The usability of green building rating systems in hot arid climates: A case study in Siwa, Egypt

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The usability of green building rating systems in hot arid climates: A case study in Siwa, Egypt

In the last ten years there has been a proliferation of regional building rating systems across the Middle East (ME).

Most those emerging rating systems and labels emulate the British and American rating systems BREEAM and LEED that emerged in industrial countries context with an impact reduction paradigm. Thus they are neglecting the local historic, climatic, economic, technological, cultural and social context of the ME. This paper presents a case study of a recently constructed eco-lodge, AlBabenshal, in Siwa, Egypt, that performs beyond the existing rating systems requirements. The paper illustrates the environmental and sustainability design strategies adapted to AlBabenshal Lodge buildings' context. In this study, the usability of existing rating systems in the ME is surveyed and their response to climate, occupants and society is evaluated. The paper presents a set of sustainability principles addressing (1) the site, (2) water, (3) energy, (4) resources, (5) comfort, (6) heritage and (7) social responsibility. In addition, the building is examined across the environmental criteria of LEED, Estidama Pearl Rating System and the Egyptian Green Pyramid Rating System (GPRS). Results showed that the building failed to comply with the three rating systems despite its sustainability and despite winning the Egyptian Hassan Fathy Award for environmental design. The paper elaborates on this conflict and presents recommendations to improve and adapt the questioned rating systems.

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INTRODUCTION

Many scholars and committees are analysing and discussing various green rating systems across the world. The beginnings of these green rating systems date back to the 1990s. However, in the Middle East (ME) green rating systems gained increased momentum during the recent years. For example, the Green Building Standard SI 5281 (Israel) was founded in 2005, Estidama (UAE) was founded in 2007, the Green Pyramid Rating System (GPRS) (Egypt) was founded in 2008, the SABA Rating system was

proposed in 2009 (Jordan) and Qatar Sustainability Assessment System (QSAS) was founded in 2010. The aim of these rating systems is to promote sustainability of buildings in a transparent and economically feasible way for society investors and clients. This is achieved by defining and quantifying the requirements of the criteria and of objectives of sustainable building in a clear and comprehensive way. However, the problem with those emerging rating systems is that they emulate the American LEED and British BREEAM rating systems which are not enough adapted to local environmental, cultural, historical, societal and economic context. Thus certification systems must be adapted to meet the needs of the Middle East regional climate, social, environmental and economic conditions. Another important problem emerging from applying those rating systems is that they are not suitable for evaluating the sustainability of local vernacular or traditional architecture. For example the value and the quality of Hassan Fathy's earth architecture go beyond the requirements and criteria of the existing rating systems.[1-10]

Thus to put those rating system in the regional context and better adapt them to the local traditional architectural practice, the remit of this paper is to evaluate the usability of existing rating systems for the development and measurement of sustainable buildings. The paper aims to examine and refine those problems, particularly by reviewing existing rating systems in the light of a case study. The case study is a recently built (2008) eco-lodge called AlBabenshal in Siwa Oasis in the Western Desert of Egypt. The project won several environmental and sustainability awards. The research is focused on the strength and weakness as well as elements of success and failure to comply with LEED V3, Estidama V1 and the Egyptian Green Pyramid rating systems Draft1. [6,9,10]

METHODOLOGY

The research methodology adopted a dual mixed approach consisting of two phases: a field study and an analytical rating and certification study.

The first phase is based on site visits, questionnaires, interviews and comfort measurements (temperature and humidity). Stratified questionnaire and un-structured walking interviews were used for the investigative purpose and search for data. Together six employees, the project master builder and the principal architect were interviewed. Employees' satisfaction regarding thermal comfort and the acceptance to the concept of living and working in a traditional building was reported. Thermal comfort measurements were conducted during extreme summer season in Siwa. Two data loggers were placed in one of the rooms facing east on the first floor. Humidity and temperature were measured for three consequent days (28, 29,30th of July 2011).

The second analytical phase mainly focused on the rating and certification of the building. Three rating system (LEED, Estidama and GPRS) matrices were applied. With the help of a LEED accredited professional and BREEAM Assessor, site observation and investigation of the current situation in Siwa were done to decide how to apply the rating systems different criteria to AlBabenshal Lodge. Estidama and GPRS were particularly chosen for being representative for the regional context. LEED was selected because it is the most widely used rating system across the Middle East. This methodology was designed to cope with the nature of the research to help collecting the data needed for the rating systems and to put hands on other cultural, social, traditional aspects which from our earlier investigations appeared to be beyond the rating systems.

CASE STUDY

Set in the middle of a lush palm grove in the heart of Siwa Oasis, AlBabenshal Lodge (Lat., 29.2° 'N. Long., 25.5° 'E) is built of rock salt, in the vernacular architecture style (Figure 1). Siwa Oasis is an oasis in the north west Egyptian land, nearly 50 km east of the Libyan border, 300 km south of the Mediterranean coast and 560 km from Cairo. The oasis is relatively an untouched corner of Egypt's Western Desert. The 13th century old enclave of Shali, made up of once-inhabited rock-salt houses, is built side by side along steep, narrow and winding dirt roads. Abandoned in the 1980s after they were badly damaged by heavy rain falls, some of these derelict properties are now being restored to serve as extensions to AlBabenshal Lodge. As community members catch on the environmental and economic benefits of this adaptive reuse model, a micro-credit scheme financed by International Finance Cooperation (IFC) is in action. [11,12]

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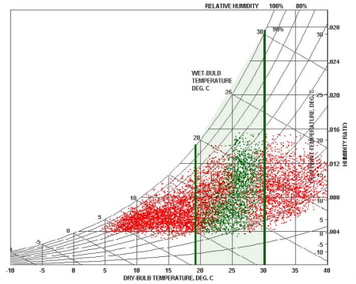
As part of the Siwa Sustainable Development Initiative, EQI Office aimed to revitalizes its unique cultural heritage by designing and operating AlBabenshal building. The oasis lived for centuries isolated, which allows the community to keep its identity and traditions including traditional skills, and creativity of the local community. The building can be seen as a model of sustainable development that could serve as a source of inspiration for other communities around the world.

Bioclimatic Site Conditions: The weather pattern in Siwa, is characterized by being extremely hot and dry (Group B, according to Köppen Classification). Average annual precipitation is less than 8mm; and average daily temperature during July is 33.4°C. However, wide variations of temperature occur in Siwa, ranging from a maximum of 41°C, during daylight hours, to a minimum of 3° C before sunrise. Average summer relative humidity is 35%. For this study, climate data were obtained from the Egyptian Organization of Meteorology (EOG). Solar irradiation is very strong, and may reach 12.8 kWh/m2 x day on a horizontal surface (during June and July). The intensity of solar radiation during the winter is relatively high and reaches 8.3 kWh/m2 per day on a horizontal surface. The psychrometric chart in Figure 2 shows two groups of clouds where temperature are falling outside the adaptive comfort model ASHRAE 55. [13-14]



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Building Description and Concept: Refurbishing existing five nearly demolished houses amid historical rubble, and tying them together in a logical design with a traditional construction method, was the challenge for two Egyptian architects, Emad Farid and Ramez Azmi. They sought a piecemeal intervention in the 800-year old settlement of Shali in Siwa. The planning and architectural concept entailed transforming group of five demolished houses to one large house resembling an old Siwan house that would serve as a hotel. Remains from the old houses were reused There are 11 rooms

Figure 1: AlBabenshal main facade with Kershif and date palm as main building materials (Courtsey EQI Consultants).

Figure 2: Psychrometric chart of Siwa using ASHRAE 55 Adaptive comfort model (Source: Climate Consultant 5).

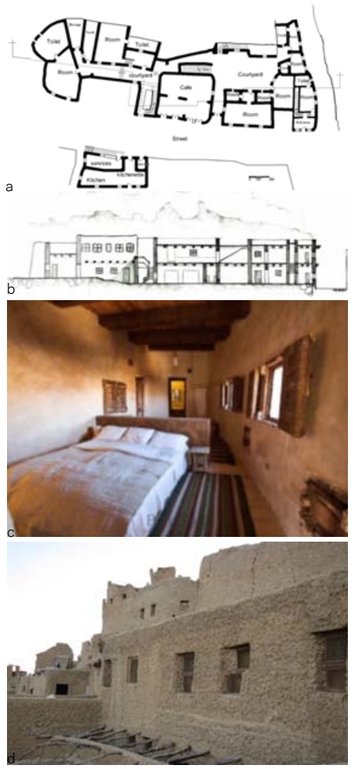

Figure 3: a.Ground floor plan for AlBabenshal (Courtsey EQI Consultants) , b. Cross section in AlBabenshal (Courtsey EQI Consultants), c.Using local material in furniture and interior design. Courtesy of Nina Wessel, d. The integration between the old site and the restored houses for AlBabenshal lodge.

designed using the natural flow of air currents (Figure 3). They overlook an open compacted courtyard without the use of tiles, mimicking the exterior of Shali Fortress, which overlooks the present market square in Siwa. There are three restaurants including one with an open terrace on the rooftop and a store selling Siwan products and handicrafts.

Construction for AlBabenshal relied on natural materials found in the surrounding environment and on "Kershef", which is the most favourable and cost effective material when it comes to Siwan weather (Figure 3). Olive tree trunks were used for the ceilings and natural stones for the floors.

RATING ALBABENSHAL

AlBabenshal is analysed and evaluated according to the most common classification categories in the three rating systems LEED, Estidama and GPRS. The six major categories are namely: 1) Sustainable Sites, 2) Water Efficiency, 3) Energy & Atmosphere, 4) Material and Resources, 5) Indoor Environmental Quality and 6) Culture and Society.

Sustainable Sites: AlBabenshal is very good integrated in its context as shown in Figure 3. The building is located in a site with a historic and cultural significance. The building is stretched horizontally along the east-west axis benefiting from the solar path and prevailing wind direction. There is no car parking capacities around the project. Locals and tourists use alternative public transportation (donkey carts and carriages for taxi) to reach the eco-lodge, which is economical and environmentally friendly without any carbon dioxide emissions. The project put into consideration keeping bird towers and beehives.

There are limited open spaces to reduce the exposure to direct sunrays especially in summer times when temperature reaches average of 35 and might reach 40 degrees especially in July. It was designed to make use of storm water; however, it is rare to rain in Siwa. Salt rocks, local stone with light colours, earth and white sand where used as finishing materials for roofs. That helps in reducing heat island effect through the reflective properties of such materials especially white sand and white salt. For night lighting the eco-lodge often depend on candles placed in salt white pots to maximise the light reflectivity from candles' flames.

Water Efficiency: In Siwa, the average annual rainfall water per year is less than 8 mm. Therefore, the building is dependent on the local water grid for drinking water supply. The water ground depends on local wells that lift water from Siwa underground aquifer. The sewage is off-grid feeding into septic tanks. The house has a water cycle that treats the sewage. The sewage (black and grey water) is treated passing through a large septic tank 4000 litre, with filtering systems. The final filtered water is processed using calcium powder to process the solid waste resulting in clear grey water. The water is then transported to feed in a bio-cleaning wetland, 4 km away from the building, used to grow papyrus and bamboo.

The outdoor landscape comprises native and indigenous plants including mint, parsley, basilicum, olive trees and palm trees. The water irrigation is done manually using flexible water tubes for the herbal spices. The internal water consumption fixtures (toilets, showers and faucets) have efficient flow rates exceeding the requirements of EPA 1992 by 40%. The water table on site is relatively high and therefore the building foundations are water proofed.

Energy and Atmosphere: The outdoor natural energy potential available in the form of daylight, air, wind, sun and nocturnal ventilation is consistently integrated and utilised in the overall concept. The building layout is stretched along the east-west axis for maximum air flow and for optimal solar protection and control. The building is designed to avoid mechanical acclimatisation systems for heating and cooling. The building is connected to the electricity grid for appliances and plugs. When the outdoor temperatures are moderate the building is naturally ventilated by outside air through opening windows onto the courtyard or directly to outdoors coupled with thermal mass. To cool the building in summer the thermal mass of the building together with nocturnal ventilation works on stabilizing the indoor temperatures below 26oC. No mechanical air supply is provided. In winter, when outdoor temperatures are extreme, the spaces are naturally supplied with warm air provided by the fire chimney. Olive tree trimmings are burned in the fire chimney. The trimming of the olive trees is managed in a sustainable way.

Material and Resources: The building shows maximum use of existing materials building materials. The project is considered a restoration project and adaptive re-use of five old deteriorating houses. 50 % of the materials used in the building are old re-used materials even doors and windows have been re-used. This includes olive tree wood, palm wood, recycled stone, recycled metal, and other products that are non-toxic, reusable, renewable, or recyclable, clay, expanded clay grains, calcium sand stone. The envelope has a very low embodied energy and is made out of a unique construction mix comprising 60% Kershef, 10% stones, 10% palm trunks, 5% unbaked mud bricks, 5% olives and clay is use as a binder (Figure 4). Because all materials used in construction have a salt base they are very sensitive to moisture. Seasoned Siwan architects are well aware of the delicate balance of water that needs to be present in the binding material so they build on levels that do not exceed 40 cm in height daily and usually build during the summer months. All the building materials used are natural local materials except of ordinary wood imported from outside Siwa. Local materials are extracted, treated and manufactured locally. Kitchen waste is separated and organic waste is composted. There are no waste products from building and construction process and all the local materials used in AlBabenshal are recyclable. While for electricity supplies and sanitary equipments they are artificial imported materials from outside Siwa.[15]

Indoor Environmental Quality : The passive design strategies ensure a high level of thermal comfort throughout the year and significantly reduce discomfort. As shown in Figure 4, the effect of thermal mass and natural ventilation has a significant effect on the reduction of indoor temperature. This is due to the 80-100 cm thick kershef walls and the well sized and positioned windows and guarantees a pressure difference and constant cross ventilation when windows are open. Also the sky night radiation from the exposed roof had a significant effect on the reduction of indoor temperatures.

Moreover, all rooms receive a basic illumination of 300 lux with almost no

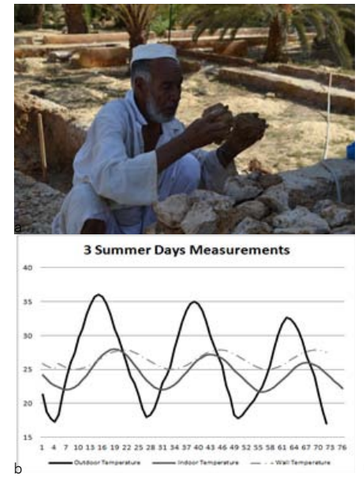

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Figure 4: a. Local builder during building process using salt rocks (Kershef) and clay, b. Temperature and humidity measured in AlBabenshal from the 28th till the 30th of July 2011.

need for artificial lighting during day. The user can easily influence his or her space in terms of thermal comfort, lighting level, protection against sun and glare by adjusting the window openings. As all the building materials are from natural sources so there is no any harm for workers. Cots are hewn out of rock salt, available in abundance from nearby mountains, while carpets are woven out of palm fronds. No chemicals were used in curing any of these materials. Candles are used for lighting in the evening and in morning time there is a maximum use of natural light. Electricity is available when need. By night, hurricane lanterns, light up the rooms and courtyard.

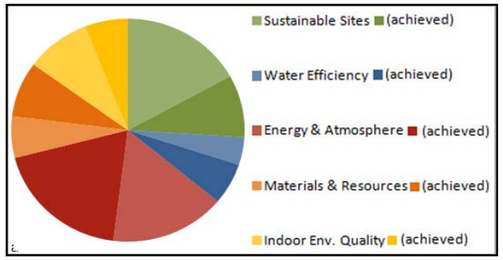
Culture and Society: AlBabenshal lodge is an integral part of the sustainable development initiative in Siwa oasis. This project aims to reduce poverty and help in keeping the cultural roots and natural assets of Siwa. The project focuses on four main domains; housing, traditional handcrafts, organic farming and renewable energy. The project architects aimed by providing this restoration model and re-using old houses in Shali town in spreading the awareness of re-using appropriate traditional local building materials within the Siwan society. The project not only helped in offering several job opportunities to Shali community but the lodge construction process helped in providing the society with skilled craftsmen who are capable to build with traditional techniques in the future. That helped in revitalizing building with vernacular methods and other traditional crafts like carpentry, stone carving and sculpturing which are about to vanish. All increased the sense of belonging and attachment to their place and appreciation to their building heritage and culture. Siwa is a conservative society where ladies normally work from home in producing traditional handicrafts. The project helped in revitalising such crafts and opened new way for increasing local economy through training ladies on using their traditional crafts in clothing and jewellery work. Their products are sold in small boutiques in the lodge. Such approach helped in increasing scene of belonging to their local society.

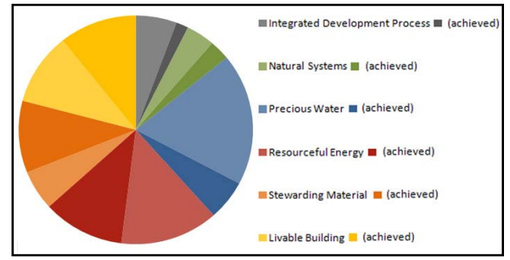
RESULTS

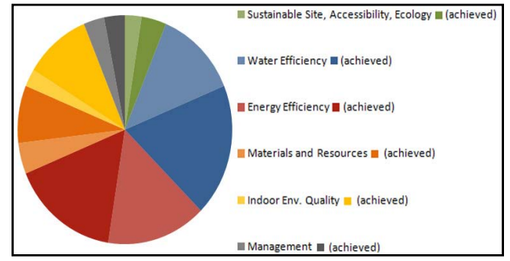
The result of the survey and rating system compliance analysis is presented in this section.

Survey: The interviews and questionnaires with locals and the project architects highlighted important embedded values in AlBabenshal project that are beyond the three examined rating systems. Those values are mainly related to culture, economy, society, building technology and traditions. The questionnaires respondents revealed their connection to this vernacular building style which is affordable and low tech. They explained that it is healthier to stay in vernacular buildings and they don't need to use air conditioning. The interview revealed that it is more economical to build with Kershef compared to other building materials for example, white or fired bricks and concrete. Also participating in the construction process was a sort of revitalization of the traditional way of community building as it represents an accumulation of social, cultural and historical values. AlBabenshal allowed them to communicate their tradition and culture which creates a sense of pride of their culture.

Certification: The research methods described early where used to evaluate the building with the help of the three rating system namely, LEED, Estidama and Green Pyramid. The assessment of AlBaneshal was based







on individual criteria/credits which were applied to the entire building. The result in each main category and the respective weighting factor for the three rating systems are summarized in Figure 5. The assessment was incorporated by examining the ability to comply with the rating system's minimum requirements, prerequisites and credits. Despite that the project potentially scored high in the examined rating systems, AlBabenshal failed to comply with most prerequisites for the major five categories for the three rating systems. This means the project in its current state cannot be certified by any of the three rating systems. Also the project could not comply with any of ASHRAE standards.

DISCUSSION

AlBabenshal Heritage Lodge demonstrated the environmental and economic benefits of restoring abandoned historic properties, motivating and enabling members of the Siwan community to restore and operate their own lodges in the future.

Recycling the old buildings encouraged local inhabitants to revive their lost tradition and conserve their identity while attracting more tourists and improve their income. A positive influence is already felt, since residents in the surrounding communities now opt to use Kershef when renewing their own personal property. Moreover, the building won several Environmental Awards including the most prestigious Hassan Fathy Award for sustainable architecture in Egypt.

On the other hand, the result of applying the three rating systems indicates that they are not suitable for evaluating the sustainability of such a local, vernacular and traditional architecture. The results are surprising and disappointing because it was expected that the project will comply, at least, with GPRS. The entry of the LEED and BREEAM rating system into the Middle East property market coincided with increasing demand for regional and local system. As a result, different systems to label the sustainability in the ME were developed under serious time pressure in the last ten years.

Figure 5: a.LEED credits vs. potential credits, b. ESTIDAMA, Pearl credits vs. potential credits, c.Green Pyramid credits vs. potential credits

The three compared systems are based on American and British standard. In the same time, there are currently no standardisation efforts working at local level to quantify and assess sustainability. As a consequence, those systems failed to accredited and award a sustainable building like AlBabenshal. This situation could be detrimental to the usability of all rating systems in the ME region. In fact, measuring sustainability is difficult and importing rating systems is not the solution. The case of AlBabenshal shows that a harmonised system within the ME would have distinctly better chances if the following issues are addressed: [16-18]

1.Adapting the certification systems to meet the needs of the ME regional climate, social, cultural, environmental and economic conditions.

2. Develop local criteria to quantify the social part of sustainability that includes community tradition and culture.

3.Develop local codes and standards.

4.Founding the rating systems based on local in-situ building performance research.

5.Facilitate the adjustment and upgrading for the specification of assessment factors.

CONCLUSION

The presented project, described in this paper, promotes a sustainable architecture that performs beyond rating systems. The value of such project lie in its ability to stand out as a showcase for designing sustainable architecture, that is contextual and sensitive to humans, climate, culture and available natural resources. On the other hand, we must understand that the examined rating systems are merely usable. Despite that the development of the examined rating systems is intended to facilitate the assessment of sustainable design; they fail to recognize the qualities of AlBabenshal. The LEED, Estidama and GPRS systems neglect the interpretation of essential sustainability measurements in their assessment set and normative standards. We conclude that the existing rating system needs to be more comprehensive and more considering to local environmental and sustainable potentials. The usefulness of rating systems in the future depends on their flexibility and ability to measure the merits of buildings like AlBabenshal case study.

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