

An analytical study to evaluate thermal performance of Nubian dwellings Before and after Displacement

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Abstract

The goal of the research is to examine Nubian vernacular architecture before relocation and Nubian houses after displacement. The paper also identifies the main architectural dwellings of Nubian houses according to identity and culture of Nubian community that is one of the most effective indicators of vernacular architecture. Moreover, it illuminates the most important approaches of Nubian heritage villages planning and different ways of achieving max passive cooling and least energy consumption in order to achieve the sustainable development required for such communities.

Keywords: *Nubian architecture, Vernacular architecture, Relocation, Identity, Culture.*

1. INTRODUCTION

Identity and Culture are one of the most serious issues of the present, and it puts us towards the problem of co-existence among the different components of societies.

Since displacement for communities is one of the dangers to loss identity and the architectural culture of these societies, the problem must be exploited in the interest of social co-existence. Before that, we must monitor the indicators of co-existence and its engines. In Principle, the indicators of cohabitation indifferent societies can be strengthened through conscious study of nature as a society with identity and culture distinguish from each one and other.

Through a comparative study between Traditional old Nubian houses before

relocation and the new governmental dwellings built for their displacement.

Research Questions

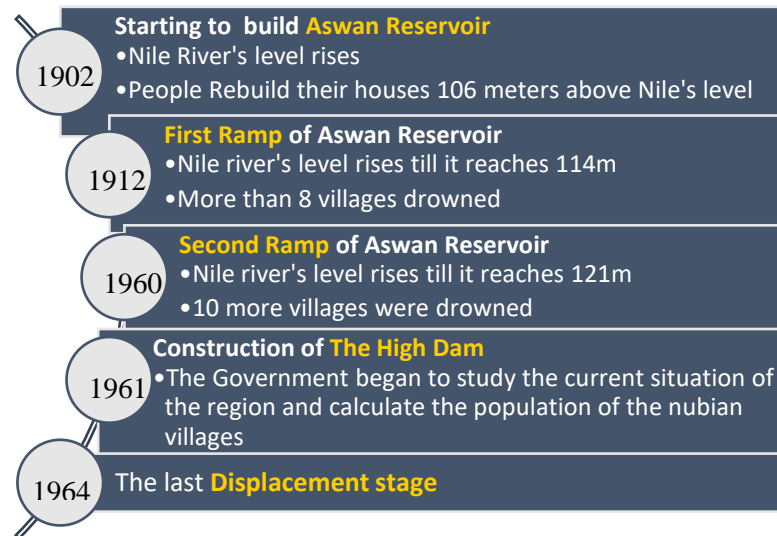
The research will also try to answer simple questions, based on the timeline for the Nubian community experiment through relocation (see Fig.1) which are summarized in the following:

Q1: Is one year enough to immigrate one of the most heritage, vernacular and traditional communities in the world (worldwide)?

Q2: Did the absence of a comprehensive program with clear points to study heritage societies subject to displacement led to the loss of features and the architectural identity present in these societies?

Q3: What are the results of displacing a society with a distinctive architectural nature such as vernacular architecture into a completely different environment?

Fig. 1 Timeline shows the Nubian community Relocation



Research Objective

The aim of this paper is to monitor and examine Nubian heritage communities before and after the displacement, based on a conscious understanding of the nature of these culturally distinct local communities and recording the relationship of this traditional spontaneous construction of these communities through an in-depth understanding of the personality and understanding of architectural dwelling meanings in order to recover the design solutions that were provided by the old Nubian peoples architecture.

Research Methodology

The Research Methodology is Qualitative, based on two axes theoretical and analytical analysis. The study was based on evaluating the thermal performance of the traditional Nubian dwelling and comparing the results of field measurements between both the traditional and the new models. The main purpose for this comparison was to improve the vernacular and environmental life qualities of the Nubian people after the relocation.

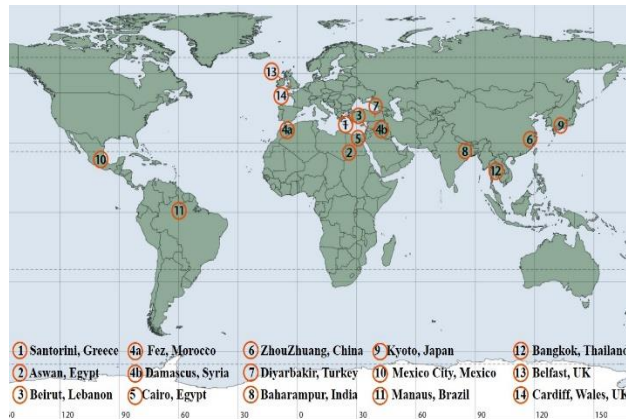
Case study Selection

The main reason for selecting Aswan city as a case study is that it contains a lot of Nubian villages which characterized by distinctive and unique urban and architectural houses dwelling. In addition, it contains new Nubian village of wadi karkar which is one of the first projects for the relocation of the Nubian community around lake Nasser. So, this study aims to achieve standards for those new housing according to the Nubian vernacular architecture. Therefore, the case study is divided into two regions the village in west Aswan which represents the traditional dwellings, and wadi karkar village represents the new Nubian house dwellings.

2. Vernacular architecture

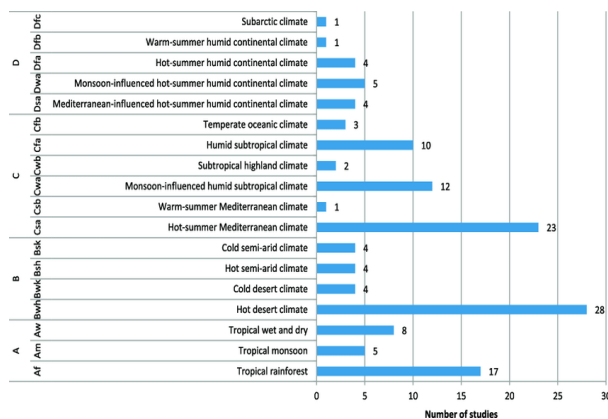
Vernacular or traditional buildings around the world evolved over time reflecting environmental, cultural, technological, and historical context of a specific location on which it was built. (see Fig.2)

Fig. 2 World Map for Vernacular Architecture, (Nguyen, A.T., Reiter, S.,2017)



Research community on vernacular architecture features increased recently as a result of the need to respond to climatic changes, environmental pollution, and the desire to decrease energy consumption.

Fig. 3 Distribution of studies by climate types, (Beck, H.E., et al.)



Since climatic factors are one of the most important engines in the collected studies, it can be seen that architecture in hot, warm and humid climates was intensively investigated in many studies. We assume that, the hot climate seems to pose many challenges to the role of architecture in regulating the indoor microclimate, such as the need to provide shading and ventilation solutions, and so it receives a great attention than other climatic zones. (See Fig.3)

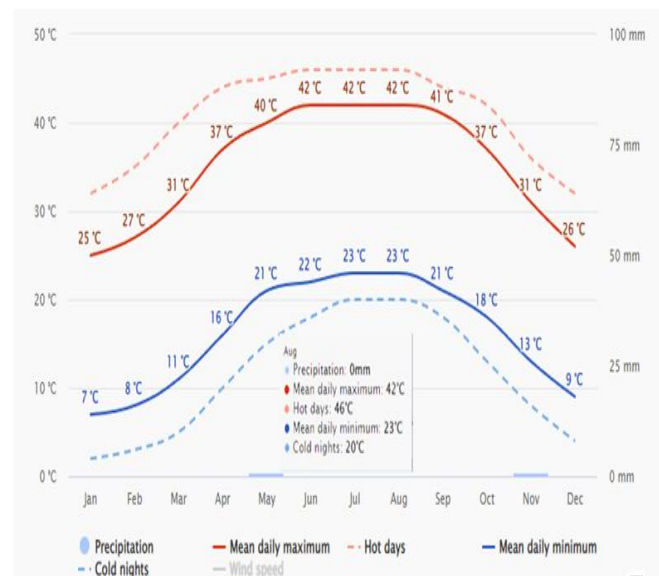
3. Climatic Properties

The study of the climate is one of the important criteria to be studied in order to know the division of climate regions and the extent of their impact, the climate elements such as wind, temperature, solar radiations greatly affect the site and its urban formation.

Classification of climatic region of Aswan

Aswan's climate is classified as a hot, dry desert climate according to the Köppen-Geiger (BWh) which represents the description of the type of climate where Group (B) represents: the arid or semi-arid region, thus this region is characterized by an increase in the rate of evaporation. The potential transpiration depends on the average annual rain, which makes its plants tolerant of heat and drought. As for (W): a desert area, so the two symbols (BW) mean dry desert climate, which increases its annual average temperature is about (°C18), and the symbol (h) is: hot climate.

Fig. 4 Average temperatures and precipitation for Aswan city



(<https://weatherspark.com>)

Selected period of time

The study was carried out based on the climatic data of the meteorological station for the city of Aswan on August 2021 which represents a sunny summer day, and also the maximum number of days that witnessed the highest temperature recorded during the first fifteen days of August available for field measurements within the case studies. (See Fig.4)

4. History of Nubian Architecture

Experts specializing in Nubian heritage confirm the importance and value of their vernacular architecture, except that the traditional architecture is playing an important role in Nubian civilization, Where the art of architecture in the Nubian civilization is one of the highest and uniqueness elements.

The beauty that distinguishes Nubia is not only in the pharaonic temples that were scattered on the river but in the beautiful Nubian villages on both sides of the Nile, where it reflects the character of the Nubian community.

Displacement of Nubians community

It is a Fact that the history of the Nubian people represents a series of successive sacrifices since the beginning of the last century, in which Nubia stretched 350 kms from the first waterfall to the second waterfall south of Aswan along the Nile River from the village of Daboud in the north to Adandan at latitude 22 A degree at Wadi Halfa, where the Nubians living in these villages were displaced.

"We gave up the remains of our ancestors so that the homeland would not die."

With these words, the people of Nubia express their feelings about the fifty-year-old story of struggle and sacrifice, which passed the memory of the displacement of the Nubians from their ancient country along the Nile to the eastern desert of Kom Ombo, until Egypt

completed the construction of the High Dam project in 1964. (See Fig.5)

1st Immigration: Nubians and Aswan Reservoir 1902

2nd Immigration: First Ramp of Aswan Reservoir 1912

3rd Immigration: Second Ramp of Aswan Reservoir

4th Immigration: Construction of the High dam 1964

Fig. 5 A memorial photos of Nubia in the phase of displacement



(<http://www.elwatannews.com/news/details/586954>)

Nubian villages Relocation project

After the decision was made to start the High Dam project in May 1961, the Ministry of Social Affairs was notified to assume its responsibility in conducting the research and studies required for the displacement of the Nubian people from their old villages along the Nile from the site of the Aswan Reservoir to the borders of Sudan.

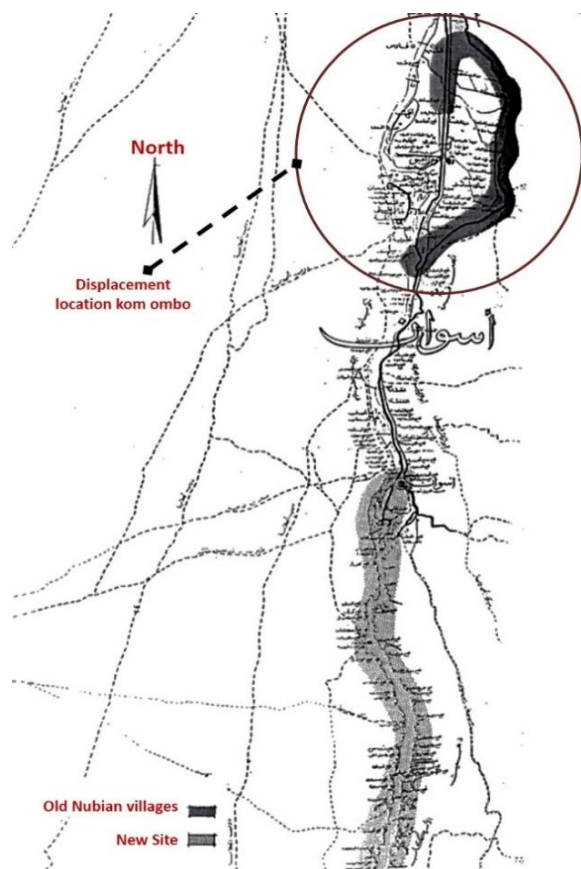
A. Displacement site selection

Implementation of the project to displace the people of the country of Nubia was at the expense of the government after choosing the new site so that it would be safe from the danger of flooding and also be close to the original site of the Nubia and have a similar and stable climate.

The site was chosen east of the Nile, 12 km from the Nile, extending from Kom Ombo in

the north to Aswan in the south. The site is bounded from the north, east and south by the Red Sea Mountains. (See Fig.6)

Fig. 6 A comparative figure showing the locations of the ancient Nubia villages south of Aswan and the displacement villages in the Kom Ombo area north of Aswan. (General Survey Authority 2014.)



B. Old Nubian Villages

Old Nubia consists of three groups each group of villages took a specific area and settled in it on the banks of the Nile. (See Fig.7)

Despite the similarity of these three groups in the general framework of Nubian life, except each group had its own language, traditions and social system, and the three groups were known by the following name:

a. Kunuz

It's located in the north with a length of about 125km, kunuz known as "Matoken" which reveal to the language spoken by these tribes. Kunuz lives in 17 villages end with the one called "Almadiq".

b. Alarabs

This group of tribes setteled in the central region known as "wadi alarab", which starts by villages of "Alsubua" from the east side and ends by villages of "Almaliky" from the west side, the Arabs lived-in 5 villages along 45km, their spoken language was the Arabic language and they preserved many of their Bedouin traditions.

c. Fadija

This group of tribes located in the southern region between the village of "Kresko" along till the Sudanese border with about 172km, the word Fadija means the fugitives from the south, the spoken language known as "Fadiga".

Fig. 7 Distribution of ancient Nubian villages in relation to the classification of assets. (Zakaria Hussein Siddiq Farag,2005)

C. Criteria of displacement

The old Nubian villages begun to disappear under the waters of the Nile after the formation of Nasser's lake.

Therefore, the Nubian people were subjected to a number of migrations started when Aswan reservoir was built in 1902, and other two migrations was in 1912, 1932.

About ten Nubian villages have voluntarily left their villages for fear of drowning when the level of the Nile River rises and they chose locations near to the old site 15km far called "west sohail", they kept on their traditions, building materials, type of buildings, these villages were a living model for the ancient Nubian villages.

The last migration in 1963, was subjected to the committee for displacement that decided to relocate the rest of the villages to the Nasr Nubia center in kom ombo desert

The decision of the Higher Committee for Displacement headed by the Minister of Social Affairs as the first responsible for the project to displacement the Nubian villages with a group of representatives of the Nubian people, ended with placing the villages according to their old order and status.

5. Nubian architecture dwellings

5.1 Nubian house dwelling before relocation (See Fig.8)

a. The main Entrance: The main entrance is located in the wall opposite the Nile River, it is 1.2 by 2.4 m, and is used as an entrance for guests. It is an indirect entrance, as it opens first to a space called "Dahlez" from which access is made to the hostess and to the main open courtyard where the rest of the house elements.

b. Dahlez: Entrance transition area main entrance portico.

c. Mandarah: it is the guest room, and located next to the main entrance and occupies a large part of the main façade, it is the only room with large windows that open onto the street, Nubians have been interested decorating it with colorful designs and vernacular materials, its dimensions range from 4×6 m to 6×8 meters and its height range from 5 to 8 meters.

d. Main courtyard: it is the most vital space, in which most majority of the family activities take place, that's because it is located between the different spaces of the entire house, its dimension is about 8×7meter square, it is wide unroofed courtyard, part of the courtyard is devoted to make semi shield covered with palm leaves.

e. Mastabah: It is a part of a stone building along the main facade with a height of 60 cm.

It is used in most activities such as eating, barbecuing, sitting guests and sometimes sleeping on hot summer nights.

f. Bedrooms: The bedrooms are often on the north side of the house and their doors open to the main courtyard, which provides them with privacy from the outside.

g. Kitchen: The kitchen in the Nubian house is no different from any house in the valley. Usually, it opens to the yard, and in one of its corners is the traditional Nubian oven called (Duka).

h. The barn: it is located at one side of the house or behind the yard or on it, and it is far from the bedrooms on the opposite (south) side and is covered by palm leaves.

i. Toilet: small at a side of the house.

j. Storage rooms: it is one of the most important elements in the Nubian house.

k. Diwani: The Nubians were interested in constructing a special suite with its services and a small courtyard could be attached, unlike the main courtyard, and it was dedicated to the daughters of the family, the girls, with their husbands in the first period of marriage.

5.2 Nubian house dwelling after relocation (See Fig.9)

a. The main Entrance: located to the left or to the right in the main facade of the house it is direct to the court yard or sometimes there is a lobby before the court.

b. The lobby: sometimes Nubian citizens created it to provide a little privacy to the rest of the rooms in the new relocated house because the "Dahlez" disappears from the new house.

c. Mandarah: located also near the entrance but it is smaller and not well ventilated.

d. The main courtyard: it is not located at the center also in the new housing it is attached from 2 sides with dimension may reach 7×6 meter square with no shaded area in any of its parts.

e. Mastaba: Disappeared.

f. Bedrooms:

Prototype 1 (large): 4 rooms.

Prototype 2 (medium): 3 rooms.

Prototype 3 (small): 2 rooms.

g. Kitchen: it has been neglected with smaller area and no space for the traditional Nubian oven.

h. The barn: Disappeared in most models of the new housing.

i. Toilets: inside the house with no ventilation's solution.

j. Storage rooms: disappeared

k. Diwani: disappeared.

Fig. 8 Nubia before relocation

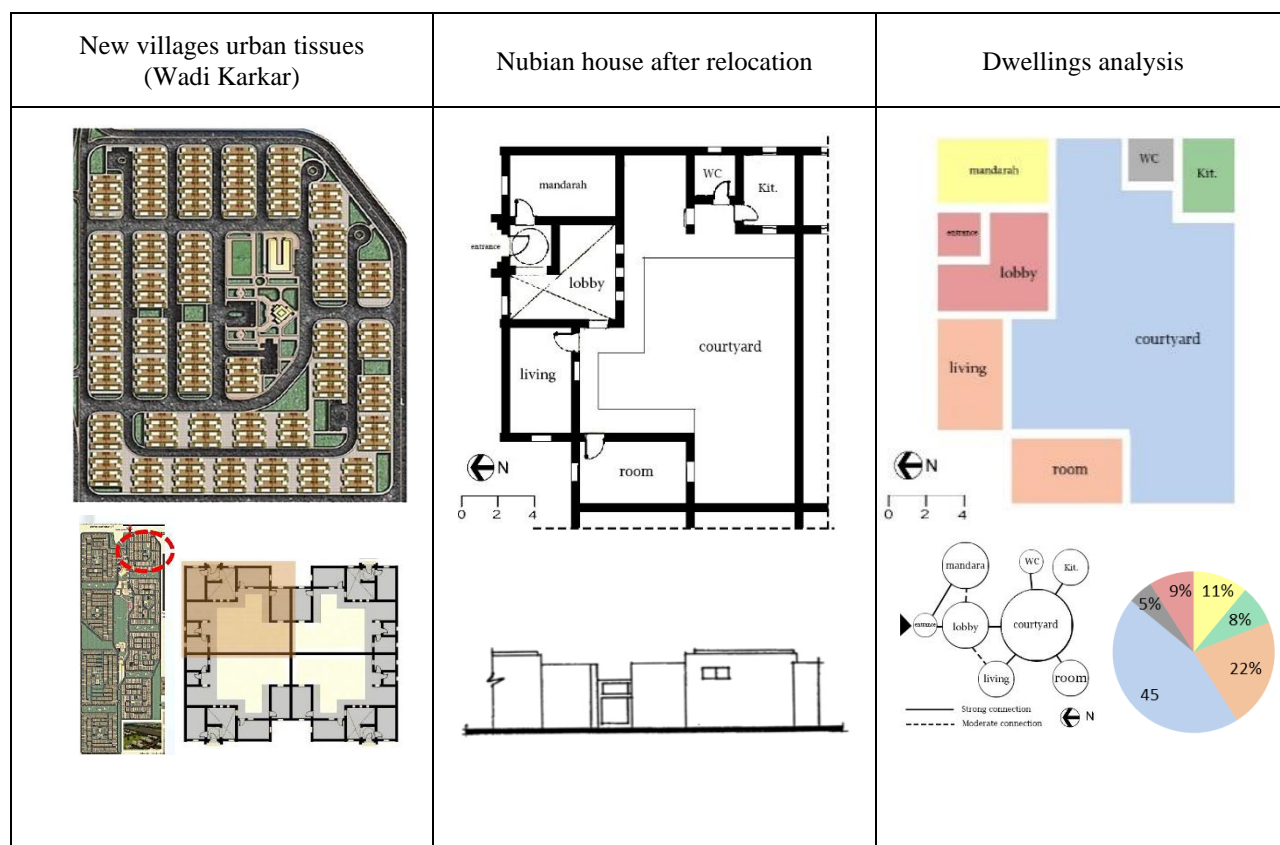
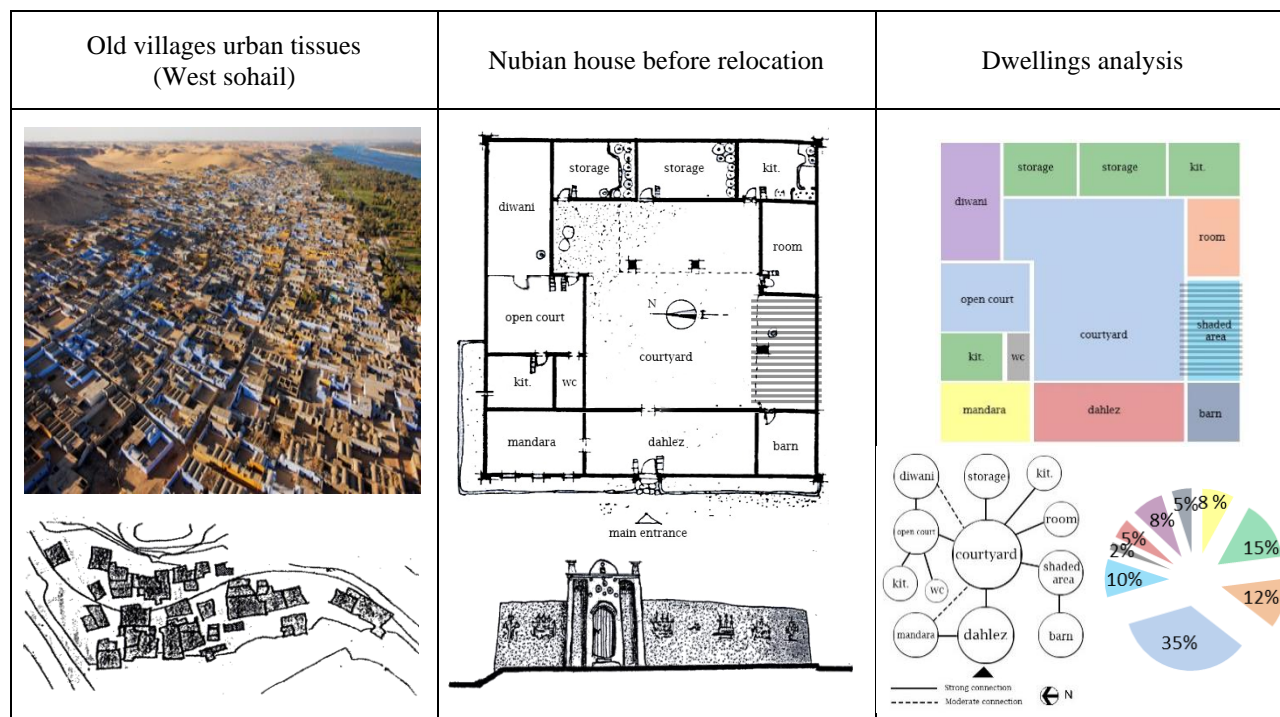


Fig. 9 Nubia after relocation



6. Field Measurements:

This part describes each of the devices used in field measurements, the periods and locations of Field measurements and also the results analysis.

6.1 Measurement tools:

The HOBO U12 Data Logger (See Fig.10) is used to conduct field measurements in each of the two models chosen to study their thermal behavior. Three measuring devices were used for the same period to illustrate the comparison between the two models. As (Table 1) shows the accuracy of the device.

Fig. 10 Hobo U12-011 temperature and humidity.



Table 1 HOBO U12 specifications

Measurement type	Measurement range	Measurement accuracy
Temperature	From (-20°C to 70°C)	±0.35 °C
Relative humidity	From (5%) to (95%)	±2.5 %

6.2 Measurement periods and location spots:

Field measurements were conducted on the two models for a period of (15) days from (1) to (15) August 2021, which represents most of the hot summer days, where it was relied on 3 devices (HOBO U12 Data Logger) to measure Each of the air temperature and relative humidity at two points in each model, one in the inner courtyard and the other in a room that have the same northern orientation as shown in of the traditional model (See Fig.11) and the new model (See Fig.12).

Climate data was collected for the same measurement period for the city of to be used in the comparison stage and as input data in the simulation process.

Fig. 11 Measurement location in room (1) and the inner courtyard of the traditional Nubian house

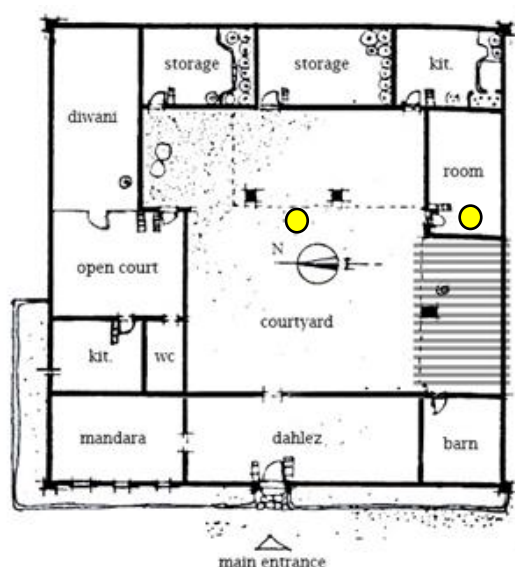
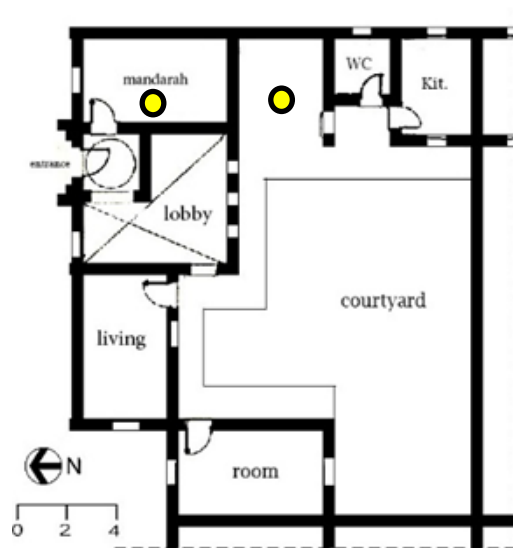


Fig. 12 Measurement location in room (2) and the inner courtyard of the new developed Nubian house.



6.3 Climatic data:

The results obtained from the climatic analysis refer to the period 1-15 August 2021 (See Fig.13) (See Fig.14) indicates that the average daytime temperature is about 36.4°C, with a maximum value of the temperature is about 42°C with a humidity of 10% and a wind speed of 23.7 km/h in just 3:00 pm on August 1. While the lowest temperature value was about 29°C. With humidity 24 % and wind speed 3.9km/h and that at exactly 4.10 am, the temperature rises in the afternoon, and decreases during the night hours and in the early hours of the morning due to the influence of solar radiation and its angle of inclination to the ground during daylight hours. The prevailing wind direction for the measurement period (See Fig.15).

Fig. 13 Temperatures analysis for the period of measurement.

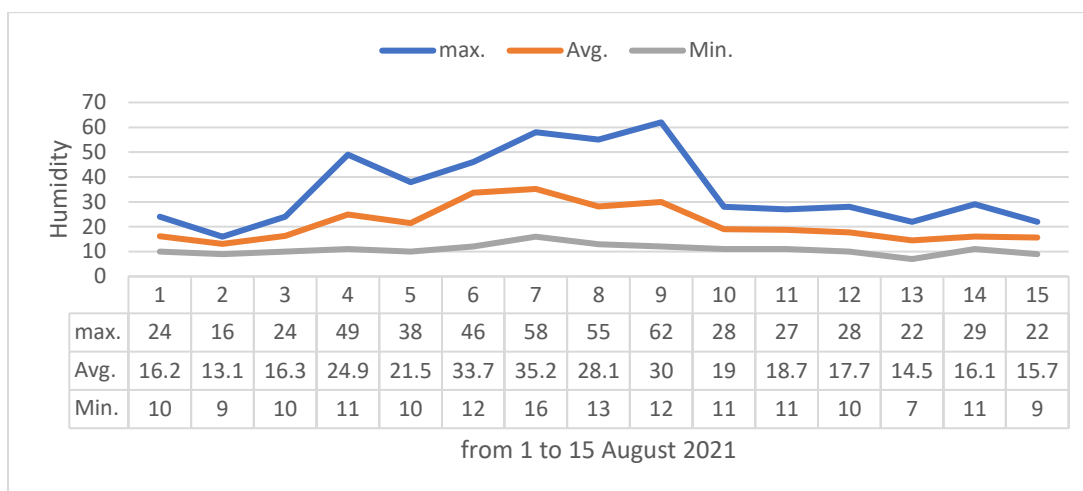


Fig. 14 Humidity analysis for the period of measurement

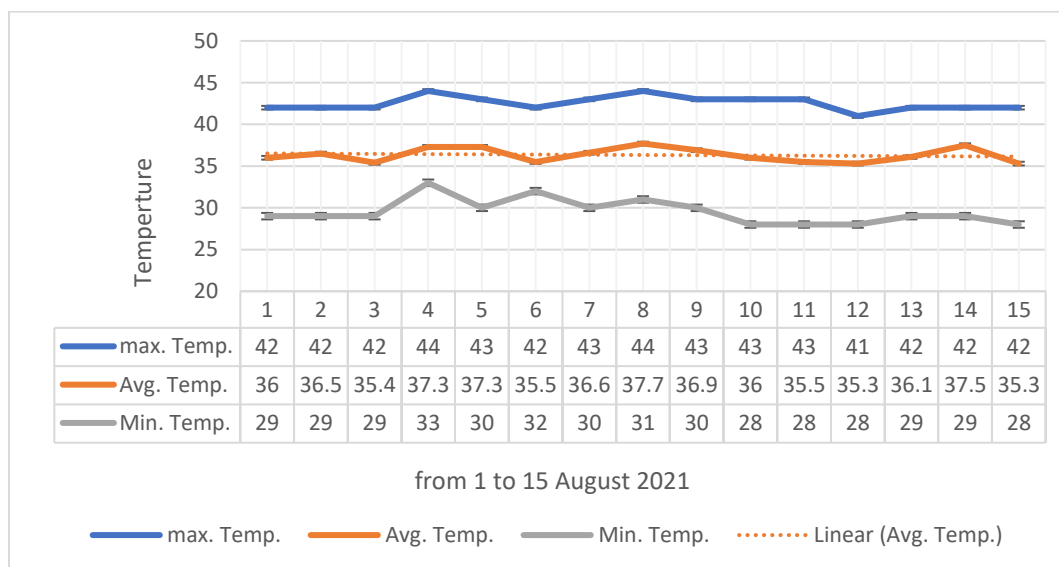
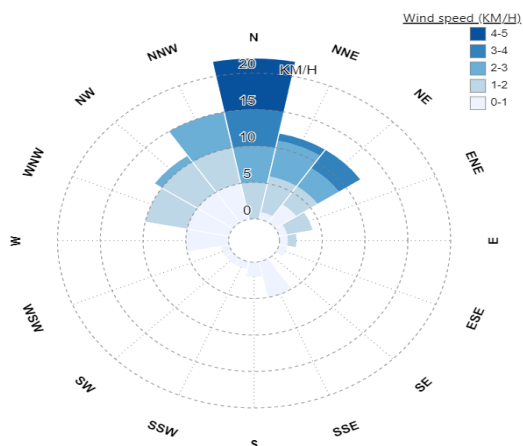


Fig. 15 wind rose for august 2021

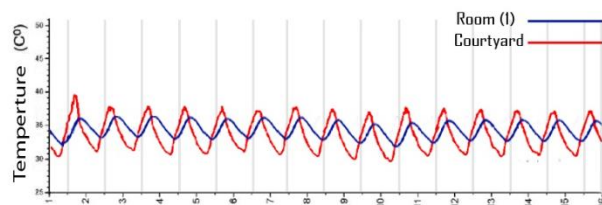


6.4 Field measurements Results

6.4.1. The traditional Nubian house results

In general, the temperature curve shows the increase in temperature during Noon hours and decreases during the night hours to reach its lowest value during the early hours of the morning. (See Fig.16).

Fig. 16 Temperatures Measurement results for room (1) and courtyard in the traditional Nubian house.



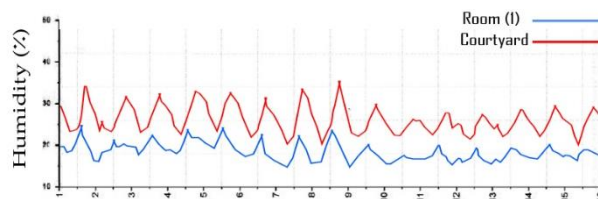
The results indicate an increase in temperature during the day to reach its highest value, which is (36.4°C) with a relative humidity (11%) inside room No. (1), with temperatures in the courtyard (39.1°C) and humidity (27.5%), while the meteorological temperature for the same time reached (38.4°C) with humidity (9.8%). Thus, it can be observed that the room temperature decreases with a difference of (2.7K) from the temperature of the inner courtyard and with a difference of (2K) from the meteorological temperature. The air temperature in the courtyard also increased from the meteorological temperature by a difference of (0.7K), Which indicates the clear effect of exposure of the courtyard to solar radiation and increase the heat gain of the yard during the noon hours.

The highest temperature was recorded inside the yard to reach (43°C), with relative humidity (28.3%), with Room temperature (33.5°C) and humidity (18.6%), While the meteorological temperature reached at the same Time (41.4°C) with humidity (11.2 %). This indicates a decrease in the room temperature by (9.5K) from the yard and (7.9K) from meteorology data. This is a relatively large difference to show the extent of the thermal insulation effect of the construction materials used which is adobe brick for the traditional Nubian house. As the air temperature in the yard also increases from Meteorology as in the previous case, but with a difference of up to (1.6K).

The results of the relative humidity in room (1) also indicate that the humidity during daylight

hours is similar to its average reaches (21%) and gradually increases during the night hours to reach (24%), As for the yard, it increases on average Relative humidity during the night hours and the early hours of the morning to reach (38%) while decreases in noon to reach (28%), By studying the relative humidity curve, it is clear that the humidity levels decrease relative during the period between ten in the morning and six in the evening, and the rates of Relative humidity rises until the next morning. (See Fig.17).

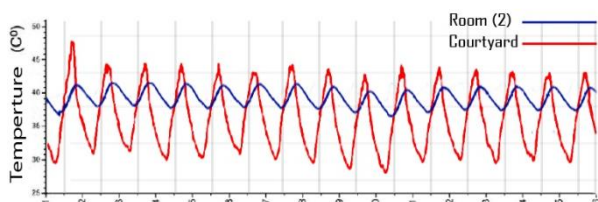
Fig. 17 Humidity Measurement results for room (1) and courtyard in the traditional Nubian house.



6.4.2. The new developed Nubian house results

As in the previous case the temperature curve for both the room and the courtyard shows the rise in temperature during the afternoon hours for a period of time Measurement, it also decreases during the night hours, reaching its lowest value during the first hours of the morning. (See Fig.18)

Fig. 18 Temperatures Measurement results for room (2) and courtyard in the new developed Nubian house.



The results indicate an increase in the temperature inside the room (2) during the day, reaching the highest value of (40.50°C) with

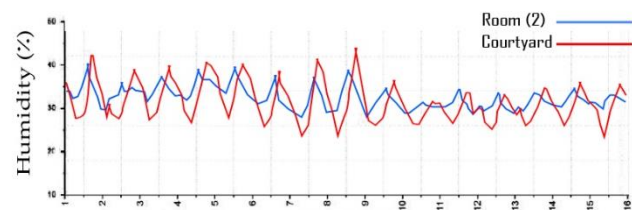
relative humidity (28%), With courtyard temperatures (39.7°C) and relative humidity inside it (21.8%), While the meteorological temperature for the same time was (35.8°C) with humidity (14.7). Where it can be observed that the room temperature increased from the yard with a difference of (0.8K) and increases by a difference of (4.7K) from the meteorological temperature, the air temperature in the courtyard also increased from the meteorological temperature by a difference (3.9K), Which indicates the clear effect of solar radiation on the courtyard as before and the increase in its temperature from the meteorological temperature, As for the room that recorded a high temperature, this is the result of building materials used in the new developed Nubian house, which are materials with a high thermal conductivity coefficient, so heat is transmitted to the space continuously.

The highest temperature was recorded inside the yard (48.20°C) and relative humidity (17.4%), with Room (2) temperature (38.8°C) and relative humidity (28.7%), While the meteorological temperature reached at same Time (43.6°C) with Humidity (12%), This indicates a decrease in the room temperature by a difference of (9.4K) from the yard and (4.8K) from meteorological temperature, This shows the impact of the continued exposure of the yard to solar radiation until late hours, which increases the heat gain of the building materials used in it, and when its temperature increases the room temperature increases with it.

The results also indicate the relative humidity of the air in the room (2) To the variance of the humidity curve to reduce the humidity During the afternoon hours, its average reaches (33%), It slightly increases during the night hours to reach average humidity up to (37%), In the courtyard, the average relative humidity increases during the night hours and the first hours in the morning to reach (41%) While it decreases in the afternoon hours to reach (33%), By studying the relative humidity curve,

it is clear that the relative humidity rates decreased during the same period Previously, between ten in the morning and six in the evening After that, the relative humidity rises Until the next morning in each room (2) and the inner court of the new developed Nubian house. (See Fig.19)

Fig. 19 Humidity Measurement results for room (2) and courtyard in the new developed Nubian house.



7. Conclusion

The main aim of the paper was to make a practical study analysis to one of the Nubian dwellings in the traditional village of West Aswan and the new one in Karkar Valley to evaluate the thermal performance and thermal comfort of the interior spaces of both dwellings, Thermal comfort is valued in interior spaces at the measurement points for room (1) in the traditional dwelling and room (2) in the new developed Nubian house dwellings, focusing on the critical hours of the hottest day throughout the measurement days, which is August 1 from through meteorological data.

Where the results indicate the occurrence of both room (1) in the traditional Nubian house and room (2) In the new developed Nubian house outside the thermal comfort zone during the afternoon hours from 12:00 noon until 5:00 pm, But room (2) is located in the very hot area, where it reaches Annoying feeling of discomfort, as for room (1), it approaches the limits of thermal comfort, which requires natural ventilation in order to achieve thermal comfort.

This paper could be considered as a guideline for architects and designers, vernacular architecture approach is coordinating between human beings, buildings, and physical environment in order to achieve comfort in Energy efficient buildings Therefore, all these factors must be taken into account when studying or analyzing any model, especially in traditional architecture, to obtain accurate results that actually help in improving the internal environment of the spaces.

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