The research focuses on the design of two of them the Sabil and the Hammams, as shown in figure (4).

2.3.1.1 Sabil Buildings (Drink Rooms)

a) Sabil Definition

The word (Sabil) in Arabic, means a path or road. It is used in the Holy Quran in its verbal and figurative meanings, as the path to justice and belief or as a drink place [14]. The Sabil building is a public place dedicated to watering passers-by and considered a Charity building [15]. As an architecture function, it built separately or attached to different buildings (mosque, school, houses). This type of buildings was built to meet societal needs through the realization of religious values [16].

In Islamic civilization Al-Sakka profession was the person who responsible about transporting water from reservoirs and the Nile to different buildings and with the expansion of Islamic cities it became necessary to build a service buildings provide population and passers-by with fresh water and these buildings called Sabil (The water Dispensary) [16].

b) Sabil Architecture

The architectural composition of the sabil was consists of three floors. The underground floor is the water tank, the intermediate floor is the Sabil main room from which fresh water was introduced to the passer-by, so this room was higher than the street and the upper floor always a Kuttab (primary educational institute to educate Muslim orphans free of charge).

The Sabil has no direct entrance from the street but its entrance always shared with the main entrance of the building, and the number of tanks in the Sabil buildings was not limited, for example Sultan Qaitbay Sabil has two tanks and the geometric shape of the tank was rectangular (some times square) covered with a dome rested on columns and archways

Regarding to the hot-dry climate and to protect the users from the sun the designer placed a sunshade made of wood on the roof of the building as in Abdul Rahman Katkhada Sabil the designer used a duel sunshade.

c) Water as a design tool for the fenestration system of the Sabil buildings

Providing water as the main function of the Sabil affected the design of the fenestration system of the building as follows:

- The Sabil room used to have more than one window from which the fresh water was introduced to the passer-by, Its geometric shape always rectangular, and the designer used a copper beams to protect it, and in order to carry the drinking cup a marble sheet used to cover the lower frame of the window
- There were three openings on the water tank; the first must be accessible from the street in order to supply the tank with water. In beside one of the water tank wall was placed the second opening and it used in lifting up the water from the water tank to the Sabil room, The third opening placed on one corner of the Sabil room and used in going down inside the water tank for maintenance and cleaning, the going down to the water tank done by a stair usually not more than 17 steps [17].

2.3.1.2 Public Hammams Buildings (Baths)

Islamic instructions call for cleanliness and considering it a part of the qualities of the Muslim. For this reason and the unavailability of baths inside houses, except in palaces and large private houses, it was necessary to erect public baths [14].

The path plan consisted of three basic elements. The door way leads through a corridor to the first element which is the unrobing hall, it consists of several wans opening onto unheated durqa'a, which includes a central fountain, and stone or marble decks where the bathers rest, have a drink, or smoke before and after taking a bath. Attached to the unrobing hall is the manager's room to provide the bathers with soap and towels. Then comes the second element which is a room slightly heated and separated from the unrobing hall by a

corridor, it includes some benches for the bathers to sit and get used to the temperature and humidity of the bath, especially before leaving. The third element is the hot room, the central part of which is covered by a lantern above a marble basin filled with hot water, and the floor of the room is covered by a marble, surrounded by cells for massage including private basins.

Public paths were founded in early Islamic period; Hammam Al Tanballi (12 A.H. / 18 A.D.) is one of the famous hammams in Cairo. The bath consists of three main elements: the first is maslakh (the area for changing clothes and for waiting before and after taking the bath), the second is Bait Awal "first house", and the third is Bait al-Harara "House of Heat". The house of heat was the main element of the bath, it is a central space with a square courtyard in the middle and an octagonal fountain in its center, surrounded by three iwans their floor are higher than that of the courtyard. From analyzing the plan it is apparent that it has adopted the introvert pattern in a way that only the entrance shows on the façade.

(a) (b) (c)

(d) (e)

Figure 4: Water constructions: (a) Hammam Al Muayyad Shaikh, (b) Hammam Al Tanballi, (c, e) Sabil Abd Al Rahman Katkhuda, (d) Sabil Qaittbay, [Author]

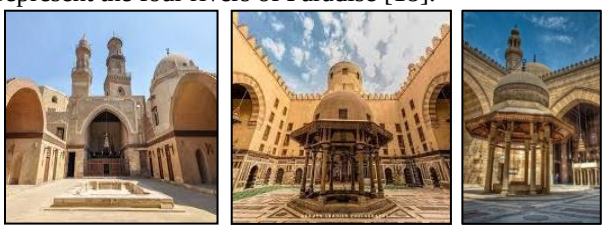
2.3.2 Ornamental Water in the Recreational Spaces in Islamic Architecture

Ornamental water provided solely for aesthetic or beautification purposes as fountains, ponds, waterfalls and man-made streams. Islamic architecture depended on three criteria in the design of ornamental water, they are: (1) Changing the physical static from of the water into a dynamic form, (2) depending on the the fluidity of water over stone in order to reach the dynamic in the visual image of the water composition, (3) putting water in layers over stairway to provide dramatic views.

There are four types of recreational spaces in Islamic architecture their architectural design depended on water, they are: the courtyards, the gardens, the squares and the districts. The section presents the role of water in the design of the courtyards and the gardens.

2.3.2.1 Water In The Courtyard Prototype in Islamic Architecture

Islamic architecture placed a fountain at the center of courtyard in different buildings as shown in figure (5) and this was for two purposes: (1) the function purpose to introduce the ablution service and (2) the environmental purpose as a cooling agent for the internal spaces. Islamic architecture used water in fountains to be a source of dynamic in the visual image of the architectural space through the ever-changing of its appearance. The central fountain symbolizes the origin of life, cleanliness as well as purity, but the watercourses represent the four rivers of Paradise [18].



(a) (b) (c)

Figure 5: The composition of the fountains in the courtyard prototype: a) Sultan Qalawun Madrasa, b) Amir Sarghitmish Complex, c) Sultan Barquq Madrasa [Author]

2.3.2.2 Water In The Gardens Prototype In Islamic Architecture

Garden is the famous recreation space in Islamic architecture, and water in gardens used to bring the freshness and vitality for the garden beside water the trees, and it can be seen in fountains, pools beside the irrigation system. The research determined three criteria demonstrate the water sustainability in the design of gardens in Islamic architecture as follows:

Water Conservation: Water conservation defined as: Any beneficial deduction in water loss, use, or waste, and the main goals of water conservation efforts is sustainability - To ensure availability for future generations, the withdrawal of fresh water from an ecosystem should not exceed its natural replacement rate [29]. Islamic architecture to prevent too much waste water it used narrow channels to transport water for substantial distances and in these underground conduits prevent pollution to take place.

Water Reuse: Water reuse is an integral part of overall of water management strategy which viewed as a way to increase water resources and from a socio-economic point of view, water reuse represents a hybrid research object located midway between supply-side and demand-side approaches, and involving both technological and socio-economic challenges [30]. Olega Grabar characterizes the water reuse in the fountains of Alhambra as a dynamic system in its design, rightly to the evolution of water reuse in the Mediterranean in the pre-Islamic and Islamic periods [31]. Regarding to the three aspects of sustainable architecture (economical, environmental and social aspects) the reuse of water is a significance feature of economic sustainability of water in Islamic gardens.

Water Management: Water management viewed as a way to increase water resources that reconcile different

goals such as the fight against poverty, economic development, environmental and human health protection, etc. [30]. Water in Islamic culture was not used only to satisfy basic human needs for drinking, washing, and farming, but very often as an important aesthetic element. Different water features like pools and fountains are present inside the gardens of great palaces and other public buildings. These aesthetic water elements are referring to the symbolic meaning of water in Islam and to the image of gardens in Heaven [32]. Water management was so precious and highly appreciated, even in prophet Muhammad's time believers were warned to spend water responsibly and were discouraged to waste it even during the ablution. Additionally, providing water to others (humans, animals, or plants) is considered a good deed and will be rewarded [33].

2.4 Principles and Criteria Of Water Sustainability in Islamic Architecture

This section presents the principles of sustainability in Islamic architecture in general and then in more precisely presents the principles of water sustainability in Islamic architecture.

2.4.1 Principles and Criteria of Sustainability in Islamic Architecture

Islamic architecture introduced sustainable solutions that enable the recovery and reuse of water. The research determined three criteria of sustainability in Islamic architecture, as follows:

2.4.1.1 Environmental Sustainability

Environmental sustainability is the ability to maintain an ecological balance in our planet's natural environment and conserve natural resources to support the wellbeing of current and future generations. Islamic architecture achieved environmental sustainability through three criteria: thermal comfort, natural ventilation and natural lighting.

2.4.1.2 Economical Sustainability

Economic sustainability based on two parallel practices: supporting long-term economic growth and avoiding negative environmental, culture and social impact. The main feature for economical sustainability in Islamic architecture is building with renewable materials as stone, brick and clay. These renewable materials beside its economic criteria it enhances the thermal isolation and avoiding the damaging of natural resources.

2.4.1.3 Social Sustainability

Social sustainability is a process for creating sustainable successful places that promote wellbeing, by understanding what people need from the places they live and work. Islamic architecture achieved social sustainability through using many of architectural treatments, three of them as follows:

Urban pocket: It is a social space the urban designer created it along the paths. It has three functions: (1) emphasizing the entrances of the important buildings, (2) orienting the pedestrian along the path and (3) increasing the social interaction between the citizens [19].

Urban wall: The architectural designer deal with the outer wall of the building as an urban wall connecting between the internal architectural design of the building and its urban context through three functions [20]. (1) absorbing the deformation which happened in the internal spaces of the building due to the deviation of the building site from the street, (2) not only maximizing the role of the Qibla direction as a design factor in the design of religious buildings but also smoothing the relationship between it and the street orientation, and (3) generating inside regular spaces through changing its thickness.

Urban window: Urban window is a window that connects the function of the internal architectural space with the external urban space [20]. In Mamluk buildings large rectangular windows with iron grilles were located near the floor, thereby establishing visual contact between the mosque and the street [21].

2.4.2 Principles and Criteria of Water Sustainability in Islamic Architecture

Water concerns had taken great importance in the Holly Quran and the sayings of the Prophet Muhammad. The research determined four principles and criteria of water sustainability in Islamic architecture, as follows:

2.4.2.1 Water Rights (Separation and Integration)

Water rights in Islamic architecture depended on the sustainable utilization of water based on avoiding its depletion as a natural resource. The clear example of water rights in Islamic architecture is the system of distributing irrigation water between farms. In the Shariah, there is a responsibility placed on upstream farms to be considerate of downstream users. A farm beside a stream is forbidden to monopolize its water. After withholding a reasonable amount of water for his crops, the farmer must release the rest to those downstream. Furthermore, if the water is insufficient for all of the farms along the stream, the needs of the older farms are to be satisfied before the newer farm is permitted to irrigate [22]. This notion of water rights indicates the separation and the integration process between the water networks.

2.4.2.2 Water Conservation and the Reuse.

Water conservation based on using water without wasting it through two practices: maximizing the efficiency of water usage and minimizing the unnecessary water usage. The Prophet said: "Don't waste water even if you are on a running river". Islamic architecture emphasized on "the reduction in use produces a reduction in waste", so that water conservation not only means the treatment of water that is supplied to a building but also the treatment of the water that leaves the building.

2.4.2.3 Water Pollution (Collecting/Recycling)

Water pollution means damaging the water properties to become unusable for human needs. Muslims are not allowed to pray before cleaning with pure water which

must have three characters: colorless, odorless and tasteless. Islam not only stresses on preventing pollution of water resources but also stress on collecting gray water and waste water to be recycled and reused. Islam forbidden having a bath in stagnant water and one of Prophet Sayings "No one should bathe in still water".

2.4.2.4 Building Underground (Green Design and Water Management)

Underground house (earth house) is a structure with earth against the walls, on the roof, or that is entirely buried underground, this done to avoid the internal architectural spaces the harm of the external climate. This type of buildings reach the thermal comfort through the thermal storage of the mass of soil. In Islamic architecture this type of buildings was more common in Arab world, for example in Tunisia and Libya there was a fully built underground houses.

3. THE METHODOLOGY OF WATER SUSTAINABILITY IN ISLAMIC ARCHITECTURE

There is no survived record describing the procedures of achieving water sustainability in Islamic architecture. Although some have tried to determine the principles of water sustainability in Islamic architecture, their work has no explanation about the procedures of achieving these principles. This section attempted to illustrate what called it the 'Methodology of Water Sustainability in Islamic Architecture, as shown in figure (6).

3.1 The Methodology Idea

Islamic architecture achieved water sustainability by depends on a so-called "Balanced Integrated Approach", this approach based on two principles, they are:

Principle 1: the balance between sources and consumption of water through minimizing water consumption and enlarging water conservation.

Principle 2: the integration between the usage of water at the level of the urban design and at the level of the architectural design of buildings.

The methodology main objective is presenting the principles of water sustainability principles in a way make them suitable for contemporary architecture.

3.2 The Methodology' Principles and Procedures

Table 2. The principles and procedures of the methodology of achieving water sustainability [Author]

The Methodology Of Achieving Water Sustainability in Islamic architecture	
Principles	**Procedures**
1- Water sustainability at the level of urban design	
1) Separation	- Separating between water networks (drinking and irrigation)
2) Conservation	- Conservation in landscape usage.
3) Integration	- Integrating water with the built environment - Integrating between storm-water, groundwater and wastewater
4) Reuse	- Reusing the reclaimed wastewater (irrigation or sub-potable water) - Reusing gray water in land irrigation, toilets and car washing
5) Management	- Raising the efficiency of water use - Reducing water demand for landscape irrigation - Avoiding the leakage - Spreading water conservation awareness
2- Water sustainability at the level of architectural design of buildings	
1) Green Design	- Designing for water conservation: (rainwater harvesting, gray water reclamation, low-flow plumbing) - Using Water as a symbolize factor
2) Collecting	- Collecting and utilizing rainwater
3) Utilization	- Using water as a design tool in the design of the architectural space - Using water as connection element between spaces - Using water as an environmental adaptively factor - Using technologies to reduce the amount of water used by appliances and sanitary ware.
4) Recycling	- Recycling of domestic waste water
5) Management	- Lowing-flow plumbing fixtures such as faucets and flush valves. - Maintaining the water cycle through recycle / recycle-dirty water from the ablution activities and paths in buildings.

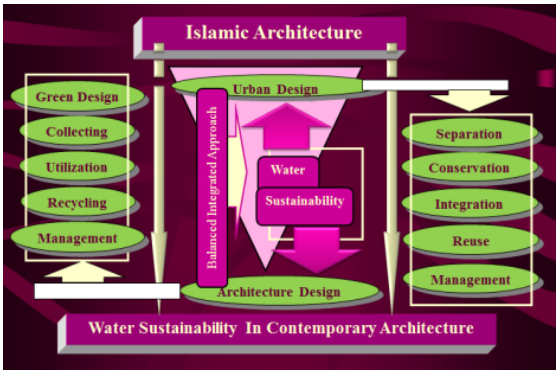


Figure 6: The Methodology of Achieving Water Sustainability in Islamic architecture [Author]

4. ANALYTICAL STUDY

This research attempts to understand how the water sustainability in Islamic architecture has been reached at the level of urban design and at the level of architectural design. This section analyses the case-study buildings according to the suggested methodology of water sustainability in Islamic architecture. The research selected the case-study according to two criteria: (1) water as a design tool controlled all aspects of the building design; (2) the designer achieved the principles of water sustainability in the building. The research selected Alhambra palace in Spain and Al-Ghuri Sabil in Egypt.

4.1 Water Sustainability In Alhambra Palace - Spain

The Alhambra is a remarkable legacy left by its founder, Muhammad ibn Al-Ahmar (1238-1273) of the Nasrid dynasty [23], River Darro was the main sources of water which brought to the royal palaces and gardens, and the designer employed a complex canalization system for this water supply system [24]. The research analysis Alhambra palace not from a historical or architectural point of view but it depended on the suggested methodology of achieving water sustainability in Islamic architecture in the analysis process.

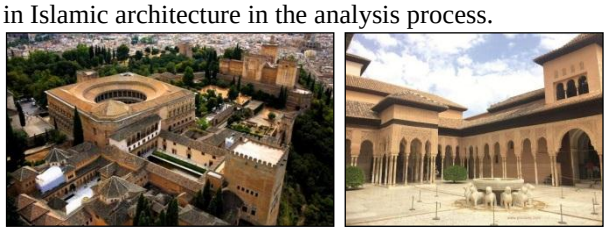


Figure 7: Water and the geometric composition of Alhambra Palace – Spain [25]

4.1.1. Water sustainability at the level of the urban design in Alhambra palace

The following table demonstrates the principles of achieving water sustainability at the level of urban design in Alhambra palace and the designer decisions and procedures for achieving that.

Table 3. The methodology water sustainability at the level of the urban design in Alhambra palace [Author]

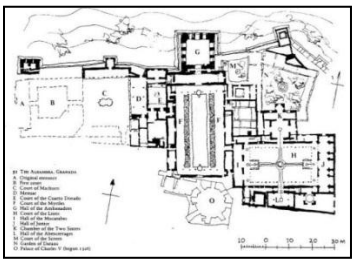
The Methodology Of Achieving Water Sustainability at the level of the urban design	
Principles	**Procedures**
1) Separation	➢ Regarding to the multi uses of Alhambra as a complex of administration with several courtyard gardens and residential architecture [23], the designer in the urban design separated between the sub-portal water network and the irrigation network,
2) Conservation	➢ Depending on water conservation as a design criterion appeared in two positions in Alhambra palace: (1) At the Court of the Lions the designer balanced between the composition of architecture, vegetation and water conservation [23]. (2) At the court of the lions the designer at the longer east-west axis projected the pavilions sheltering fountains to make the overflow draining go through channels to the center as a symbol to the rivers of paradise, the designer done this to combining water conservation with the Islamic doctrine.
3) Integration	➢ Abd Rahman I (756-788 A.H.) the first ruler of Spain built the earliest Islamic garden exemplar called Al-Rusafa [26]. The design of the garden in Alhambra depended on the integration of water with the built environment, for example its orchards were watered by a pipe which ended in a pool, over which there was a lion, the water entered through its hindquarters and poured out through its mouth [27].
4) Reuse	➢ Doubling the function was a criteria of the water reuse in Alhambra design, for example beside watering the gardens the designer used the water in the visual image of the space, this clear in using the water to reflect surrounding architecture and plants [26], also the designer intelligently reused the water as thermal comfort tool (a cooling agent) such as in Acequia hall. ➢ The designer in Alhambra relied on the principle of water reuse to control the overall composition of the building and he used water as a spatial component and a transitional mediator that creates a balance between the spatial formations. This appeared in the reuse of water from the fountain of the Two-Sisters Hall to go through a water channel extended into the courtyard of the Lions hall.
5) Management	➢ As a kind of water management in the fountain of lions the flow direction is reversed. The lower cylindrical structure in the bowl's center is pierced around its perimeter by two rounds of holes. Water spills out of the smaller outlets, eight in sum, onto the surface of the bowl to be recaptured by the larger ones. This configuration creates a continuous back and forth movement on the water's surface, broken by the jet spurting from the centre of the fountain. The last water from perceived in this fountain is the twelve liquid arches sprayed from the lion's mouths to fall on the ground basin at their feet. [23]. ➢ The management of water through avoiding the leakage in Alhambra appeared in tightening the connections in pipes and channels that transport water from tanks to the palace and to the irrigation networks.

4.1.2. Water sustainability at the level of the architectural design in Alhambra palace

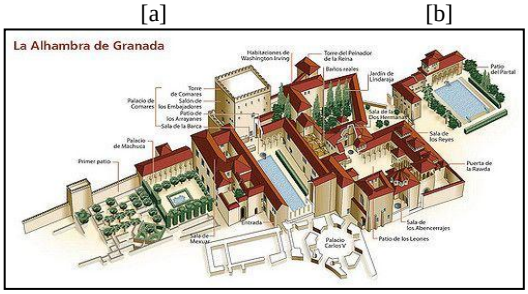
The following table and figure (8) demonstrate the principles of achieving water sustainability at the level of architectural design in Alhambra and the designer decisions and procedures for achieving that.

Table 4. The methodology of achieving water sustainability at the level of the architectural design in Alhambra palace [Author]

The Methodology Of Achieving Water Sustainability at the level of the architectural design	
Principles	**Procedures**
1) Green Design	➢ Green design is based on improving energy-efficient in use and designed for long life. A clear example about design for long life in Alhambra is the designer decision to limit the use of water in the project in the in-between spaces, this design decision was for two aims: (1) to use water as a connection element between the building compositions, (2) to enrich the relationship between the man and the space through achieving spiritual refreshment and spaciousness. ➢ Using symbolizes as a green design criteria appeared in Alhambra on using the reflection of the sky on the central ponds which distributed in many parts of the building to symbolize infinity, continuity and soul purification.
2) Collecting	➢ Regarding to the high amount of rainwater in Alhambra palace, the designer collected it and stored it in a huge underground tanks to reuse it in the irrigation system by a complex canalization system.
3) Utilization	➢ The designer utilized water to form a passive ventilation system, as in the Court of Myrtles, where there is a twelve stone lions located on a dodecagonal basin and this composition placed on the middle of rectangular pool, by that the capture of the wind and reduce its heat can be done. ➢ The designer utilized water as a symbolize factor, for example the courtyards in the palace are private gardens constructed in a small space located in a building the distribution of the spatial elements on it follow the description of the paradise in Quran.
4) Recycling	➢ Water recycling in Alhambra is so clear in the design of the court of the Lions which is a water clock-fountain. This clock depended on its work on shadow, when shadow casts on them shooting water on both ways starts and this like alarm to Muslims means that now is the time for prayer [26], the water that circulates as a kind of recycling to be clean enough for ablution.
5) Management	The designer distributed water in all parts of Alhambra as a connection element ties all architectural components and this facilitates the transportation of water between all gardens in the palace as a flexible type of water management. The uses of water in the palace are dynamic in terms of its design. A clear example for this is in the Hall of the Two Sisters and the Abencerajes the water move in a circular path as a dynamic management of water. (Fountains in the centres of the Halls drain again into the centre).
	➢ The management of water appeared in the manipulation with static and dynamic compositions of water to connect internal and external spaces, as placing the dynamic water composition (fountains) in the Lions hall and connect it with the static water composition (pools) in the two sister hall.



[a] [b]

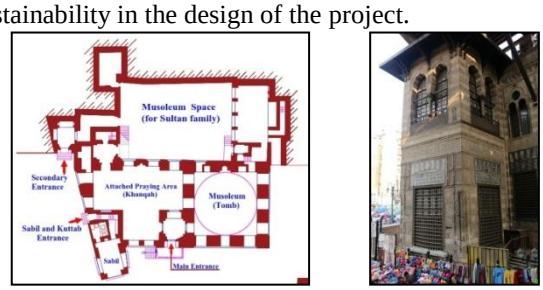


[c]

Figure 8: Distribution of water in Alhambra palace: (a) the plan, (b) water canals, (c) design composition [25]

4.2 Water Sustainability In Al Ghuri Sabil – Egypt

The building is located at the end of al-Ghuriyaa Street at its intersection with al-Azhar Street, this location gave it an important role in shaping the visual image of the historic Cairo. This section analysis Al Ghuri Sabil not from a historical or architectural point of view but it depended on the suggested methodology of achieving water sustainability in Islamic architecture in the analysis of the procedures of achieving water sustainability in the design of the project.



(a) (b)

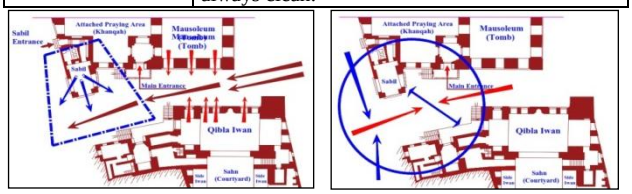
Figure 9: The architectural composition of Al-Ghuri Sabil in historic Cairo - Egypt [Author]

4.2.1 Water Sustainability At The Level Of The Urban Design In Al-Ghuri Sabil

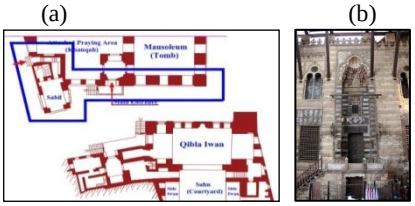
The following table demonstrates the principles of achieving water sustainability at the level of urban design in Al-Ghuri Sabil and the designer decisions and procedures for achieving that.

Table 5. The methodology water sustainability at the level of the urban design in Al-Ghuri Sabil [Author]

The Methodology Of Achieving Water Sustainability at the level of the urban design	
Principles	**Procedures**
1) Separation	➢ The designer separated between the process of supplying water to the tank and the process of supplying water to passersby on the street.
2) Conservation	➢ Water conservation appears in taking care with keeping the water tank clean for water storage, beside that maintaining the cleanliness of the channels and sewers that transport water to and from the tank.
3) Integration	➢ The designer integrated between the main function of the building (offering water to the thirsty) and the building urban context, this done by using some of architectural design tools as urban window, urban pocket and urban walls, as shown in figure (00).
4) Reuse	➢ The reuse of water appears in the redistribution of the rest water in the tank to the city's residents by Sqaa person (a person responsible for distributing water to homes and he was granted a license to practice this profession), beside reusing the rest of water in drinking cups and the falling water under the cups.
5) Management	➢ The management of water appears in the designing of urban context to be suitable for organizing the process of introducing water to the thirsty and also the distribution of the supplying openings of the water tank to be a part of the urban context, as shown in figure (10). ➢ A kind of management was the maintenance operations for the tank and the cups to keep them always clean.



(a) (b)



(c)

Figure 10: The architectural treatments for achieving water sustainability in Al Ghuri Sabil: (a) urban window, (b) urban pocket, (c) urban wall [Author].

4.2.2 Water sustainability at the level of the architectural design in Al Ghuri Sabil

The following table demonstrates the principles and procedures of achieving water sustainability at the level of architectural design in Al-Ghuri Sabil.

Table 6. The methodology water sustainability at the level of the architectural design in Al-Ghuri Sabil [Author]

The Methodology Of Achieving Water Sustainability at the level of the architectural design	
Principles	**Procedures**
1) Green Design	➢ In Al Ghuri Sabil the principles of green design appeared on depending the designer in natural ventilation and natural lighting of the Sabil space through a fenestration system that suits the architectural function of the sabil.
2) Collecting	➢ The designer collected in one space three architectural functions, which are the Sabil room, the water tank, and the water supply windows.
3) Utilization	➢ The designer utilizing different architectural treatments to enhance the architectural functions of the building as in the fenestration system: 1) The designer used a fenestration system consists of a windows preceded by an iron grille to be suitable for the architectural functional performance. 2) In the space between the entrance and the drainage window the designer used two windows to illuminate and ventilate the water collection basin from the tank and the outlet opening.
4) Recycling	➢ In front of the Sabil window which used to introduce fresh water to the passer-by there was a marble sheet which used to carry the drinking cups, under this marble sheet there is a tank used to collect the water which fall down from the cups to be recycled.
5) Management	➢ The water management in Al Ghuri Sabil appears in the management of supplying water to the tank and the management of the maintenance process of the tank. ➢ The management of the maintenance and cleaning process depended on using two openings: one the accessible to it is from the street for the supplying water process and the second is to left up the water from the tank beside using it for going down inside the tank for cleaning.

4.3 Remarks about the analytical study

The research on holding the analytical study depended on two approaches of thinking: The First is up-down approach. This approach depends on looking at the water sustainability on the case study from up as a whole subject, and then goes down inside it to reach its main component. The Second is down-up approach, This approach depends on beginning from down, from the water sustainability procedures and designer decisions and goes up, step by step, to draw a picture a bout how was water sustainability achied in the case study project.

From the analysis of water sustainability in Al-Hambra palace-Sapain and Al-Ghuri Sabil Egypt the research reached that Islamic architecture in achieving water sustainability depended on ten principles divided in two categories: (1) five principles for achieving water sustainability at the level of the urban design of the city they are: Separation, Conservation, Integration, Reuse, Management, (2) five principles for achieving water sustainability at the level of the architectural design of buildings they are: Green Design, Collecting, Utilization, Recycling and Management.

5.APPLIED STUDY

In this section the research applied the methodology of water sustainability in Islamic architecture in one of contemporary housing projects in Egypt.

5.1 The Applied Study Aims

This applied study has two aims:

(1) Checking the validity of the suggested methodology of achieving water sustainability for applying and achieving water sustainability on the contemporary architecture,

(2) Emphasizing that those principles and criteria of water sustainability which preexists in Islamic architecture can be used as a guide-line for achieving water sustainability on contemporary architecture.

5.2 Case-study Description

Project Name	Al-QUDAH CITY "City of Judges"
The Owner	Egypt Judges Club (Minya)
Location	Egypt, El Minia City, New Minia City, The Extension area (840 Fadan)
The Designer	Consult office "The House of Modern Architecture": the office prepared the design of the general layout and the design of the residential buildings, prepared the working drawings, obtained building permits and then supervised the construction process.
Design Approval	The design of the project was approved by Ministerial Decision No. 303 of 2016, Minister of Housing – Egypt. The buildings construction licenses approved by New Minya City Authority
The project components	The project include 25 residential buildings, a services area (containing administrative and commercial services), and a recreational services area (kids area and swimming pool).

5.3 Water Sustainability at The Level Of The Urban Design In AL-QUDAH City

The following table and figure (11) demonstrate the principles of achieving water sustainability at the level of urban design in AL-QUDAH city and the designer decisions and procedures for achieving that.

Table 7. The methodology of water sustainability at the urban design in Al-Qudah city [Author]

The Methodology Of Achieving Water Sustainability At The Level Of The Urban Design	
Principles	**Procedures**
1) Separation	➢ At the layout design the drinking water supply network was separated from the irrigation network of the gardens.
2) Conservation	➢ The quantities of garden irrigation water were conserved by reducing the number of outlets and using an electronic system to control the quantities of irrigation water flowing from the irrigation outlets.
3) Integration	➢ The integration of water with the built environment appeared on relining on water as a component of the visual image of the pedestrian paths, for example the designer used the dancing fountain at the entrance of the project to integrate between the users and space.
4) Reuse	➢ The water distribution system depended on reusing gray water and raining water for garden irrigation and washing cars, as in fig. (14).
5) Management	➢ The management of water distribution was achieved through increasing the number of valve chambers and the number of valves per line this to ensure a reduction in the amount of water leaking ➢ An important criterion of water management in Al-Qudah city is spreading water conservation awareness among residents, and the designer to achieved this relied on distributing a large numbers of signs which indicate the importance of water conservation and indicate the procedures of water conservation.

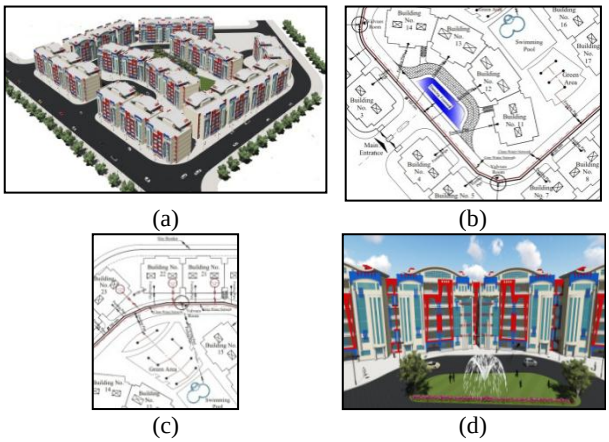


Figure 11: Procedures of water sustainability at the level of urban design in Al-QUDAH city: (a) the urban design of the layout, (b, c) the separation between the drinking networks and irrigation networks, (d) the dancing fountain at the entrance of the project [Author]

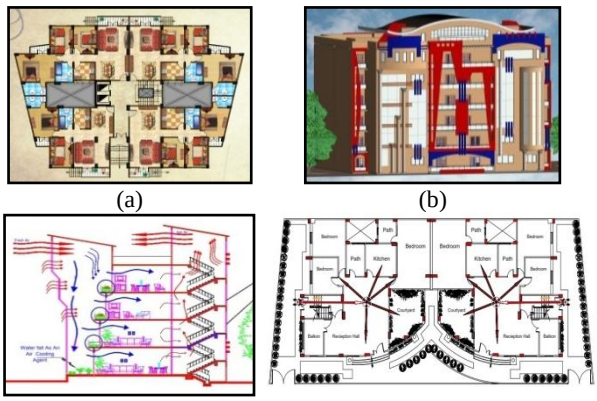
5.4 Water Sustainability At The Level Of The Architectural Design In Al-QUDAH City

The following table and figure (12) demonstrate the procedures for achieving water sustainability at the level of architectural design in AL-QUDAH city.

Table 8. The methodology of achieving water sustainability at the level of the architectural design in Al-Qudah city [Author]

The Methodology Of Achieving Water Sustainability at the level of the architectural design	
Principles	**Procedures**
1) Green Design	➢ The designer depended on the design for water conservation to achieve the green design, this was through ensure the quality of sanitary connections and low flow plumbing to ensure that leaking and damaged quantities are reduced
2) Collecting	➢ In Al-Qudah City there was a system for collecting rain water from the roofs and collecting gray water from paths and kitchens, these water go to a collection water tank. The system then reused this water in a car washing and irrigation system as shown in fig. (14) which indicates the design of the collecting system and the placement of the tank in the building design.

3) Utilization	In Al-Qudah City the designer utilized water in three functions: ➢ As a connection element between the urban context and the internal architectural spaces, as the fountains in the in-between urban spaces ➢ As an environmental adaptively factor, as using waterfalls in the courtyards of the buildings to achieve the thermal comfort. ➢ As a design tool for the visual image of the project, this clears in using water as a main component of the entrances.
4) Recycling	➢ Reusing gray-water, whether from hand washing basins or showers, to be stored and used for garden irrigation and car washing.
5) Management	➢ The water management in building design depended on ensure the periodic maintenance of internal water connections, whether pipes or outlets, to reduce water loss beside lowing-flow plumbing fixtures such as showerheads, faucets and flush valves. ➢ The project construction restricted by using modern technologies to conserve water and prevent leakage in the plumbing connections,



(a) (b) (c) (d)

Figure 12: Procedures of water sustainability in the design of residential buildings in Al-Qudah city: (a) the distribution of water plumbing in the flats, (b) water in the building's roof, (c) using waterfalls in the courtyards, (d) water in the courtyards as a connection element [Author]

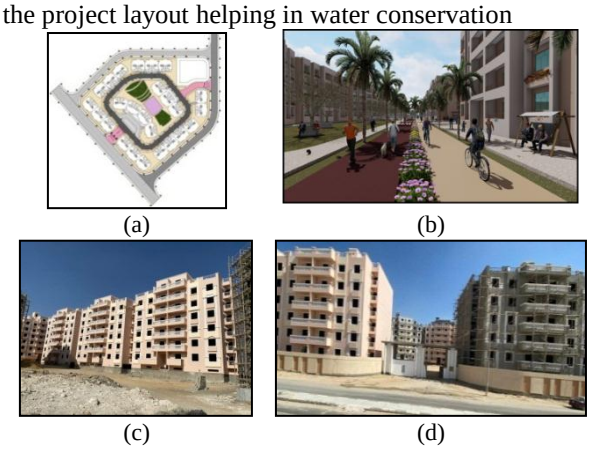
5.5 The Results of the Applied Study

From the applied study the research detrmined the following results based on the criteria which derived from the analytical study. These results can be seen as a guide line for achieving the principles of the sustainable use of water in contemporary architecture at the level of urban design and the level of architectural design.

5.5.1 At the level of the urban design

1- Qudah city contain 25 residential buildings and a commercial building beside the recreation spaces, this multi uses led the designer in the urban design to separate between the sub-portal water network and the irrigation network and these design decisions helped in reducing the amount of ater consumption, as shown in figure 11 (b, c), this led the research to conclude that separating between water networks in the layout (the sub-portal water network and the irrigation network) is an effective way to reduce the consumption of water.

2- In Qudah city the designer concentrate the green area and the recreation functions (swimming pool and kids area) in the middle of the project as shown in figure 13, and this helped in reducing the amount of water which demand for landscape irrigation, this led the research to emphasize that collecting the green areas in one zone in the project layout helping in water conservation



(a) (b) (c) (d)

Figure 13: Qudah city a) the concentration of the green area at the middle of the layout, b, c) the position of the water features between the residential buildings, d) the outside spaces between buildings [Author]

3- In Qudah city one of features of environmental sustainability is using water in the outside spaces and a clear example for this is distributing fountains in the project layout and this helped the designer to make a visual connection between the inside and the outside spaces beside that helped in decreasing the outside temperature as a type of environmental sustainability, this led to deduce that reliance on water as a main element in the visual design of the project helps in the environmental sustainability of the project.

4- In Qudah city the designer raised the efficiency of water reuse by developing a proposal for the design of water system at the residential buildings that allows for the reusing of gray water in land irrigation, toilets and car washing, as in figure 16 this led the research to conclude that the effective design of the water system in the buildings is the secret factor in reaching effective reuse of water in the whole project also beside that the research reached to emphasize that reducing water demand for landscape irrigation and avoiding the leakage are an effective solutions for sustainable use of water at the level of urban design.

5- In Qudah city the designer reached the water sustainability in the design of gardens through the use of modern technologies in the design of the irrigation system and this led to avoid the leakage of water in the water distribution/water supply/and water transportation and this is an effective solutions for management of water at the level of urban design, this led the research to emphasize that the use of modern technologies in the design of the irrigation system is effective method for water managenment.

5.5.2 At the level of the architectural design

1- In Qudah city the designer depended on water as a tool of green design of buildings, for example he depended on water as avisual connection element in the visual design of the layout and between the inside and the outside spaces as shown in figure 14, this led the research to emphasize the following result: water is an effective element in achieving the criteria of green design in the green design process of buildings.

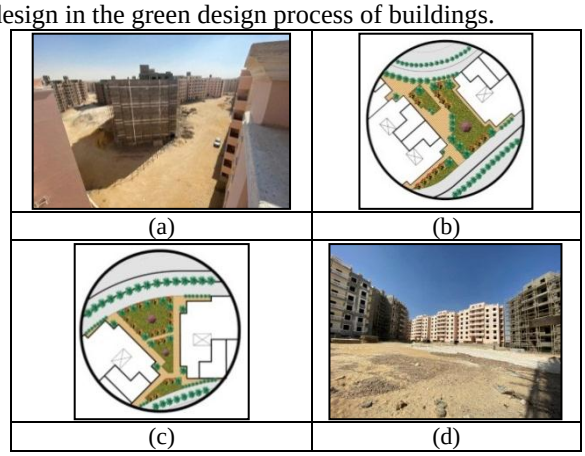


Figure 14: The position of water between the building and in the visual axis in the design of the layout in Qudah city [Author]

2- In Qudah city the designer depended on water as an environmental adaptively factor through placing water inside the court and above the roof of the buildings as shown in figure 15, and this led to reduce the temperature of the fluid air which pass through the inside architectural spaces, this led the research to conclude that water is an effective environmental adaptively factor

Figure 15: Placing water inside the courts and on the roof of the buildings in Qudah city [Author].

3- In Qudah city the designer used a recycling system depended on collecting the graywater (rain water and water from hand washing) in a collection tank which placed in the basement and then reused it in irrigation and car washing, and the aim of this system is to decrease the water consumption in buildings, this led the research to emphasize that the recycling of water from the different activities inside the buildings is an effective tool for decreasing the water consumption in buildings

4- In Qudah city the owner of the project and the consultant designer to prevent leakage in the plumbing connections as a kind of water management they restrict the construction company to introduce a gurante licence for water connections beside obligated it with the regular maintenance of the internal water connections, this led the research to resulted that the effective managent of water in the design of buildings must depend on the creative solutions such as lowing-flow plumbing fixtures, installing small showerheads to reduce the flow of the water. and water in which the vegetables & fruits have been washed must use to water the plants:

6.RESULTS

The results of the research can be summarized in the following points:

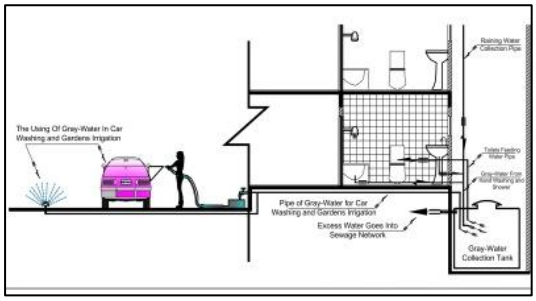
1) The re-evaluation of water sustainability in terms of historical heritage and ancient tradition gives a great contribution to the knowledge and studies of water architecture in contemporary architecture and increasing the awareness of the historical and cultural value of these sites.
2) The principles and criteria of water sustainability are not exclusive to one culture or civilization without the other, and from vetting this notion the research reached to emphasizes that water sustainability isn't a recent idea but its roots, basics and criteria was ingrained and inherent in Islamic architecture.
3) From the analysis of water constructions in Islamic architecture the research reached that the cornerstone of a realistic future vision of water sustainability is decentralized wastewater treatment and utilization at the local level and this requires both technological development and greater individual and community responsibility.
4) A primary analysis of water constructions in Islamic architecture shows the designer used water as a spatial logical order that underlines the disposition of the design pattern in it and there is a technique the Islamic architecture depended on it to generate the architectural design through using water as a design generator tool.
5) Rainwater has traditionally been collected by gardeners for watering plants. Their systems collect rainwater from a downspouts draining the roof [28]. Depending on this notion the research suggested a collecting system for rainwater and the gray water, as shown in figure (13).

   a- The system idea and operating system:

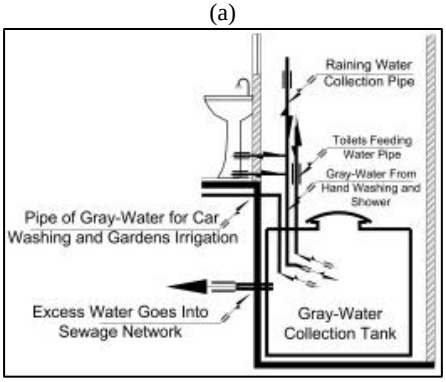
   It diverted the rainwater and the gray water inside the building where it is filtered and stored in a collection water tank to be reused in car washing and in the irrigation of the gardens

   b- The components of the collecting system: it consists of two components as follows:

   - Water tank: in which the rain water and the gray water are collected.
   - Four water pipes: (1) The first pipe carries the rain water from the roof of the building to the water tank, (2) The second pipe carries the greay water from the hand washing basins and showers to the water tank, (3) The third pipe carries the water from the water tank to the irrigation system and car washing places, (4) the fourth pipe carries water from the water tank to the flush box of toilets.



(a)



(b)

Figure 16: The design of the collecting system of the rain water and the gray water [Author]

6) There are five criteria controlled the using of water as a design tool in Islamic architecture, they are: (1) water make 'spirit of a place and the sense of belonging to space', (2) the presence of water enriches a place's experience through seeing, hearing, or touching the water, (3) the symbolic dimension of water in architecture lead to and enrich the beauty dimension, (4) water sustainability criteria was the main hidden factor which controls the design process of buildings, (5) water was not only a design tool but also a design generator which around it the design of buildings revolved.
7) By achieving water sustainability in contemporary architecture and reducing water consumption in building the following benefits will be achieved:
   - Consumer will face lower water charges.
   - Groundwater resources will be conserved for future generations.
   - Reduced stresses on current water infrastructure.
   - Reduced pressure to construct new reservoirs and water mains.
   - Reduced hot water consumption leading to lower energy use.
   - Reduced energy use to treat and pump water supplies and sewerage.
8) Dealing with water in contemporary architecture must depend on the simplified-analytical-integration approach. This approach based on three aspects: (1) dealing with water shortage under the umbrella of environmental crises, (2) At the scale of residential projects gray water must be reused in land irrigation, toilets and car washing and (3) The social sustainability of water usage must depends on spreading water conservation awareness.
9) To create a more sustainable world contemporary architecture has to merge between two elements: the social/cultural properties of the local environment and modern technologies and this must done under the umbrella of the principles of water sustainability in Islamic architecture.

Conclusion

This research emphasized that the principles of water sustainability in Islamic architecture are suitable for cotemporary architecture when it comes to providing a full picture of sustainability, and it demonstrated how water for Islamic architecture was not only a design tool but also a design generator which around it the design of buildings revolved, beside that this research built a bridegwe between the criteria and princnciples of water sustainability in Islamic architecture and in contemporary architecture and solved the separation problem between the two eras.

The research contribution to the field of the study can be summarized in the following two points: (1) The output of this research of the principles of water sustainability in the architecture and planning can be a model for the contemporary architecture to deal with wisely challenge natural resource constraints, especially for future generations. (2) This study review and recognize the role of water in the past process of Islamic architecture with an analytical- interpretation approach in order to show the role of water in the circle of creation and understanding of architecture as causes of inefficient contemporary theories put forward in this area, by exploring the sustainability of water.

The research recommend with the following studies as a future researches: (1) water sustainability in Islamic architecture have to be critically analysed not only by city planners, architects and landscape architects, but also by urban/architecture sociologist and economists, to provide clues for the designers who are about to provide contemporary sustainable architecture. (2) The designers in contemporary architecture must take water sustainability in Islamic architecture as a starting point to look carefully and critically at the state of architecture and how buildings in the Muslim world are planned and designed, as well as to start contemplating the prospects of finding much better sustainability solutions which will be inspired by and infused with the values of Islam, and will be responsive to the exigencies of different times and regions.

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