A comparative study for human aspects in acclimatization of adobe vernacular architecture. A case from Denmark and Egypt

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A COMPARATIVE STUDY OF HUMAN ASPECTS IN ACCLIMATIZATION OF ADOBE VERNACULAR ARCHITECTURE.
A case from Denmark and Egypt.

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Abstract
Today's architecture swarms with concepts of energy and resource efficient buildings. In contrast, vernacular buildings are characterized by low-tech climatic responsive strategies and by their inhabitants' resource and energy savings practices during construction and operation of their dwellings. That makes vernacular buildings highly relevant to resource efficiency in contemporary building research. The main focus of this study is to explore and analyse human behaviour to reach responsive and conscious resource efficient solutions in two different climatic context; in Egypt and Denmark. The aim is to suggest sustainable principles out of human conduct for contemporary resource efficient building practice. Though Danish and Egyptian climates and cultures are very different from each other some human approaches to sustainability appeared to be similar. That was evident through a comparative analytical study applying case-study methodology for two courtyard adobe dwellings; one in each country. The paper contributes to existing vernacular sustainable building studies by filling a knowledge gap on how human factors is a key parameter in acclimatization in buildings and how that can influence resource efficient building practice.

Keywords: Vernacular architecture; acclimatization; human behaviour; Denmark; Egypt

INTRODUCTION
Parallel to the population growth in the world, the demand for energy and resources increase, and countries search for new methods of resource energy conservation is an urge. Moreover, the consumption of energy, which is mostly of fossil origin, causes environmental impacts for ecological cycles. Due to the need for supplying the climatic comfort conditions in buildings most of the energy is consumed in heating, cooling and acclimatization. Sustainability was found to be a subjective term for many vernacular building materials and construction technology. Vernacular local culture and tradition were major factors in how building-related to sustainability. Attempts were made to fulfil modernisation and official requirements in a creative and well-conceived way. This prevented loss of value and building information and ensured sustainable future reuse. This vernacular building outcome emerged, mainly resulting from differences in the local society created by environmental and economic factors.

This study in hand discusses the influence of human aspect on vernacular passive acclimatization approaches and sustainable use from a building-related perspective using two courtyard adobe dwellings. A combined site survey and comparative case study revealed the influence of human behaviour to sustain a comfort living environment within harsh climatic conditions. The outcome of this study is divided into two parts. The first will catalogue and compare principles from the two selected dwellings concerning human conduct of resource-savings, such as use of passive energy strategies and rational building principles involving strong/ weak materials and use of protection layers. The second part will discuss how the identified principles may contribute to future sustainable building through direct adoption and implementation of vernacular passive concepts or by developing and interpreting the principles for contemporary application.

Presentation Of The Two Cases

Figure 1: To the left, the Mayor house in Balat town, Egypt (Source: Dabaieh)
Figure 2: To the right, Abeline' Farm, Holmsland, Denmark. At the time of construction, the area was naked and had no shrub (Source: Eybye)

Mayor courtyard house, Balat, Egypt

The Mayor house is located in the town of Balat in the Western Desert of Egypt (25° 34 ´N, 29 °16 ´E), built at the eastern entrance of the Dakhla Oasis. It is situated at the junction of two old caravan routes in the Western Desert (Bard & Shubert 1999). Records refer to Balat as early as the sixteenth centuries (Maqrīzī 1898). It is around 800 KM away from Cairo, the capital city. The town is famous for trading, olive oil juicing, pottery making, blacksmithing, grazing and farming. According to the Central Agency for Public Mobilization and Statistics in Egypt, Balat's population was about 6,500 in 2006 and projected a growth of 10,000 by 2030.

The house is considered one of the oldest houses in the town that is still in a good condition. It is dated back to the early 19th century. It serves as the office and resident for the town Mayor and his family. It had a central location in the town urban structure. The main skeleton of the house is from adobe construction. The wall is constructed from sun dried mud blocks and the roofs are from acacia wood. The house is not only the remarkable public building in terms of its architectural design but has a special architectural identity

as well. The design reflects the intention of locals to show their accepted values in the community together with the functional purpose of such building.

This house provide more than just functional answers to essential life needs. Due to the flexible geometry it also have the potential to respond to future requirements. While traditions have always played a role in the design configuration, sticking to locals traditions has never caused inhabitants to deny the need for continuous development and growth for their building and for the whole town as well. The architectural design has reached a high level of precision through an ever-evolving building process; inhabitants get the most use out of spaces to fit their needs, even as those needs change. The house is now listed building but it is deserted for the last 7 years after the death of the Mayor and it is now open for public.

Abeline's Farm, Holmsland, Denmark

The farms in the dunes of Western Jutland are situated close to the West Coast of Denmark in the area from Fjand in the north to Nymindegab in the south. In former time this area was characterized by harsh climate conditions, poor quality of the soil and lack of forests. Instead the area offered a range of other landscape types; west coast and eastern inlets, dunes covered with Lyme grass and heath, fields and meadows. A particular vernacular building practice developed in this area, which today is considered sustainable in many ways, such as passive energy strategies, recycling and use of local and organic materials. The overall characteristics of the farms are that they are almost always single-located, have their four wings built together, primarily built of local building materials and are orientated according to the prevalent west wind and the sun. The building practice was prevalent from 1775 to 1880. Most of the farms were supported by a mixed economy which included farming and fishing, and sometimes the farm owner also held the position as wreck master. (Alsted 1994, Jensen 1975)

Abeline's Farm, situated near Hvide Sande at Holmsland, exemplifies the farm in the dunes and follows the particular vernacular building practice, which characterizes these farms. The farm was built in stages from 1854 to 1871 by the local wreck master, starting with the barn and finishing with the farmhouse. The farm was owned by the same family and passed on from generation to generation. Abeline's Farm was listed in 1974 and became a museum afterwards. Today Abeline's Farm is regarded as one of the best preserved farms of Holmsland.

CASE STUDY METHODOLOGY

The methodology used is a case study methodology applying a comparative analysis technique of two courtyard dwellings in order to explore human factors of sustainability in building. Two cases have been selected, of which one is situated in Egypt and the other in Denmark. Comparing two cases situated in very different cultural and climatic contexts may seem both theoretical and difficult. Hence, criteria for the cases selection have been carefully chosen to secure common basis of comparison. Both cases are courtyard dwellings situated in rural contexts, built under hard conditions such as scarce resources and harsh climate, involve earth building technology and finally, both dwellings were built and owned by local officials. As to age, the Egyptian dwelling is built in 1837, while the Danish dwelling is built in stages from 1854-71. The two different climates and cultural contexts widen the range of identified sustainable principles and illustrate how inhabitants in different climates and cultures tackle challenges in both diverse and similar ways.

Both cases are analysed by a frame of sustainability, of which human factors are emphasised. Human factors can be both tangible and intangible, and they primarily touch upon social, cultural and economic aspects of sustainability. Yet, these aspects of sustainability may also lead to environmental sustainability. The features of the cases that will be analysed and compared are the following: 'climate

responsive design', 'layout and spatial organization', 'rational use of building materials' and 'relationship between dwelling and inhabitants'. Each of the features are elaborated in the first sections of the comparative analysis. While the building design is analysed for the two cases in terms of culture and way of life, the method of analysis is based mainly on in situ observations combined with a detailed documentation of specific facts about desert vernacular building techniques and ethnographic descriptions of the farms of Holmsland.

COMPARATIVE ANALYSIS

Climate Responsive Design

Climate responsive design reflects man's deliberate building design according to local climate challenges, and solutions cover a wide span from large scale examples such as landscape elements used for shelter to small details to prevent air and water leakage. Applying climate responsive design in a dwelling prolongs its lifespan. Moreover, these solutions often have been developed over time in communities within their traditions and handed on from generation to generation. Therefore, this item refers to economic and cultural sustainability.

Application of climate responsive design in Mayor house

Egypt is a hot arid country lies within the hot desert climate (BWh) according to Köppen climate classification. The Sahara Desert covers a significant portion of Egypt's territory. The desert is split into two by the Nile. The weather in Egypt tends to be hot throughout the year. This is mainly attributed to the large tracts of the Sahara Desert. However there are a few exceptions, the desert can get quite chilly at night and some parts of Egypt even experience snowfall during the winter months.

The case study from Egypt discussed in this paper is located in the Western Desert which is in a higher altitude and characterized by hot daytime temperatures and much lower overnight temperatures. Based on the statistics and reports of the Egyptian Meteorological Authority (EMA) in 2010-2013, the Western Desert oases, annual mean maximum day temperatures in the shade is within range of 38 degrees, rising in some instances to 45 degrees. In the summer, a daytime temperature can reach up 55 degrees. Night temperatures average 20 degrees, dropping to as low as 10 degrees and in cool winter months it drops at night to 0 degree. In these areas as the altitude makes for lower temperatures that often drop below freezing in winter. Generally, the humidity is low and rains are rare, but strong sand storms during windy seasons raise sandy dust, these are particularly common during March and April. These dusty winds are important factors in the adaptation of the dwellings to the desert climate because wind direction is unstable and dwellers have to create effective solutions to avoid its hazardous effects.

Environmental characteristics of the architecture, the buildings' south and west exterior walls are shaded to avoid the unbearable heat of the sun, especially in summer. Passive ventilation solutions are applied using bottomless pottery vessels that are inserted into the ceilings of the last floor during construction in places where these holes can serve both as both skylights for indirect light and ventilation openings. They allow pleasant air to flow down from the roof floor to the ground floor. In addition, all these openings also serve as smoke exhaust ducts, for example, for bread ovens or kitchens if placed on the ground floor. When it is cold on winter nights or during a sandstorm, the openings can be closed by a piece of pottery or by a cotton pillow. The staircase shafts or interior courts also serve to create ventilating air flows.

The average thickness of external mud brick walls ranges from 35 cm to 80 cm. Thick walls serve as heat insulators, create natural thermal regulation and provide protection against the extreme temperatures that build up between the outdoor and indoor climates. The dimensions of openings (windows) range from 35 cm × 40 cm to 40 cm × 50 cm. They are relatively small to avoid direct sunrays and reduce glare in summer. Some are placed facing north to capture pleasant winds on summer nights and the others face south for warm sun in winter. Inhabitants tend to close the windows firmly with cotton pillows whenever needed to protect them from glare, sand storms and strong winter winds. The house residents tend to open windows for cross ventilation on summer evenings to get rid of warm heat transmitted from the walls during day time. This leads them also to use ingenious systems for air traps; for example, the courtyard and the staircase shafts function as wind catchers or as wind scoops.

Figure 3: A collective shots for the Mayor house showing from left to right, the passive climatic responsive solutions in coping with hot climate like shaded courtyards, small windows facing prevailing favourable winds and staircase that acts as air shafts (Source: Dabaieh).

Application of climate responsive design in Abeline's Farm

Denmark has a temperate coastal climate according to Vahl climate classification. This climate is characterized by close distance to the sea, windy weather and frequent precipitation. Summers are short and cool, while winters are mild. Average daytime temperature is 20 degrees in summer, in winter average daytime temperature is 2.6 degrees. Extreme temperatures measured are 36 degrees in summer and -31 degrees in winter. Furthermore, daylight is scarce in Scandinavia in the winter, and sky is clouded 80% of the time. Hence, adequate daylight must be secured. The area of Holmsland is characterized as harsh in particular, as it is more rainy and windy due to the West Coast. Hence, most important in this area is to protect the building from precipitation and wind. West wind prevails, while east wind is rare but very cold in wintertime. Wind, precipitation and daylight form climatic design criteria (Dahl, 2008).

Abeline's Farms is situated in the flat area just east of the dunes, as they provide shelter from west wind. Building the four wings of the farm together secures a sheltered courtyard. The farmhouse is east-west orientated, so the prevalent wind only cools the gable. In order to respond to precipitation the buildings have slanted roofs to lead water away quickly. Chimney pipes are placed in the ridge to minimize problems with leaks. The wide eaves protect the walls. At the base of the buildings ground is paved with pebbles to lead precipitation away and prevent mud splashes, as thatched buildings have no gutters. Ensuring a suitable amount of daylight is central to the wellbeing of the inhabitants, particularly in the winter, and the farmhouse has a large number of windows to the south. These window openings are about 100 x 100 cm and 50 x 100 cm. As the winter sun is low, sunlight comes deep into the southward rooms.

In summer, sun light only comes into the front part of the southward rooms. Sunlight thus contributes to heating during the cold winter months, while the house is kept cool during summer.

Figure 4: Climate responsive design as seen in Abeline's Farm, showing from left to right: half-hipped roofs reduce wind pressure on the gables, wide eaves protect the building from precipitation and summer sunlight, and pebbles lead precipitation away (Source: Eybye)

Layout And Spatial Organization

Layout and spatial organization concerns social structures, traditions and comfort. This includes how family life and cultural customs are supported by the layout of the dwelling. Related to comfort is in particular use of passive energy strategies to secure the thermal well-being of the inhabitants. Hence, layout and spatial organization refers to social, cultural and economic sustainability.

The Mayor house architectural design and interior space organization / Layout and spatial organization of Mayor house

Social formation in the Western Desert is family-and kin-oriented. Most families prefer to live in the same neighbourhood as their kin. Social organization is primarily based on blood relations, which play a main role in the site selection, configuration, grouping and location of dwellings within towns and villages (Dabaieh 2011, Hivernel 1996). The social structure of desert societies and evidence of the community strength is shown in the organizing of space. A strong architectural base has evolved to enrich the lives of inhabitants through reflecting their socio-cultural structures and values. It is for this reason nearly impossible to isolate cultural and traditional artefacts and ways of producing them from the influence of religion, norms and daily practices in the final building outcome (Dabaieh 2011).

The design and configuration of the house basically depend on the way the Mayor's wife moves inside the house. The oven and the small chicken coop are placed on the top floor nearby the kitchen to make it easy to manage daily activities. The location of openings is decided by the wife as well, that is, it is up to her where to place the windows to the courtyard of the grandparents' house and to the street to monitor passers-by.

Culture and tradition also plays a major role in the spatial organization of the house. For example, privacy is highly represented in the design of the dwelling. The concept of privacy is based on a mixture of religious and cultural norms. The hierarchy of spaces allows and reflects privacy in different types of social activities. Space is planned to change gradually from semi-public spaces to semi-private

to private. In the same time the concern for thermal comfort is still achieved by providing proper shading and allow for cross ventilation between different spaces. When the Mayor is expecting guests from the town community representatives that should be in a place where women can walk around the house freely without being noticed by strangers. Also the urban design of the town allows for houses common courtyards to be connected to the town tunnelled streets and cool recess. The Mayor's wife can socialize and talk with neighbours in parallel with finishing her household activities without being visible to the outside.

Normally large extended-family like this case of the Mayor house, have a main hall in the centre for family gatherings, meals and socialization. You can find a degree of complexity that is derived from the diverse needs for a large extended family living together and functional office space for the administrative uses of the Mayor. Generally, there is great flexibility in changing the functionality of spaces. Adding rooms and extending houses both horizontally or vertically are common, easy and affordable. For example, when the children grow up and decide to marry, depending on the available space and the family's financial situation, the parents add another room for the newly married couple or they build another attached house with an internal connection. There is also flexibility in the functional use of space. For example, the entrance hall on the ground floor is normally employed for multiple functions. It can be used as a reception and meeting hall for the Mayor during day time and in the afternoon is used as dining and sitting area while at night as sleeping area on cold winter days. Minimal furniture helps in the flexible change in functions.

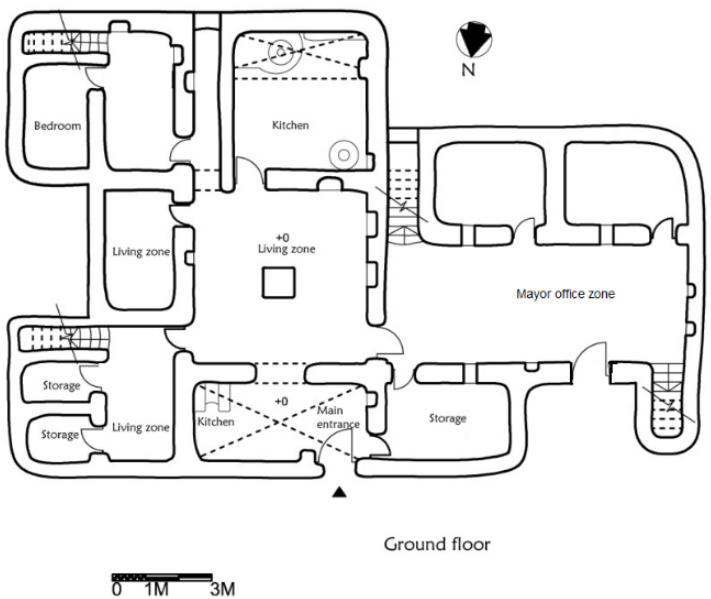

Figure 5: Layout of Mayor courtyard house showing the organization of rooms and spaces (Source: Dabaieh)

The roof floor is an important part of the house with many facilities for conveniences and daily activities. To provide a natural fence around the roof floor, long palm tree branches are used. For more privacy, tall exterior fences (parapets) made from mud brick are built. They reach up to 1.5 metres and are designed with high openings used for ventilation and to make it easy to look through and keep an eye on the community members' comings and goings. Above and beyond the view from the street, ringed by high parapet

walls, are sleeping porches, which inhabitants use as mentioned on summer nights. Mud pots for storage of grain and mud bread ovens have their own spaces on the roof floor, as does the chicken coop. Grain storage has always had a very particular meaning especially in old times. It is to store the grain and other food essential to the family's survival for the whole year.

The toilets in the house are dry toilets (compost) and it is semi-covered in order to allow air circulation to get rid of bad smells. The lack of covering also allows sun rays to speed up the process of drying the waste and killing any bacteria. The toilet is located on the mezzanine level between the ground and the first floor. The orientation of the toilet is in the opposite direction from the prevailing wind. The toilet has an opening in the bottom of this tower to collect the wastes when they are completely dry twice a year. The wastes are used as soil fertilizers or fuel for ovens.

Layout and spatial organization of Abeline's Farm

At the end of the 18th century Danish agriculture was reformed. This included for instance lifting of community farming and land turnovers in order to make agriculture more efficient. Furthermore, farmers' conditions were improved. At Holmsland land turnovers ended by 1804, and in 1830 copyhold of the Holmsland farms ended, as the farmers obtained freehold (Jensen 1975).

A household typical of a Holmsland farm would include the farmer, his wife, their children, one or two maids and a farm hand. Moreover, a household would usually include the former owners of the farm. As part of the making over the farm, the former owners received accommodation and support by the new owner (often a son or a daughter) of the farm in order to secure their old age. A farmer holding position of wreckmaster was obliged to accommodate wrecked sailors after shipwrecks. Finally, a household could include tenants, foster children and summer tourists. Hence, the typical farm of Holmsland would be a small community of different people (Andersen 1997).

Figure 6: Layout of Abeline's Farm including organization of rooms in the farmhouse (Source: Eybye)

Layout and spatial organization of Abeline's Farm highly reflects a large household and local climate conditions. The four wings of the farm are organized as follows; to the north is the large barn providing shelter, to the west is the stable, to the east the gate wing providing sheltered access to the courtyard and to the south is the farmhouse. Building the four wings together reduces outer walls

and thereby loss of heat. The shape of the farmhouse is long and narrow. Hence, all rooms are provided the possibility of natural daylight and moreover, the house can be ventilated naturally by opening the windows. The primary living rooms are placed in the middle of the house facing southwards to take advantage of sunlight, optimize thermal comfort and reduce use of energy having only one outer wall. Bedrooms and bed recesses are placed in connection to the primary living rooms, which reduces use of energy for heating. Practical rooms such as kitchen, scullery, larder, pantry and milk room are placed northwards as storing food and dairy in cool rooms are important. Porches and entrance halls reduce loss of heat, and one never enters directly from outside into a living room. The gables are climatic buffer zones. To the west are the scullery and maid's chamber. To the east were rooms for the former owner of the house. This part of the house was later rebuilt to accommodate summer tourists.

The traditional Danish farmhouse is accessed from the courtyard, which was used for all kinds of purposes. Contrary, the farmhouses of Holmsland are accessed from the south – and not through the courtyard. The courtyard of Abeline's Farm was primarily reserved for the dwellers of the farm and their doings. Animals were only rarely found in the courtyard.

Rational Use Of Building Materials

Rational use of building materials and resource efficiency relate to the design and construction process of the building. Contrary present construction, vernacular dwellers of the 19th century had no machines for building construction. Moreover, they had to obtain all the building materials by themselves. Building at that time required enormous manpower and hence, the vernacular construction processes were very rational in order to save power and materials. Rational building practices and techniques developed over time to secure this process. Therefore, rational use of building materials relates to both cultural and economic sustainability.

Rational use of building materials in Major house

Earth is an environmental building material and copes efficiently with the harsh arid desert climate, especially during hot summers. It was mentioned in the book Building without Borders based on Hassan Fathy's experience in Egypt that traditional earthen interiors remain cool during the day and release warmth at night, (Kennedy 2004). Economically, constructing an earthen house in the Western Desert costs almost nothing because its material is obtained from the surrounding environment. In addition, a house built with such local resources can be easily enlarged at low cost, as need arises. As people build by themselves, there is no cost for workers' fees. In fact, neighbours and families help each other in the building process. Moreover there are no transportation or manufacturing costs. Although earth may be perceived as a weak building material, due to desert vernacular trial and error experimentation of uncountable ideas, earth structures have managed to survive for centuries. Also the delicate craftsmanship, wisdom and accumulation of experience have led to good designs that are comfortable for living and sustainable to this day.

Due to the shortage of natural resources and raw materials in the desert, there are several creative ideas and solutions that maximize the use of the scarce available resources adopted in this house. They used by-products of buildings materials. For example, when tree trunks are used as beams for roof support, the medium sized branches that remain are used for wall supports in corners or in making small shelves in kitchens and living areas or for windows or lintels for doors. The small branches are then tied together as a mesh to be used as secondary layers over the main roof beams and used in a vertical science with a wooden frame as small interior doors. Finally, the leftovers of small wood pieces are used as a fuel for ovens.

When the house was built men and women in the town collaborated together. Men were mainly responsible for raising walls and roofs and doing the first plastering layer of the house. Women are responsible for bringing water for the clay mix. They also help in

the mud brick casting process, assisting by handing the bricks to bricklayers during building and by doing the final interior and exterior rendering of the house. Women do decorate the exterior together with men in some cases. During the lifetime of using the building, the ladies in the house do a monthly maintenance and rendering of the floors and walls. They sprinkle new clean sand on the floors and the roof of the house every month. They are also responsible for regular maintenance of the houses if needed in case of cracks.

Room sizes are rather small due to limited availability of long wood logs. The same goes for ceiling heights, as the higher the ceilings the thicker the bearing walls must be and this reduces the room areas as well. The flexible structure system makes it easy to connect the house together with neighbouring ones with possibility of extension. Some of the wood logs are reclaimed wood from old and demolished houses in the town.

Rational use of building materials in Abeline's Farm

The building materials for Abeline's Farm were primarily provided from the local environment. As mentioned, the area was characterised by a number of different landscape types. Inlets provided reed for thatching, meadows provided turf for the ridge and mud for adobes and mortar, while beaches provided pebbles the courtyard paving and shells for mortar. Furthermore, ship wrecks provided timber, metal and all sorts of things. Wreckage was sold by auctions at the wreck masters' farms. Clay for bricks came from the eastern side of the inlets and was transported by boat across the inlet to the area. Economically, local materials such as reed, turf, mud and pebbles were cheap but required hard work.

Lack of forests meant that timber on a large scale was recycled from ship wrecks and old houses being dismantled. In Abeline's Farm timber parts such as beams, rafters and collar beams are recycled from wrecked ships, and it is likely that wooden floors and ceilings also are recycled from ship wrecks. A few pieces of furniture are wreckage as well. Recycling was very common practice all over Denmark, as materials were either expensive or required hard work to obtain and process. Written sources tell us that whole houses have been dismantled, moved and rebuilt in Denmark (Porsmose 2008).

In preindustrial time, timber was the most important building material in Denmark, and almost all vernacular dwellings were half-timbered constructions with wattle and daub infill. In contrast, the farms in the dunes are built of bricks and adobes. As mentioned, the West Coast of Denmark was challenged by lack of forests, and this is presumed to be one of the reasons why masonry spread from Holland to Friesland and further up the West Coast of Denmark (Von Jessen 1975). Another reason is thought to be the harsh climate of the West Coast, where bricks have longer durability than wood. Yet, brick baking was costly due to the consumption of fire wood. Hence, rational building practice developed. In Abeline's farm walls exposed to weather were masonry, while inner walls, walls surrounding the courtyard and the north side of the barn were built of adobes, as these were less exposed to the weather. Mud came from the meadows, where it was knead and cast into adobes. Then the adobes dried, perhaps covered with straw or sea weed as protection from weather. Adobes for building were usually made the year before construction, so their full shrinkage was obtained. Adobe walls are vulnerable to humidity and precipitation and therefore, they were plastered and lime washed as protection layer to extend their durability. Base and corners were particularly fragile, and they were made of baked bricks. The farmer would often produce his own bricks for masonry with help from his farm hand and children - just like the adobe manufacture. Clay was taken home in the autumn and was knead and moulded to bricks in the early part of the following summer. The bricks dried in the empty barn during summer, was moved to the gate room in harvest and baked in small owens in autumn. The baking process produced bricks of heterogeneous quality, and the weakest bricks were used in less exposed parts of the building, such as cornices and masonry arches, as these often were protected by the wide eaves of the building (Jensen 1975).

Roofs are thatched with reed. This is a highly flexible material that easily adjusts to the shape of the roof. Furthermore, reed is hollow and works as insulation. Thatched roofs contribute to reduced energy consumption. Depending on climate and orientation, a thatched roof is expected to last for minimum 30 years. When the roof is worn out, it is used as fertilizer and thereby recycles back to nature. The only disadvantage of reed is fire risk.

Knowledge of materials and their qualities were important to vernacular dwellers. Different types of wood possess different abilities. Usually the most exposed building parts, such as lower parts of doors are made of stronger wood types such as oak to prolong durability. All together, the construction of Abeline's Farm point to deliberate use of strong and weak materials in accordance with climate, use of protection layers to prolong durability and recycling, which reduced efforts in obtaining and processing materials.

Relationship Between Dwelling And Inhabitants: Durability, Flexibility and Maintenance

Relationship between dwelling and inhabitants touches upon topics such as durability, flexibility and maintenance. Organic materials, which are often used in vernacular buildings, need regular maintenance to prolong durability and thereby lifespan of the dwelling. Maintenance was often regarded as part of everyday work. Hence, relationship between dwelling and inhabitants concerns social, cultural and economic sustainability.

The Major house and the inhabitants

The roles of the inhabitants in the building procedures in desert communities are allocated among family members. These roles are more like basic life activities and habits than professional work. We can say that the building process never stops, but is always integrated into daily life. Building and maintaining dwellings is a dynamic practice that develops according to current needs and past customs, and that helps dwellers feel engaged and interactive with their dwellings. All family members share work and different tasks are distributed among them. Rules allocate work differently in the different oases since all rules are based on the local cultures and traditions.

Traditionally in the town of Balat and in the Western Desert generally, women have, throughout history, taken a central role in planning, construction and use of desert vernacular buildings. Both men and women share the work in all the building phases in addition to taking part in the regular monthly and annual maintenance. Everyone in the town learn various construction and building skills. Men are mainly responsible for raising walls and roofs and doing the first plastering layer of the house. Women are responsible for bringing water for the clay mix. They also help in the mud brick casting process, assisting by handing the bricks to bricklayers during building and by doing the final interior and exterior rendering of the house. They may decorate the exterior together with men in some cases. Women do a monthly maintenance and rendering of the floors and walls. They sprinkle new clean sand on the floors and the roof of the house every month. They are also responsible for regular plastering maintenance for the houses twice a year and some times more if needed in case of structure cracks.

Abeline' Farm and the inhabitants

The dwellers of Abeline' Farm supported themselves by a mixed economy. This was reflected in the situation and the layout of the farm. The farmhouse was large due to accommodation of wrecked sailors. In times with scarcity of money, the western part of the house was let to a family. Hence, the layout of the house had to be flexible to support variable needs and able to adopt changes to a

certain degree. Preferably changes were made within the existing farmhouse, such as accommodation rooms for the former owner. There are, however, examples of other farmhouses which have been extended lengthwise to adapt to changes.

Abeline's Farm is built of materials from the local environment, and as more of these are organic, they need regular maintenance. Particularly the outer adobe walls needed regularly maintenance, which took place every spring and was done by the females of the farm. Sealing up roof and painting woodwork such as gates, doors and windows were also important. In general, maintenance was considered as part of everyday work and it took place in the times of the year, when the dwellers were not preoccupied with fishing or harvesting. Furthermore, the applied building materials possess the quality of possible repair. An example is the lower parts of window frames, which are more exposed to rot and therefore can be changed without discarding the whole window, thus saving resources. The south elevation of the house with its symmetrical composition and neoclassical elements indicates that the dwellers were proud of their farm and made it a point of honour to maintain their house.

COMMONALITIES AND DIFFERENCES IN ACCLIMATIZATION AND RESOURCE EFFICIENCY PRACTICE

Despite very different cultures and climates, the two vernacular dwellings in this study pointed to similar challenges and solutions. Our analysis revealed that vernacular architecture arises from a rare mixture of tradition and a variety of personal preferences. Vernacular housing reached a high level of design perfection and that is particularly due to the use of inherited traditions in the building process. Dwellers have managed to reach more or less the same solutions, methodologies and best practice adapting to harsh climate to create adaptive environmental solutions. Though this study has focused on the social, cultural and economic aspects of sustainability, the principles pointed out are to a large extent also examples of environmental sustainability. From the two case studies we found some common sustainable and resource efficient practices from which:

- Dwellings are carefully built in accordance with local climate using passive strategies for lighting, cooling and heating, which reduces energy consumption.
- Inhabitants take part in both design and construction phases, which encourage resource savings and rational building practice.
- Self-help building process as locals build their own dwellings, so there is almost zero labour cost.
- The sustainability of managing the balance between preservation and use of local resources and of the limited local materials.
- Economic perception in using local building materials which are almost cost-free, such as the use of wood trees grown on their farmlands and the cast mud bricks using earth from their surroundings.
- Minimum waste outcome from local available resources and an ability to be inspired by the cradle to cradle ecological cycles from surrounding nature.
- Almost no waste product is produced during buildings process.
- High degree of reuse such as earth material, timber etc.
- Dwellings are flexible to changes in space configuration or for future extension.
- Building materials can be maintained and repaired, prolonging durability and reducing waste.
- All family members take part in maintenance process so reducing maintenance cost and keeps the building in a good shape.

We also noted some differences in the climatic adaptation and responses:

- The adaptation to cope with heat versus and cold weather which are ventilation versus wind and precipitation.
- Different approaches to daylight: avoiding direct sunlight to reduce glare versus encouraging daylight especially in winter time.
- Shaded courtyards to provide summer cool air for cross ventilation versus exposed courtyards to direct sun for winter heating.

LESSONS LEARNED AND RECOMMENDATIONS FOR APPLICATION IN CONTEMPORARY BUILDING DESIGN

Thus an important issue today is how we can learn from vernacular practice and still be able to respond to modernity and at the same time respond to the need for sustainability, recyclable materials and green technologies. One lesson to learn from our case studies to be adopted in contemporary design is encouraging using natural local building materials and building methods rather than costly imported materials. That makes the building process more resource efficient and reduce a lot of transport cost and CO2 emissions. Moreover, the advantage of using local material and methods allows the use of existing work force of craftsmen and skilled locals and that it also reduces costs compared to procedures using imported building methods and materials. We need to learn, how dwellers are conscious about the future, as they develop logical solutions, especially as regards the comfort inside their dwellings.

Second, building in accordance with local climate prolongs durability of the dwelling. Before construction starts, dwellers must consider heat, ventilation, wind, precipitation and daylight in the design of the building. Hence, passive energy strategies can be applied, which improve comfort and reduce energy consumption. Furthermore, possibilities of the building site must be considered to take advantage of contextual elements and situate the dwelling advantageously.

Third, knowledge of materials' qualities are important to build in a rational manner. Vernacular dwellers know that exposed parts of buildings need strong materials and sheltered part can do with weaker materials. Use of protection layers prolong durability in a cheap manner, thus reducing resource consumption.

Finally, in present building practice enormous amounts of waste are generated, as buildings being demolished are considered to be rubbish and down cycled. Building parts from demolished houses must be seen as resources and recycled, as vernacular dwellers do. By the use of 'simple technology', such as vernacular building practice, materials can be separated and recycled. Moreover, 'simple materials' as wood, earth and clay can be maintained and repaired, thus reducing waste, resources and energy.

Sustainable Recommendations For Application In Contemporary Building Practice

The study shows that adobe buildings have many sustainable qualities to offer. None the less, the common norm in both Egypt and Denmark that people tend to prefer industrialised modern building materials, as adobe are considered to be old fashion. Furthermore, adobe buildings need maintenance, which doesn't contribute to their popularity. However, in order to meet the needs for sustainability this construction principle should be considered, as it also offers human aspects of sustainability. A number of these sustainable principles, which easily apply in contemporary building practice, are listed below:

-Using natural building materials as it has no carbon footprint and can be recycled back to nature when the building is dismantled.
- Local materials reduce transportation, economic costs and keep your neighbour employed.
- Climate responsive design prolongs durability and reduces resource consumption.
- Applying passive energy strategies whenever possible to reduce relying on active mechanical systems.

CONCLUSIONS

The frame of sustainability in this paper comprises both tangible as well as intangible aspects for two adobe residential courtyard buildings in two extreme climatic and cultural conditions in Denmark and Egypt. Hence, the analysis tackled human aspects particular to social, cultural and economics of sustainability. This relates to items as climate responsive design, layout and spatial organization,

rational use of building materials, durability, flexibility and maintenance. Both cases were selected based on certain criteria from which both dwellings are built under harsh climate conditions, scarce resources and built with adobe building technology. It was clear from the study that cultural and social characteristics need to be considered in this analysis as they give insight into the physical setting, explain many variables and clarify the reasons for specific characteristics of the built environment.

This comparative case study shows that human aspects are very important in order to build in a sustainable manner and that vernacular dwellings display a wide range of ingenious solutions in order to be resource efficient. The vernacular in both cases is a record of the lifestyle of the past when inhabitants were trying to find a sustainable way of life, just as they are trying to now. Vernacular exhibits the potential of the local community to organize spaces, evolve a strong architectural base and enrich their lives through their own local culture. Our study tried to draw some recommendation ideas for lessons learn from acclimatization in both cases for contemporary practice. More deep studies are still needed for the influence of human factors in climatic adaptation in buildings as such factors are always missing and the focus normally is on physical and tangible building practice. Our study was based mainly on our observations and site analysis. More investigations is needed by involving residents to share their own experience and using post occupancy evaluation to assess the efficiency of passive strategies applied.

REFERENCES

Alsted, G. 1994. Abelines gård: En strandfogedgård på Holmsland Klit. Hvide Sande: Den selvejende institution “Abelines gård”

Andersen, P. D. 2000. *Den vestjyske klitgård*. Herning: Poul Kristensens Forlag ApS.

Bard, K. A. & Shubert, S. B. (red.). 1999, *Encyclopedia of the archaeology of ancient Egyp*t. New York: Routledge.

Dabaieh, M. 2011, *A future for the past of desert vernacular architecture: testing a novel conservation model an applied methodology in the town of Balat in Egypt*. Diss. Lund : Lunds universitet.

Dahl, T. & Friis Møller, W. (red.). 2008. *Klima og arkitektur. København:* Kunstakademiets Arkitektskoles Forlag.

Hivernel, J. E.1996, *Balât, Etude ethnologique d'une communauté rurale*. Institut français d’archéologie orientale le Caire.

Jensen, K. V. 1975, *Bebyggelse og landskab på Holmsland Klit*. Aarhus: Arkitektskolen i Aarhus.

Jessen, C. v. (red.). 1975, Landhuset: byggeskik og egnspræg, gode raad om vedligeholdelse og istandsættelse, København: Gyldendal.

Kennedy, J. F. (red.). 2004, *Building Without Borders: sustainable construction for the global village*. Gabriola, B.C.: New Society Publishers.

Maqrīzī, A.A.1895, *Mawaiz wa al-'i'tibar bi dhikr al-khitat wa al-'athar* ,Vol. 1.Bulaq. National Archives of Egypt.

Website

Central Agency for Public Mobilization and Statistics 2014, Available online, http://www.capmas.gov.eg/?lang=2 Accessed 3 March 2014

Egyptian Meteorological Authority 2014, Available online, http://nwp.gov.eg/ Accessed 1 January 2014.

Danish Meteorological Institute, Available online, http://www.dmi.dk/ Accessed August 2014.

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