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ANALYSING THE VERNACULAR ARCHITECTURAL TYPOLOGY OF SINDH AND BALOCHISTAN: DWELLINGS AND THEIR VERNACULAR DESIGN

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ABSTRACT

This paper analyzes the vernacular architecture in the hot-arid regions of Balochistan and Sindh to identify indigenous construction techniques and design strategies that have been part of the vernacular architectural tradition of the aforementioned regions. The paper aims to connect the age-old oral traditions of the remote region concerning construction techniques and materiality that have been translated into the vernacular architectural language/construction methodologies, dwelling layouts, and the overall identity of the region. Through a case study methodology of the local housing typologies found in the selected regions, the research will analyze various dwelling archetypes and their construction materials found in the highlighted region, such as the Chapper House, Kothi House, Chaunro House, built using rammed earth, compressed earth blocks, bamboo, and adobe. Furthermore, the research methodology also involves the analysis of relevant passive design strategies found in the identified vernacular case studies, such as verandahs, courtyards, clustering of houses, ventilation, and *jaalis*, which will be identified and analyzed to understand their effectiveness as vernacular design strategies in combating the challenges of the harsh desert climate.

Keywords: Vernacular architecture, passive design, dwellings, extreme climate, vernacular materials, Pakistan.

DEFINITIONS

Vernacular Architecture For the purpose of this research, vernacular architecture is defined as design based on local needs, availability of construction materials, and the reflection of local traditions.

Passive Design For the purpose of this research, passive design is defined as traditional sustainable building design strategies that favor the use of available climatic resources such as the sun, rain or wind.

Dwelling For the purpose of this research, a dwelling is defined as a building, specifically a house where people live.

Traditional Building For the purposes of this research, traditional buildings are defined as buildings that use common, regional, and local forms, materials, and building knowledge in construction.

INTRODUCTION

Regarding the geographical location of the typologies of vernacular architecture found in Balochistan and Sindh, their respective climatic conditions have much to contribute to the architectonics and design strategies that have evolved over the years (AlSayyad, 1995). In recent years, Pakistan has been extremely vulnerable to the effects of climate change and global warming. With the current prevalent climatic concerns of an unprecedented rise in temperatures,

excessive rainfall, flash flooding, and drought spells, the constraints concerning the documentation of established dwellings in the rural areas of Sindh and Balochistan that are retrofitted to adapt to these weather changes need to be addressed and consequently documented.

The vernacular architecture and its derivation from the cultural identity of the region being explored as a part of this research inquiry (AlSayyad,1995), namely in the regions Sindh and Balochistan, is also closely related to its climate. With extremities in a climate where average temperatures exceed 44 degrees (Centigrade), a critical understanding of comprehending and highlighting the underlying influences of the vernacular oral traditions about the dwelling typologies and their materiality of the aforementioned regions is vital. To understand the process behind the evolution of dwellings in Sindh and Balochistan, the creation of living conditions over time that are acceptable to its inhabitants is also important to study (Oliver, 2003).

Keeping in mind this intricate relationship between the built environment and its people, this research inquiry explores how existing local dwelling archetypes in the highlighted regions of Sindh and Balochistan, utilize relevant vernacular passive design strategies within these dwellings and their layouts as the research methodology. The case studies that are presented in this paper look into the vernacular response to harsh climatic conditions as a derivation from the oral traditions of the local community of the afflicted areas thereby informing the resultant building typology and material selection. The selection of the case studies as the research methodology for this paper namely the Chapper, Kothi, and Chaunro dwellings/houses is executed to understand how dwellings are conceived in such climatic environments with their available resources as an architectural response. This research exercise intends to comment on this indigenous building practice for archival and even practical purposes in the future which can then be utilized within the contemporary architectural and construction industry in Pakistan.

LITERATURE REVIEW

The Zero Carbon Culture Centre (The Makli Foundation), Makli, Sindh: Yasmin Lari.

The Zero Carbon Culture Centre (map shown in Figure 1 below), also known as the Makli Complex, is a pioneering initiative by Architect Yasmin Lari that intends to highlight the vernacular and social culture of Makli and its inhabitants (Lari, 2015). One of the main reasons why this case study has been selected for perusal is because of its geographical location and architectural response as per the site context. The culmination of the entire built semantics in the form of the Makli Foundation is a prime example of inclusive architecture that is geared towards safeguarding yet integrating the people from the prevalent and foreboding environmental concerns of the region that are a by-product

Figure-1: Map showing the location of the Zero Carbon Culture Centre in Makli. The unique location of the centre amidst a peri-urban site shows the dynamic nature of the centre.
Source: Google maps, accessed on 31/03-2024

of natural disasters. This center has been carefully curated in a rural region with multiple villages that are barren, face poverty, and lack shelter, water and sanitation services, and basic infrastructure. The complex incorporates environmental, cultural, and technical dimensions for bringing about social change that aims to eradicate the mindset of the people from a cycle of dependency to a culture of self-reliance and pride in traditional methods of dwelling and rehabilitation. Furthermore, the local integration within the construction process of this complex has also enabled the creation of a circular economy that allows them to earn from providing their services as builders, artisans, weavers, and laborers, for both men and women.

The Zero Carbon Culture Centre harbors various spaces that are not only communal in their spatial layout but are also designed to conduct hands-on workshops for locals to reinforce their workmanship skills and celebrate the vernacular heritage of the construction techniques and material knowledge that they hold as intangible knowledge (Crook, 2021). These spaces are directly informed by the intangible local oral tradition and practices that have ultimately shaped their public spaces of interaction over time, which is the main premise for Crook's (2021) suggestion for the celebration of the vernacular.

The main pavilion itself is a manifestation of the local craftsmanship paired with vernacular building methodologies and material utilization. These vernacular building techniques include the utilization of bamboo, limestone, and mud brick, all local materials that are long-term, durable, and easily sourced by the local builders themselves. As a part of the proposed strategies by the Heritage Foundation's Final Report for the Shelter Project in Sindh (2011), the main idea is to use local materials to avoid environmental degradation and to ensure the longevity of the built structures. The main pavilion of the complex takes the form of a huge hangar topped by a large, thatched roof and surrounded by bamboo screens that replicate local artisanal patterns. This is also a means for them to showcase their identity and local heritage. Throughout this complex, a variegated typology of rooftops is explored concerning their shape as a vernacular building strategy. These include flat, conical, and pitched roofs (Heritage Foundation, 2011). As suggested by the Heritage Foundation after several experiments, this roof structure also known as the 'Karavan Roof' consists of four to six bamboo joists that are placed on lime concrete ring beams on the top of leveled walls. Furthermore, these joists are constructed by local builders where it is fabricated on-site, and then installed with professional guidance from the Heritage Foundation (2011) as well. The Zero Carbon Culture Centre acknowledges the indigenous wisdom and techniques for low-carbon and low-cost construction that responds sensitively to the climate and context of its locale. The entire development of the complex, as suggested by the Heritage Foundation in their Final Report (2011), has been a by-product of local surveys, experiments, and cross-communication between professionals and the intel from the locals of the complex.

The architectonics of the building ensures that the space remains cool and usable throughout the hot summers without any air conditioning as shown in Figures 2 and 3. Vernacular cooling techniques informed by traditional practices within the local region over time include the usage of local materials, experimentation with orientation with respect to sun direction, incorporation of courtyards, and usage of vegetation for cooling. (Further details of the environmental impact of these vernacular passive cooling strategies will be discussed in the research methodology section). Other surrounding facilities include accommodation for visitors and a series of igloo-like structures which are used as additional workshop spaces and single room shelters.

Thatched roofs, as shown in Figures 2 and 3, act as natural insulators and ventilators for internal environment control. The surrounding bamboo bracings, as shown in Figure 2, are used for structural support of the building. Furthermore, the utilization of the verandah typology, or 'sehans,' within the Makli complex amidst the surrounding igloo-like structures serving as shelter spaces, makes use of mud-plaster construction techniques, as shown in Figure 3, which aid in the overall internal climatic control. Additionally, climatic sensitivity in correlation with oral tradition is seen through the usage of smaller-sized windows instead of roof vents for sunlight and ventilation. This also aids in the reduction of thermal gain, alongside the extension of the roof structure as shading devices, to formulate semi-covered spaces, as demonstrated in Figures 2 and 3

"This complex also capitalizes on the usage of readily available local materials, namely clay soil, bamboo, and lime, to create buildings that can withstand the effects of climate change, to which the site is particularly prone. To execute this without contributing further to global warming, the sustainable properties of the materials mentioned above are paired with the idea of participatory design, where inhabitants and artisans of the complex, mainly women, contribute to the construction process and engage in self-subsistent activities such as organic soap-making and raised bed farming (Lari, 2015)."

Figure-2: Usage of domed thatched rooftops and bamboo bracings for enabling thermal comfort and structural support as a part of the vernacular building tradition.
Source: INTBAU 2019

Figure-3: Usage of conical thatched rooftops for enablilng thermal comfort as a part of the vernacular building tradition paired with mud plaster construction.
Source: Lari, 2015

Building construction that applies vernacular material knowledge construction i.e., of bamboo, serves as a highly durable sustainable resource that sequesters Carbon dioxide throughout its life (Heritage Foundation, 2011). Bamboo as a material allows the local artisans to easily manipulate it according to their construction methodologies informed by traditional norms (Heritage Foundation, 2011) to create contemporary architectural elements. These include prefabricated bamboo panels and cross-braced 'Dhijji' frames as shown in Figure 4 below.

Moreover, the type of vernacular bamboo structural framework shown in Figure 4 ensures functionality in the face of natural disasters such as allowing stilt foundation construction during flooding and providing structural support in case of earthquakes as well. Apart from bamboo, the use of lime as a building material reduces the overall carbon footprint of the built structures as it continues to decarbonate and slowly turns back into limestone.

In conclusion, the Zero Carbon Culture Centre at Makli acts as a blueprint for a shelter designed by Yasmin Lari specific to the Southern region (Sindh/Balochistan in particular) of Pakistan. This project demonstrates how rural inhabitants embody their sense of cultural identity in the built environment using traditional construction techniques. Most importantly, it is an example of creating comfortable living conditions for the people whilst instilling a sense of autonomy within them. Through indigenous materials, this ultimately results in contextually relevant and climatically responsive buildings produced by local artisans and laymen that aid in not only rehabilitation of people affected by natural disasters

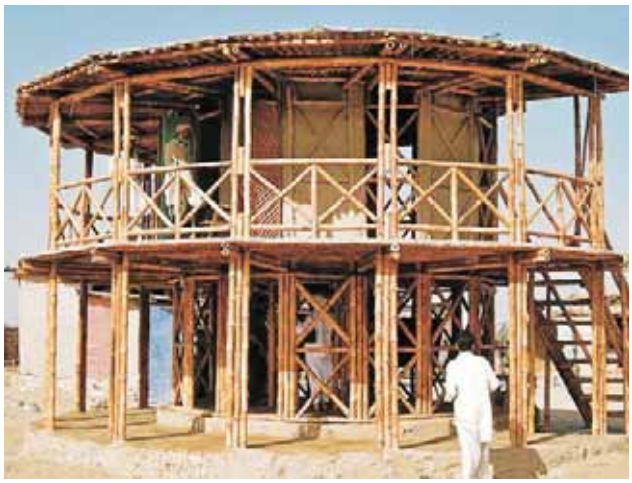

Figure-4: Employment of the 'Dhijji' framework at the Makli complex as a structural support system.
Source: Lari, 2015

i.e., floods and earthquakes, but also create an economic regeneration within the local community leading to improved livelihoods in the rural region.

Gourna Village, Luxor, Egypt: Hasan Fathy.

Hasan Fathy's project of renewing the Gourna Village at Luxor is a potent example of how he transformed the village settlement for the better whilst staying true to the Egyptian vernacular roots. Using the architectural language of the region to rekindle the Egyptian cultural identity, this project aligns with this research paper because of multiple reasons. "Furthermore, it must be noted that this case study is a classic example that has been referred to by various academics

and researchers, such as Attia, S. Ahmed*, when commenting on the vernacular built environment and climatic conditions of similar regions." This is one of the primary reasons why this case study has been examined for the research inquiry being made for this research paper.

Firstly, the geographical, climatic, and cultural context of the Gourna Village and how Hasan Fathy sought to reclaim it reiterates the importance of regional vernacularism and its deeply rooted construction methodologies. Moreover, the semblance this case study holds about the research setting of this paper is also relevant due to the commonalties seen in the climate and vernacular material culture of both regions i.e., between Sindh/ Balochistan and Egypt as demonstrated by Figure 5a and 5b respectively. The average temperature for both regions is 41 degrees with minimum rainfall overall. This substantiates the similar harsh climatic conditions of both regions under speculation and as discussed further, also creates a mutual usage of vernacular materials such as clay, brick, and mud that are climate responsive for both Egypt and Pakistan.

Hasan Fathy in this project made use of local Egyptian architectural elements, materials, and construction methodologies which not only reduced the overall carbon footprint of the built structure but also ensured a comfortable indoor micro-climate for the inhabitants of the village without any intrusion of artificial temperature controlling mechanisms.

With the help of mud construction, domes, as demonstrated in Figure 6a below, have been incorporated as a prominent visual architectural element of the village settlement. This building technology (i.e. the usage of domes, different-sized apertures, and mud as a cooling material as shown in Figure 6b) ensures that the internal thermal capacity of the buildings is kept low and consistent and promotes efficient air circulation within the buildings of the village (Figure 6b). Moreover, the mud-brick domes have been fitted with specially designed windows with small openings oriented towards the windward direction that form a steady and more pressurized wind stream.

The Gourna Village also reflects Egyptian vernacularism within the spatial planning and overall zoning of the community itself. Courtyards and an intricately woven network of pathways promote the proximity of the strong communal ties of the Egyptian community which Fathy has embedded in the redesign of the village. Despite introducing a revamping of the space, the socio-cultural traditions of the village have been given due diligence. Places of worship such as the mosque and social congregation i.e., marketplace

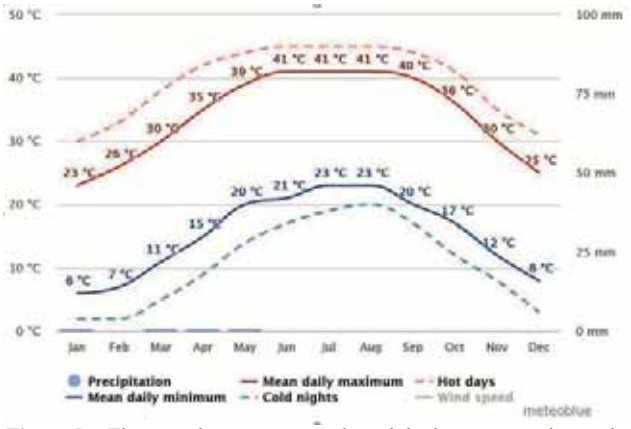

Figure-5a: The annual temperature and precipitation patterns observed in Luxor, Egypt.
Source: Meteo Blue, 2023

and theatre have been placed as equidistant epicenters on the northern side of the village from the living quarters thereby creating a sense of connection and immediacy for the people that aligns with their lifestyle as shown in Figure 7.

This Egyptian vernacularism as highlighted in the Gourna Village project is also further exemplified via the domain of participatory design as observed in the previous case study of the first literature review. Being a predominantly communal setup, the presence of grouped activities focused on the employment of local craftsmanship is a pertinent theme of the rural region and is also seen evidently in Luxor as well. The integration of the local village members in the construction and redesign of the Gourna Village project also created a similar means of employment for the poverty-stricken individuals. Moreover, this mechanism instills a sense of cultural pride in the people and serves as a means of restoring and preserving their Egyptian vernacular heritage. This aspect of participatory design does not only align with the design methodologies for the previous case study (The Zero Carbon Centre by Lari) but also aligns with the ideology and design conception behind the case studies that are further discussed in the research methodology section of this paper.

In conclusion, this case study as a part of the literature review has close ties with the vernacular and climatic context under speculation of this research paper. Ranging from the similarity in material culture, specifically baked bricks and mud plaster construction, in addition to the harsh climatic conditions (primarily higher temperatures with low annual rainfall) and a socio-cultural context where the concept of 'pardah' privacy is also enunciated, the Gourna Village proves to be a relevant exemplar to this research to

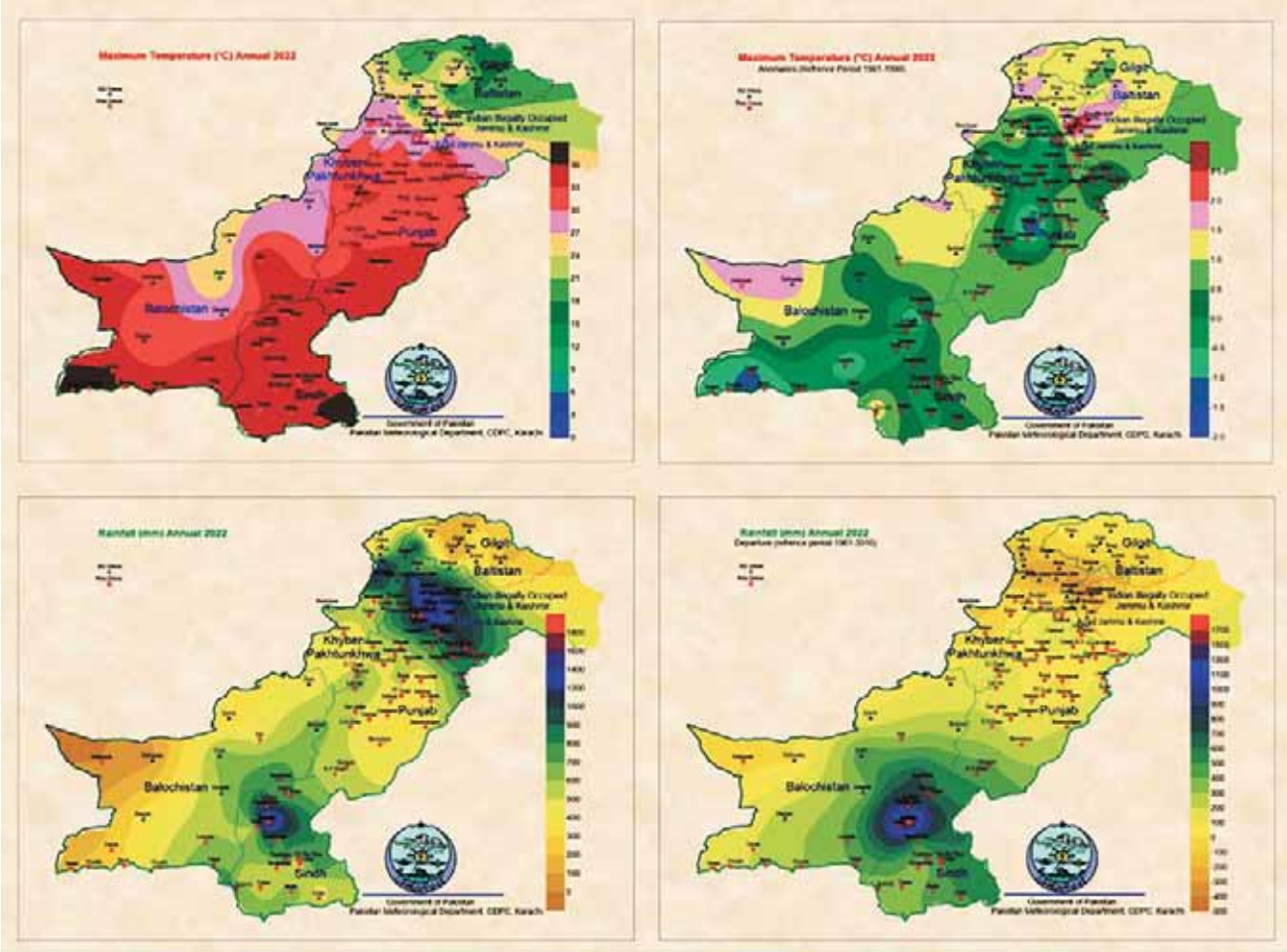

Figure-5b: The annual temperature and precipitation patterns as observed in Sindh and Balochistan.
Source: Pakistan Meterological Department, 2022

Figure-6a: Mud domes with smaller sized apertures ensure a more pressurized wind stream.
Source: Laylin, 2010

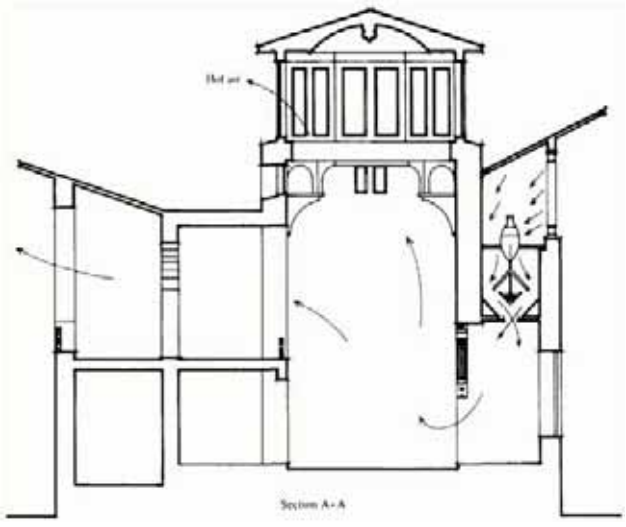

Figure-6b: Mud domes with smaller sized apertures showcase air flow within the building complex.
Source: Laylin, 2010

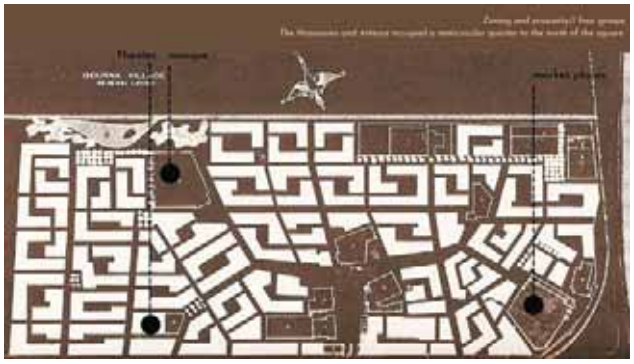

Figure-7: The master plan of Gourna Village illustrates the spatial zoning of the dwelling units and the social spaces stitching them altogether
Source: Vault, 2010

comprehend the vernacular traditions and their impact on dwellings in the context of the Balochistan and Sindh regions in Pakistan.

Context: Climate, Topography, and Living patterns

Analyzing the physical context of the research setting in Balochistan and Sindh regions of Pakistan, these areas face harsh climatic conditions characterized by wavering summer temperatures of an average high of 45 degrees as shown in Figures 8a and 8b respectively in Sindh and Balochistan.

These high temperatures as shown in Figures 8a and 8b have resulted in unprecedented disasters which prove to be fatal for the inhabitants of the area. As such, understanding the prevalent conditions of this region and evaluating them to create dwelling units based on oral traditions that are responsive to their region's climate is imperative. Both regions being examined are known for their persistent hot temperatures, socio-cultural tribal lifestyle, and proximity to the Western Mountain ranges of Pakistan's barren terrain.

"With temperatures set to surge in the coming years due to the increase in global warming, the sun's position and daylight in Sindh and Balochistan, as demonstrated in Figures 9a and 9b below, indicate that direct sunlight is observed during the daytime for up to 9 hours on average. This not only intensifies the harsh and hot weather of the region but also increases the need for locally informed active and passive cooling techniques, as well as shading devices, to be integrated into the built fabric of the rural settlements". Furthermore, the intense sunshine hours paired with the lack of cloud cover, shade, and little rainfall from both the Monsoons and Western Depressions, the harsh climatic condition of the region stated earlier is substantiated.

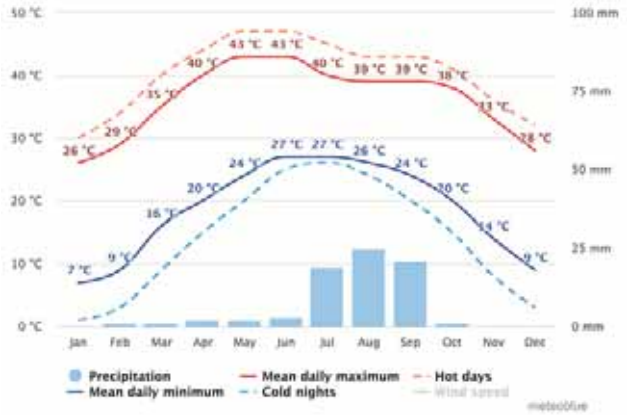

Figure-8a: Temperature variances for Sindh demonstrate arid climatic conditions throughout the year.
Source: Meteo Blue, 2023

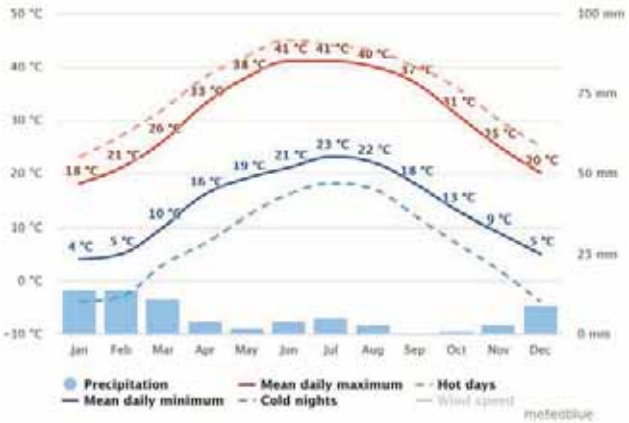

Figure-8b: Temperature variances for Baluchistan demonstrating arid climatic conditions throughout the year.
Source: Meteo Blue, 2023

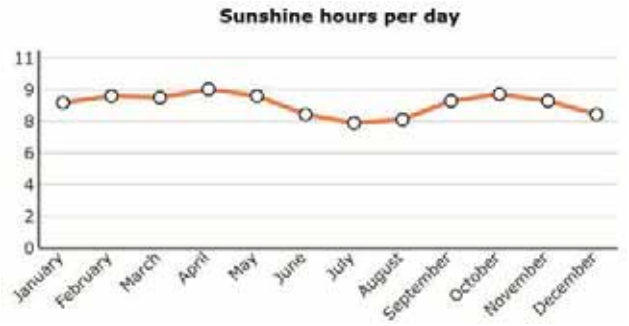

Figure-9a: Sunshine hours as observed in Sindh annually which shows April as the sunniest month of the region creating an overall hot climate with no cloud cover.
Source: World Data 2023.

Concerning the local vegetation of the area, the abundance of Babul trees as forests alongside grass and shrubs serves as a potential local material for construction in the region. However, in contrast, one sees the lack of wood in the Balochistan region which is made up for by the presence of soil with a higher clay and sand content thereby enabling efficient local construction through mud-clay brick. Moreover, the sedimented soil in this area also provides structural support for the consequential vernacular construction methodologies which have been further elaborated upon in the research methodology section of this paper.

Regarding the socio-cultural setup of both regions, one observes a predominantly tribal setting with a rich history of tradition. The cementing factor of the living patterns of the people of both Balochistan and Sindh is their religion and cultural traditions, which provide a base for their community, social order, and most importantly the architectural style of the built environment and spatial semantics of their vernacular dwelling spaces.

Decoding the traditional values that contribute to the creation of a familiar environment for the inhabitants of the region (Nanavati, 2018) is derived from the fundamental rulings of the spatial semantics of their dwelling spaces. This includes the concept of 'pardah' or segregation between the males and females and the utilization of recreational activities as a means of knitting together the village community. The determining process of the anthropometrics of their dwelling spaces is done so concerning the size of their families, cattle, and utilization of living areas which is based on their traditional foods and cooking methodologies. Being a tribal setting where families live in proximity, barricading their private quarters with exterior walls of mud and stone to add further security and privacy to their villages is also seen. Nomadic tents with the use of reinforced fabric are also common materials used which add to the living comfort of the rural community (Oliver, 2005).

When analyzing the independent vernacular in the vicinities of Sindh and Balochistan, the predominant overall characteristics of the settlements (Government of Balochistan Secondary Education Department, 2019) can be traced back to the typical features of their respective rural dwellings. The most apparent spatial qualities that are observed in the vernacular dwelling units that are a derivative of the local culture, as shown in Figure 10 include the presence of connectivity between interior spaces through partitions, inculcation of 'pardah', centralization of communal zones and a very distinct divide between the public and private zones.

The spatial planning and quality of the aforementioned living spaces as shown in Figure 10 directly correlate with the thermal capacities of the household located in a region facing constant hot climatic conditions. The incorporation of vernacular architectonics in these dwelling units such as the orientation of the dwellings, *verandahs*, *Jharoka's, Mashrabiya's* (screens), courtyards, and *Mangh*, all enable thermal comfort (Laghari et. al., 2019).

Paired with these vernacular construction techniques and the use of locally sourced materials that are also climate

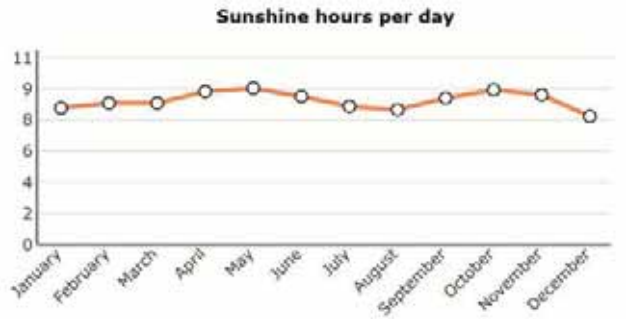

Figure-9b: Sunshine hours as observed in Balochistan annually which shows May as the sunniest month of the region creating an overall hot climate with no cloud cover.
Source: World Data 2023.

Figure-10: Typical Adobe house plan observed in the rural areas of Sindh.
Source: World Housing Encyclopedia, 2012

responsive to the region of Sindh and Balochistan, the sense of space within a rural setup is further enhanced both tectonically and visually (T, Bahari).

VERNACULAR TYPOLOGIES

Three types of vernacular rural dwellings in Sindh and Balochistan are analyzed: Chapper House, Kothi House, and Chaunro House.

Chapper House

The Chapper House is a basic house type commonly found in rural Sindh. It generally consists of one or two rooms called *Landhi*, with a courtyard and a verandah acting as a passive cooling strategy. An informal kitchen space is located in the courtyard in the shade of a verandah or a tree. The courtyard also houses the cattle pen. The overall compact design of the house minimizes the total surface area exposed to the harsh sun thereby ensuring thermal comfort within the house as well. Additionally, the non-habitable spaces of this housing typology are placed towards the East-West orientation that receives maximum daylight (Safiruddin, 2005).

The Chapper house is categorized into three types based on its construction materials and techniques.

- Bamboo Chapper House, where walls are constructed of bamboo and plastered with mud and husk. Wooden logs are used for the roof framing, filled with a layer of *sar* and *kanna* and plastered with a layer of mud as shown in Figure 11.

- Mat and Log Chapper House (Figure 12), where walls are constructed using wooden framing, covered with matting, and plastered with mud. A hip-roof frame is constructed with matting laid over a wooden frame, which is then covered with *sar* and *kanna* for protection against heat and rain.

- Mat and Mud Brick Chapper House (Figure 13), constructed with mud bricks, laid in with mud and lime mortar and plastered with a mixture of rice straw and mud to provide strength and insulation. The roof is constructed using a wooden frame, covered with a layer of thatch matting, and plastered with mud and straw for protection against rain and heat.

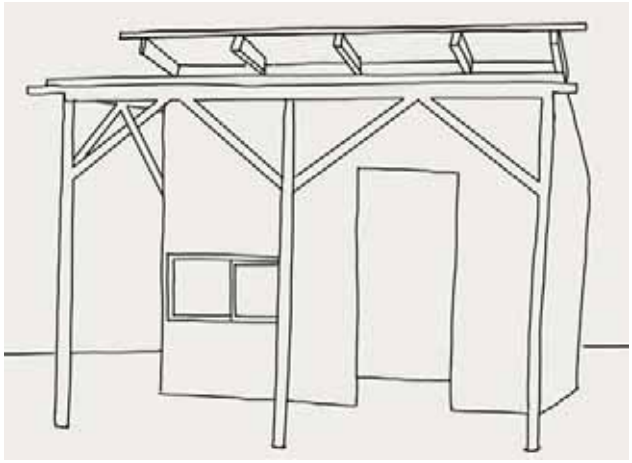

Figure-11: Visual Representation of the Bamboo Chapper House.

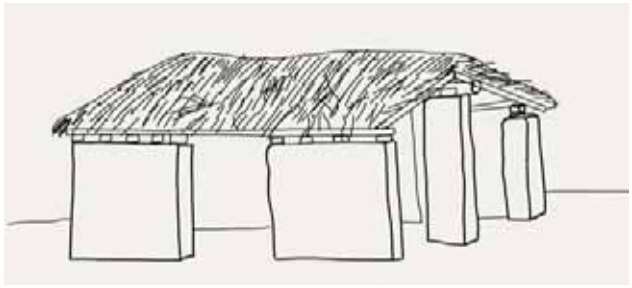

Figure-12: Visual representation of the Mat and Log Chapper House.

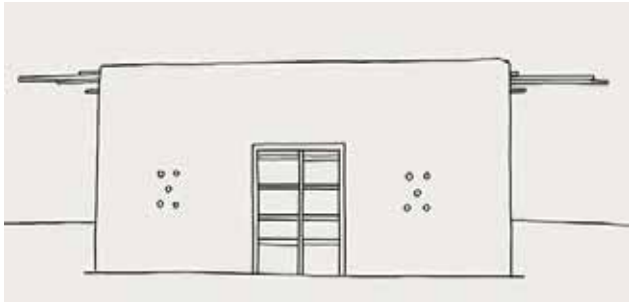

Figure-13: Revisualization of the Mat and Mudbrick Chapper House.

KOTHI HOUSE

Kothi house, constructed of mud brick with a thatched roof, is a vernacular house typology of rural Balochistan. It generally consists of two rooms with a verandah in front serving as the living room. A courtyard extends beyond the verandah and serves as open space for the family under the shade of the trees. The courtyard also houses an informal kitchen and cattle pen. Apart from serving as the main design feature and dwelling space, the courtyard is also used here as a passive cooling strategy to reduce heat gain (Safiruddin, 2005).

The Kothi house is categorized into three types based on its construction materials and techniques.

- Mud Kothi House is constructed of mud walls and a flat thatched roof. The walls are constructed using wooden framing, filled with a mixture of mud and rice straw. Wooden logs are used to build a frame for the roof, on top of which wooden planks are laid out and plastered with a mixture of mud and rice straw. As visualized in Figures 14 and 15, the interior layout of the house is also simplified to fit the basic square shape of the structure (Keinay, 2010) keeping in mind the rudimentary nature of the building materials being utilized.

- Mud brick Kothi house (Figure 15) is constructed of mud bricks and mud plaster. The walls of this house are constructed using sun-dried mud bricks. Girders and wooden planks are used to provide strength to the walls. Tiers are laid over the girders to provide framing for the roof. Mud bricks are laid on top and plastered with mud and straw to provide strength and protection from rain and heat.

- The baked brick Kothi house (Figure 16) is constructed of baked bricks laid in cement, using tiers, girders, and wooden logs as support, and plastered with cement. The roof is built using a framework of tiers and girders, over which a mixture of cement, sand, and brick powder is poured. The use of baked or fired bricks in dwellings may be an indication of relative prosperity. They may also be an indication of caste, as well as class distinctions.

Chaunro House

Chaunro house, as shown in Figure 17, is primarily a round structure with a conical thatched roof. It categorizes itself within the vernacular house typology of the Thar desert. The round structure of the house helps to deflect strong desert winds. It generally consists of one or two rooms, and a courtyard encircled by a bush fence. The structure is built using a mud brick or wood foundation, with mud-brick walls covered with a layer of cotton plant sticks, dry grass, and mud plaster. A conical roof is constructed using a wooden frame. Wooden sticks, straw, hay, and grass are laid over the roof frame and tied with ropes (Safiruddin, 2005).

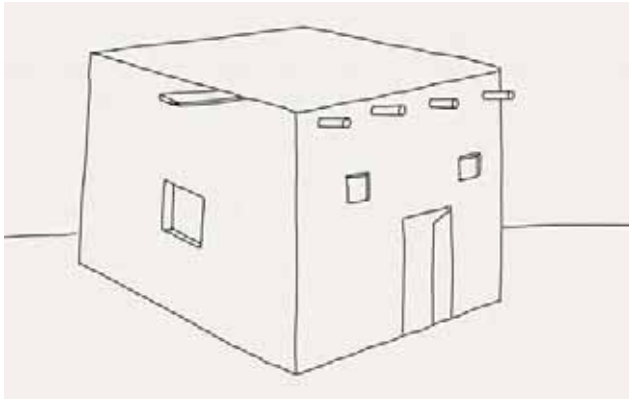

Figure-14: Mud Kothi House.

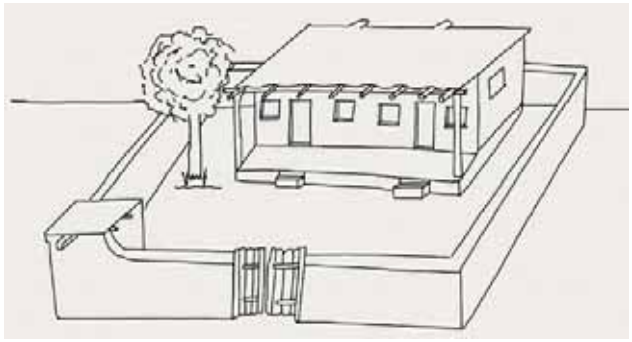

Figure-15: Mud Brick Kothi House.

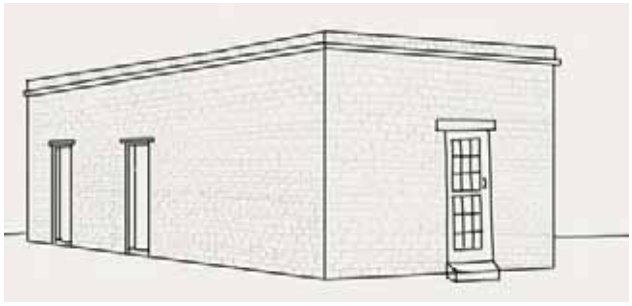

Figure-16: Baked Brick Kothi House.

Figure-17: Chaunro House.

PASSIVE DESIGN STRATEGIES

Courtyard and Verandahs for Passive Cooling

The courtyard and verandah, in the vernacular typologies discussed above, serve as passive cooling strategies by providing shade and encouraging natural airflow, which helps to lower the indoor temperature. Additionally, the verandah is designed to face a dominant wind direction to maximize shade and airflow and to optimize passive cooling effects.

Use of Natural Materials

The vernacular houses mentioned above are constructed with locally available materials such as mud bricks, wood, dry grass, thatched roofs, and mud plaster, which have high thermal mass and insulation properties, contributing to passive cooling and thermal comfort. These materials provide natural insulation, keeping the interior cooler in hot weather, reducing the need for mechanical cooling systems, and enhancing sustainability while reducing embodied energy and environmental impacts.

Orientation and Layout

Placing non-habitable spaces towards the East-West orientation in the Chapper house allows them to receive maximum heat during the day, reducing the need for cooling during the day and enhancing energy efficiency. Additionally, the overall compact design of the vernacular houses reduces the total surface area exposed to the sun, thus minimizing heat gain and ensuring thermal comfort indoors. Furthermore, the round shape of the Chanuro house is designed to deflect strong desert winds, reducing wind pressure and minimizing heat loss through convection.

Vegetation for Cooling

The use of vegetation for passive cooling involves strategically incorporating trees, shrubs, and plants into building design and outdoor spaces to mitigate heat. These vernacular houses usually incorporate vegetation, in the form of trees grown in courtyards, which provide shade, reduce heat gain through evapotranspiration, act as windbreaks, and help mitigate the adverse effects of heat.

CONCLUSIONS

Extreme climatic conditions require efficient design solutions. The house typologies discussed with regards to the materials used in their construction, may also be examined for their climatological performance. These typologies, however, have not been subjected to scientific analysis. The use of these construction techniques in these particular regions is based on vernacular knowledge and tradition. According to Paul Oliver, buildings do not control climate. He argues that the materials used in dwellings, their forms, volumes, and layout contribute to the "micro-climate" a house generates. (Oliver, 2003) Most of the dwellings discussed use local building materials such as mud bricks, baked bricks, wood, clay, thatch, either sourced from the region, or produced on site, except for bamboo. These dwellings combine simple, vernacular, and passive design strategies to generate a relatively comfortable micro-climate. The regions discussed experience hot temperatures during the day and cooler temperatures during the night. The courtyard shaded by native trees and vegetation contributes to regulating the micro-climate of the dwellings and provides an outdoor living space for the family. Trees are important climate modifiers. Moisture in vegetation helps reduce air temperature through evaporative cooling, while transpiration of leaves assists in lowering temperature and increasing humidity levels in hot desert temperatures. (Oliver, 2003) The courtyard is also used by people to sleep during the night when the temperatures cool down. Adobe walls, when exposed to the sun, absorb the heat, and slowly transmit the heat to the interior. The thermal mass of adobe and mud plaster keeps the interior cool during the day. Even though little scientific investigation and data exist on thermal comfort achieved using adobe and mud plaster in these dwellings, their continuous use in traditional dwellings may suggest that they may be effective in achieving thermal comfort. Grass, straw, and plant sticks are efficient cladding materials for walls and roofs, often tied together or used in combination with mud plaster. Thatch, widely used in the roofing of these dwellings, is resistant to water penetration and provides a thermal barrier due to its poor conduction of heat.

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