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A Feasibility Investigation of Modular Portable "Chelson Shelters" Micro-Homes to Alleviate Housing Deficiencies: A Case Study in Mithi, Tharpakar, Pakistan

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A FEASIBILITY INVESTIGATION OF MODULAR PORTABLE "CHELSON SHELTERS" MICRO-HOMES TO ALLEVIATE HOUSING DEFICIENCIES: A CASE STUDY IN MITHI, THARPAKAR, PAKISTAN

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I dedicate this thesis to my parents, Faiz-ul-Hadi Khan and Uroosa Faiz, who have always believed in me, even more than I did in myself. They made me believe that nothing in this world is impossible for me and trusted my decisions without any doubts and always encouraged me to follow my dreams. I would also like to dedicate this thesis to my Grandmother Akhter Jehan who has always supported me in my life and her infinite blessings and prayers made it possible for me to achieve my goals. In the end, I also dedicate this thesis to my siblings, Muhammad Umar Khan, Anum Faiz Khan, and Muhammad Hasan Khan, whose moral support and endless faith in me was more than a blessing.

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Many people in Mithi, Tharparkar do not have proper housing, face an unhygienic water supply, and have no sanitation facilities. These factors contribute to disease, suffering and the inability to rise above their destitute existence. The idea for building portable houses for the people of Mithi is presented to provide them with better living conditions and where they can feel a sense of security, ownership and sanitation. Research on existing building systems and materials showed that the most feasible structure for the desert environment is modular panels attached to a core unit that contains all the basic plumbing and electrical fixtures. The unit can be expanded based on family needs. Discussion with government officials showed that these could be used for the immediate needs of the people who have been suffering more acutely the last several years due to a drought. They could also be a permanent solution to the housing crisis if the "Chelson Shelter" communities worked well for ten years. The infrastructure in the Tharparker Desert is inadequate to support typical housing. These shelters have low environmental impact, use little water and electricity and would be a good solution to make a community of people that can support each other and provide security.

Introduction

There are millions who immigrated into Pakistan more than half a century ago during the Independence War. They still live in poverty and are in need of basic necessities. Their living conditions are getting worse due to neglect and recent droughts. They are dying of hunger and lack of water and many are without adequate shelter and sanitation, but the government agencies who are accountable for providing the basic necessities of life have been ignoring their plight. The governmental authorities talk about, and spend money on current political refugees and natural disaster victims, but ignore those nationals who have suffered for so long. Indeed, this research project began as a study to discover how to provide housing for refugees, but focus switched to methods to aid those indigenous poor people living the remote deserts of Pakistan.

The population in the desert area of Tharparkar, in Sindh Province, Pakistan is continuously rising each year and has consequently elevated the problem of the lack of suitable housing and sanitation in the region. According to the ongoing census statistics, there are more than 2.265 million people living in the Tharparker area in 2015. Infrastructure, such as roads, electricity, water, and sewer are minimal in rural areas and contribute to other factors which limit access to basic nutrition, health and education needs. The people in the area suffer due to these problems and there is no relief in sight(Al-Jazeera, 2014). A housing solution that could adjust to the extreme swings of temperatures in the desert areas needs to be developed (Kronenburg, 2013). This solution needs to be able to provide security, shelter from the environment, and sanitations needs with little energy, water and infrastructure support. and all this at a low cost.

The most significant environmental issue in desert areas is the unavailability of sufficient water for the flora and fauna and the people who rely on these. It is observed that only those plants and living materials, such as cactus, that are successful in adapting to the natural ecology of the region are found to grow. These, however, are not sufficient to support the humans that live in the area. Declining rainfall levels and more frequent droughts over the last ten years have caused a significant decline in the seasonal plants used for human consumption and for grazing. The droughts and governmental water usage policies and practices have contributed to the drying of river beds and depleting the reservoirs of water. The bored wells, which Tharparkar relies heavily on for water, must be deep and are thus expensive. Additionally, the water from many of these wells are very saline and nearly unsuitable for drinking.

The droughts have also caused structure deterioration since houses in the region are predominantly made of clay walls (which crumble when too dry) and thatched roofs (which cannot be refurbished due to lack date fronds). The ground water level, that has already decreased due to extreme temperatures and low rainfall, does not meet the needs of the inhabitants and the frequent droughts have made it necessary for humans and livestock to migrate to far, remote areas (Khan and Malik, 2013). Hence, many international agencies, including the United Nations, are working diligently to rehabilitate this area in an effort to conserve the natural resources available in this desert area and provide for the people living there.

The ever-increasing poverty due to a lack of jobs has further deteriorated the living conditions for the residents of Tharparkar. The main occupation of these people is animal husbandry and agriculture, primarily timber for income and for fuel. There are no

effective government policies or programs that will help the residents obtain education and jobs which would allow them to support themselves. The government is providing very limited medical and health facilities to the residents of Tharparkar during emergencies but basic necessities, like housing, food and clothing are not being taken care of on a daily basis.(Al-Jazeera, 2014).

Tharparkar residents have adapted to the environment by utilizing land management practices such as rainwater harvesting and soil conversation such that desert grassland is able to support livestock grazing. International agencies in the area have introduced new varieties of desert plants that are helping to improve the ecology of the area. Many wells for drinking water have been constructed and many water ponds have been prepared to collect rainwater (Khan and Malik, 2013).

Different Non-Governmental Organizations (NGOs), including some international organizations, such as United Nations Organization (UNO) and World Health Organization (WHO), are also making efforts to improve the lives of the people of Tharparkar. Although these organizations are involved in different energy, medical, hygiene, and food supply projects for these people, no one has taken initiatives to build portable homes for the people of Tharparkar. These NGOs take part in building mud houses for Tharparkar people because they do not have enough funds and resources to build portable or mobile homes. Similarly, USAID is also making efforts to help the government of Pakistan in Tharparkar mitigate the crisis of the poor people. However, these efforts are mainly limited to food supply, clean water, sanitation, and health services. Whereas these basic necessities of life are needed, they also need to consider building homes for these people (Dawn, 2016).

Problem Statement

People in Mithi, Tharparkar do not have proper housing, face an unhygienic water supply, and have no sanitation facilities. These are the main sources of diseases among the people.

Significance of Research

The idea of building portable houses for the people of Mithi is proposed to provide them with better living conditions where they can feel a sense of security, ownership and sanitation. This would provide protection against the elements for tens of thousands and relieve suffering caused by inadequate water and lack of sanitation.

Research Rationale

The Brundtland Commission report gave a global definition of sustainable development to incorporate the concept of portable homes for low-income populations. It suggested that sustainability encompasses all economic, environmental and social factors associated with the development of secure housing for the inhabitants. Environmental sustainability addresses the problems of handling resources efficiently such as waste, water and energy consumption (Pillai and Gupta, 2015). This means that consideration must be given to the large number of people who cannot migrate to cities because of their low income and cannot afford housing and living in cities must be housed in rural areas they already reside in. Moreover, the economic aspect of sustainability considers cost-efficiency over a certain period of time such as the affordability and durability of movable homes over a period of 10 years. Hence, the impact of sustainability on housing is huge with respect to the socioeconomic and cultural well-being of the population.

Normal housing projects consume a large amount of natural resources and produce waste that may cause air and water pollution. An area such as the Tharparkar Desert needs an effective housing plan that is sustainable as the region already has a scarcity of natural resources and cannot afford air and water pollution (Golubchikov and Badyina, 2012). The "Chelson Shelter" concept is a portable housing solution that could potentially meet the criteria given here to meet the immediate and long term needs of the desperate people of Tharparkar

Research Questions

1. Are modular portable homes a suitable housing solution for Mithi, Tharparkar?
2. Can these homes be used as a permanent housing solution for the region around Mithi?
3. What would be the requirements or specifications for such homes designed for the Mithi situation?

Study Limitations

Previous research evidence on movable home designs is limited and not directed to the Tharparkar Desert's climatic conditions. There are constraints such as governmental, political, and financial regulations for building houses in the Tharparkar region. The validity of the information gathered from governmental sources in this research cannot be guaranteed since their methods are not fully documented and their operations are not transparent.

Delimitations

Research was restricted to Mithi, Tharparkar, Pakistan due to the current conditions of the region and because the researcher had access to information from

governmental sources. The purpose of the research study is to find the most effective low cost housing solution for the people of Mithi, Tharparkar, Pakistan so only low cost options available in the local markets were considered.

Literature Review

Modern architecture in western countries seems like it would be able to satisfy the housing needs of the low income populations living in these desert areas. In this regard, ongoing research in the field of architecture is being directed to find various possible building solutions, such as using vertical screens and solar canopy shades. Because these areas have consistently high temperatures, they require the use of evaporative cooling systems or air conditioning units. Many researchers and architects have suggested that portable housing units incorporate a gravity-fed system in low rainfall areas which would enable the drawing of huge amounts of water from the rainwater collection system. For instance, people in Tharparkar store rain water in small ponds which they call “talab” and use it for drinking, washing, and other purposes However, detailed research is needed to gather information about the use of the most feasible adaptive spaces, humidity buffer and hydronic capillary systems for providing radiant cooling (Wanek, et al. 2015).

The western part of the Tharparker Desert is classified as arid as it has an average of 100 mm rainfall annually, and the eastern part of the desert is semi-arid with 500 mm of rainfall annually (Aggarwal and Chandel, 2010). The water needs are met by digging wells, using local methods and tools to pump water from the ground. This water tends to have high salinity. The rainfall in the region is highly erratic with a short monsoon season from June to September. The rains have been becoming increasingly low, which have caused serious droughts to occur in the previous decade and has exacerbated the excessive demands on drinking water in the region. For the purpose of storing rainwater, rooftop runoff can be directed into an underground tank with a capacity of 60 m^3 near their homes (Aggarwal and Chandel 2010).

The Portable Home Advantage

Portable homes are movable homes that can be designed to be easily constructed and can be moved to different places on demand. However, the portable homes which this research is carried out is for places where there are not enough resources currently to build houses. They can be permanent or can be moved according to changing demands.

Portable home designs were used in earlier times when people used tents as portable homes due to the necessity of moving their homes in response to the changing desert climate. One reason for the popularity of portable homes was the lack of space in major cities and another reason was the ease of moving these portable homes within the major cities. These movable homes are designed to be easily deployed in different situations and locations. These homes are advanced enough to look like buildings and can be transported as a whole unit, thereby remaining intact. It is believed that portable structures that can be moved anywhere are an easy way of diversifying the landscape (Sørensen, 2004). Thus, humans have created a more mobile way of living. According to Seigal's philosophy, projects that are built on the idea of portable buildings allow the use of architectural structures that may serve many different purposes.

Theories Related to Movable Homes

The needs of the growing population in the Tharparkar Desert have made it obvious that there is a great need to create adaptive housing habitats that are both economical and sustainable to cope with the adverse climate of the region. Prefabricated building methods have made it possible to protect the inhabitants from environmental conditions and are used widely in Sindh Province but these units require significant labor, are not transportable and do not provide sanitation needs. The proposed portable homes

can be easily moved or altered as required. Pre-fabricated living spaces have been previously used in many regions of the world and they are customizable to be compatible with specific area needs. Hence, the building time can be significantly reduced in case of any climatic emergency (Kronenburg, 2013). Also, these prefabricated homes tend to be environmentally sustainable as they are easy to reuse.

Previous models of movable home structures have evolved to create the current environmentally sensitive designs. In contemporary home building, ecological considerations are taken into account to make these movable homes cost-effective (Abuin, 2003). The ecological considerations that are measured before building these movable homes include renewable resources, life-cycle of the building material used and recycling of the components. These are sensitive indicators that are measured to gain ecological sustainability and to build economic pressure on the building industry (Kronenburg, 2003). The basic idea of using portable home designs is to use experimental methods that are highly sustainable and can adapt to almost any condition. Furthermore, the aim of building portable homes is to use materials that are sensitive to the social and environmental needs of the community. Thus, the design must include cultural, economic, governmental, engineering, material and maintenance concerns.

Challenges of Designing Portable Homes in Tharparkar

The biggest challenge of designing suitable portable homes for the Tharparkar Desert area is to incorporate components which will protect against heat and provide natural cooling. The presence of humidity is another factor that directly affects the microclimate of the building structure. It is crucial to design living spaces to keep the inhabitants in a comfort zone. In this regard, façade features and neighboring structures that can provide

shade are all the microclimatic components that shall be taken into consideration for the orientation of the portable structures. It is important to understand that differing types of building material can impact thermal conductivity and reflectivity. Thermal conductivity is highly influenced by the thickness of the building material used. Insulating materials can also be used to reduce thermal conductivity. It has been determined that the thickness shall be such that it may not offer a thermal resistance of more than 1.1 kcal/hm^2 C so that air can move easily from the inside to the outside (Maldonado et al. 2007).

Examples of Portable Homes in Deserts

In Arabian deserts, Bedouin tents are a classic example of movable homes for desert dwellers. These Bedouin woolen tents do not have any heating and cooling devices and are exposed to the exterior. These tents are adaptable to the environmental conditions by adjusting to the needs (Maldonado et al. 2007). If it is windy, the wall flaps are lowered. If it is hot, they are raised. If it is cold, a flap on the top is opened and a fire is used. It is observed that the Arab desert-dwellers, named Bedouins, have to perform a migratory trek when there is a change in the desert climate. Hence, they need moveable shelters or portable homes that are reliable in a variety of climates. In the Sinai and Wadi Rum mountains in the Arab regions, temperatures are known to rise above 49°C or 120˚F. It is difficult to adapt to such high temperatures in the absence of wind and shade (Cordova, 2007). For this purpose, the Bedouin tent was made up of coarsely woven goat hair that provides a breathing membrane to the dwellers to help them avoid suffocation. The black surface of the Bedouin tent also creates a deep shade, and its coarseness diffuses the heat, creating an illuminated interior environment. In the winter season, the woven fibers swell during times of rain and snow. This action closes the tiny structures in the fabric which

are opened for ventilation when it is dry, and the structure of the tent becomes tight. Schleisner (1997) conducted another study to compare strategies that can be used to achieve thermal comfort in the portable tents used in the Negev Desert. (Schleisner, 1997). He indicated that the tent dwellers adjusted the tents in a way that was effective based on the environmental conditions. The temperature ranges and humidity conditions in Sinai are very much similar to Tharparkar Desert. Therefore, Bedouin tents appear to be a sustainable solution in these regions. However, the limitations to using Bedouin tents are that most people do not want to live in a tent, but rather a solid house structure, and that they also do not provide sanitation facilities.

Studies Conducted on Portable Homes

A study was conducted by the United Nations Relief and Works Agency (UNRWA) in Palestine that modeled structures that could provide thermal comfort in low-cost structures and that could also provide homes to the refugees in the hot arid climates (Ajam, 1998). Fathy (1986) revealed that people living in hot desert climates cannot live in concrete houses. The amplified UV rays rebound after hitting concrete material in hot and humid weathers. Hence, heat gains need to be avoided to achieve thermal comfort in such conditions and to minimize consumption of energy. Ideal housing in desert areas need to be cool in the daylight and to be warm by night. In stone or mud homes, heavyweight construction and small window outlets can help to achieve greater thermal conductivity and act as a heat sink that moderates temperature swings in desert areas (Attia, 2014).

Asefi and Sirus (2012) reported that the current shelters used in the time of disasters, such as flooding, are time-consuming to establish and are heavy, making them

hard to carry. They also cannot collapse or be folded in such a manner as to make them easily stackable, which makes them prohibitive to transport. They conducted research to find lightweight and modular shelter homes that could be used without much difficulty over a longer period. A triangular structure which is movable on upper and sideways rails was proposed, so that they could be moved by sliding and folding (Asefi and Sirus, 2012).

These movable homes would need to be rapidly deployed at the time of disastrous climatic conditions. Therefore, the structural performance criteria of these movable homes need to be recognized so that they may dictate the key designing priorities. They should be extremely light in weight, easily deployable, and have an erection capability such that they can be lifted without the usage of heavy lifting equipment. They should provide enhanced insulation to reduce thermal conduction. Quaglia, et al. (2014) has proposed origami-inspired shelters to implement an effective erection strategy and to meet the design specifications for movable houses (Quaglia et al. 2014).

Interior environmental quality requirements specifically affect the building designs and building materials used. The materials chosen greatly impact energy consumption and comfort to the inhabitants. Additionally, the inhabitants' emotional condition is affected by things such as lighting, colors and feel of material. For example a brighter light or sunlight makes people more productive and less depressed. Hence, recent building approaches are focused on improving the thermal performance of the houses built. For instance, it is deemed important to identify the energy optimization of the built structure over its entire life cycle. Furthermore, energy consumption as a result of climatic responses in desert areas also needs to be identified. Huberman and Pearlmutter

(2008) have conducted a study to analyze the embodied and operational energy usage in a building in the Negev desert region in Southern Israel. In this study, the composition of the building material was studied with respect to the possible climatic conditions it might experience so that the appropriateness and life cycle of the building material could be predicted. It was observed that 60% of the energy consumption was mainly due to inappropriate materials. Thus, the lifecycle of the product can be greatly enhanced by choosing the right building material in congruence with the climatic conditions (Huberman and Pearlmutter, 2008).

Al-Obaidi (2014) conducted a study on tropical architecture and identified the effect of various building materials in dealing with climatic conditions. The study revealed that the previously used materials in tropical regions, such as clay, wood and bamboo, have been replaced with concrete, steel and glass. These materials have greatly multiplied the energy consumption of and houses because they retain high levels of heat. This high level of energy consumption is causing deleterious effects on living on this planet and has increased global warming to a large extent, especially in desert areas. This study indicated that the roofing system is the main cause of heat gain, and roofing materials should be selected appropriately. Allen, et al. (2008) suggested that concrete and clay are the highest transmitters of heat and they produce a sauna effect in the home environment. Therefore, these materials cannot be recommended in homes that are built in desert areas (Al-Obaidi, Ismail and Rahman, 2014).

The great black traditional Bedouin tents are known to provide dense shade during the daytime and release little heat during the nighttime, thus insulating the interiors from the cold air (Lakeridou, 2010).The biggest challenge in a portable home

structure is the meeting the changing international standards of thermal comfort with respect to desert climatic conditions. It is important to understand that thermal comfort established in air-conditioned buildings cannot be applied to tent structures situated in hot climates (Attia, 2014). Thus, modeling portable building structures in hot climates requires the simulation of hygrothermal properties of the construction material used. The results of the simulation procedures provided meaningful information about the impact of solar radiations on infiltration rates. In the case of Bedouin tents, the aerodynamic behaviors of the desert areas affect the infiltration rates, which in turn affect the operative temperature within the tent (Attia, 2014). Moreover, previous research literature about the significance and modeling procedures of movable housing is scarce and needs to be carefully studied with respect to the desert environments. Research is needed on the infiltration rate and thermal performance of previously used portable tent structures in desert regions. Specific information was necessary to simplify assumptions regarding the preparation of thermal comfort zones for desert-dwellers in the shape of portable homes (Haun, Collins and Gingles, 2015).

Rashid and Ara (2015) discussed the sustainability of vernacular buildings as a solution to deal with the climatic conditions in desert areas. The inherent concepts in vernacular building designs have not provided a clear stance on its use in an ecologically sustainable design. Flexibility and adaptability in the designing of portable home spaces need to be evaluated in detail with respect to desert thermal zones (Rashid and Ara, 2015).

McCluskey (2002) has proposed a particular design for movable homes to be used in remote locations. This thesis proposes a portable home that is packable, light in weight

and is biodegradable. It is assumed that cardboard panels can be easily left to decompose and can be recycled. However, this shelter can only be used for a period of six months and needs to be recycled. This portable shelter proposed by McCluskey is very similar to Bedouin tents used in Arab desert areas in that they are opened and closed based on ambient temperature and humidity changes. McCluskey (2002) conducted his study on north-central India and attempted to understand the historical and cultural formations as they also influence the designing of houses in a particular region. Hence, it seems evident that cultural and traditional influences play an important role on the designing of houses in different regions.

Another research study on the topic has aimed to understand the dwelling habits of Italian migrants in Brisbane, Australia. The research study explored the cultural influences of a specific typology of dwelling in Brisbane, Australia. Qualitative information was obtained from Italian migrants and the evidence of their left-over homes was collected to determine the influence of Italy-Australian transnational houses. The study findings revealed that the design of homes is largely influenced by socio-cultural factors, architectural and urbanization patterns (Furlan and Faggion, 2015).

Strategies of Integration in the Portable Home Era

There are three strategies of integration evident in the portable home era: independence, structuralization and conventionalization. Independence is evident at the scale of local jurisdictions with the power to regulate portable home use. They have generally favored the restriction of portable homes to parks. State portable home manufacturers associations have, in many cases, also supported independence, perhaps as a way of demonstrating to local authorities that portable homes can be excluded from

single family housing areas without banning their use. Independence, in this case, is a form of spatial segregation. In the previous period, with the creation of temporary portable home land use districts, and with the use of portable homes as emergency and temporary housing, independence also took the form of temporal segregation. Independence, then, resolves the categorical ambiguity of portable homes by declaring them a special form of housing. This clarity, however, is challenged in the case of double-wide units, which have sometimes been treated as modular, rather than as mobile, units. Independence is also apparent in the clarification of tenant-owner rights. These rights are developing as an extension of consumers' rights rather than as an extension of the common law rights protecting some tenants.

Since the early 1970's, the approach to integration at the federal level has been one of structuralization. The support systems established to promote other forms of housing have been made available to establish portable home parks, and the units themselves. The effect of structuralization has been to bring the industry under increased regulatory control, making it the only form of housing controlled by a national building code. While it is still too early to tell, the effect of structuralization at the federal level may be to alter the composition of the industry, reducing some of the organizational and product flexibility which have helped to make portable homes successful. The portable home, under its new title as manufactured housing, may become indistinguishable from modular housing and, perhaps become additionally burdened by local building and labor union resistance. The principal strategy of integrating the portable home as an artifact has been conventionalization. In the few cases where manufacturers have attempted to

introduce units with an industrial design aesthetic (i.e. units which suggest a prefabricated modularized unit), they have not been successful.

There have been proposals for the development of such units, but they have primarily remained ideas presented in design magazines. There have been a few commercial attempts (e.g. James Hills' House of Architecture), but they have been short lived. Many manufacturers offer customizing options (e.g. special windows, shingled roofs, upgraded doors, etc.), but these do not truly constitute a kit-of-parts as suggested here. The add-on market is now served primarily by some manufacturers offering prefabricated room additions. Commercial availability of such rooms began in the mid 1950's but no portable home manufacturers have been involved in their production. Clearly, the mass production of a kit-of-parts system would enhance its economics and promote the model of housing as a process. At this point however, the market is far from adequate, and the industry is poorly organized to achieve this objective. Ironically, the relatively low cost of a portable home (particularly an older, used unit) provides both an incentive and a disincentive for the development of additions. Because it is inexpensive, it may not be worth adding extensions; rather, one should move to a larger unit, trading-in the old one.

At the same time, the low cost of the unit may remove some of the financial risks that are involved in altering a conventional house. Whether a unit is located in a park or on the occupant's own lot is another important factor. The tenant/owner status of the park resident may obligate the portable home occupant to make additions to the unit (as in the Blue Skies Park, in Palm Springs, California) or it may eliminate that possibility. Building codes and zoning ordinances may also act as a disincentive. In the other models

of housing, the consumer plays a relatively passive role, influencing the system through the selection of products and services, but not directly altering the product and defining its character. Indeed, in Arthur Bernhardt's massive study of portable homes (funded by HUD), a system's analogy is used to describe the industry, but the portable home consumers are not considered a formal component of that system. Presumably, they are part of the environment in which it operates. By contrast, the rationalization of industrialized housing under the process model would elevate the user/ consumer as a key component in the system. Whereas in the product and service models the user need not have knowledge of how his or her housing is made, in the transactional model such knowledge is essential. Moreover, this knowledge is not simply knowledge about housing (i.e. a purely technical or descriptive understanding), but a tacit knowledge of housing which emerges through the act of manipulating the environment.

The historical development of the portable home illustrates a range of images and models which have been used to translate the principles of industrialization into housing. All too often there is a tendency to treat these images and models as rhetorical devices meant to illustrate a situation. Conversely, they may not be seen as images and models at all, but as objective statements regarding the nature of a situation, and therefore free of any structure in themselves. Bernhardt describes the portable home industry as a "system" of producers, distributors and park operators. He observes that it is the "market" that structures the "system." "The structure of an industry can be determined by gauging the control that individual participating firms exercise over the industry's product market"(1980, p. 405). He concludes his analysis by suggesting that the industry can best be advanced by pursuing this systems approach. Industrialized housing may indeed be

thought of as a system, but it must be understood then as a system trying to understand itself. The label "system" offers a model geared to that understanding. The analysis of the historical development of the portable home suggests a structure of development by which the use of various models and images are altered over time. The use of the theme of the "pioneer" for example, changed from an association with the return to nature (in the travel trailer period), to one of taming the wilderness (in the house trailer era). Similarly, the clever devices for improving storage that were employed during the travel trailer and house trailer eras were abandoned in the portable home period because the association with those previous periods and with dwellings made for motion in general (like Pullman Cars) no longer seemed appropriate or desirable. Thus, part of the structure of the development of models and metaphors consists of the relationship between established and emergent interpretations: between past and future.

Operation Breakthrough encouraged the development of several portable home based building systems providing multifamily housing. Suppliers to the industry have also encouraged design development. The Reynolds Aluminum Company, for example, sponsored a national portable home design competition for four years; but in 1976, it discontinued the program. Kaiser Aluminum, Owens/ Coming Fiberglass and Jones and Laughlin Steel have also encouraged improved designs. The building recession of 1974-75 seems to have dampened much of this development and innovation on the part of individual manufacturers in general. It is perhaps significant that the design of portable homes has, for the most part, been done without the involvement of professional designers. In small companies it may be the president's wife who will decide what will sail. Moreover, because of the flexibility of the production and sales aspects of portable

homes, it can be particularly responsive to consumer demands. Units which don't sell at dealer shows can readily be modified in production or removed from the product line. In its ability to respond to popular taste, the portable home may represent a true form of industrialized vernacular design.

The strategy of conventionalization, as the portable home demonstrates, is not simply a matter of imitation. In conventionalization, new features and/or meanings are projected into an established model of relationships. This projection proceeds analogically: e.g. if the double-wide portable home is like a conventional single family house, then it should be arranged on its site like a single family house and such sites should be arranged in the pattern of a suburban addition. Insofar as the model used as a basis for conventionalization is unambiguous, analogical projection can develop easily; but in the case of the house, ambiguity is introduced by changing patterns of use and form affecting the single family dwelling. Thus, projection may precede on a model which is itself becoming obsolete, and which the portable home may be helping to make obsolete.

An example of a model changing while projection is occurring is the attempt to improve the entry area of the portable home and the relationship between the front entry and the street. In the conventional house, the development of the attached garage has had the effect of making the door from the garage into the house the principal functional entrance. This development was clearly underway when detached garages along alleyways were in common use. Then it was the utility porch which served as the functional entrance. At that time, however, the front porch still served many functions. It was a place to sit on warm evenings and greet neighbors out for a walk. The front door,

together with the front porch and the path to the sidewalk, constituted a transitional greeting area which mediated a variety of relationships between the family and its neighbors. Today, when front porches are applied to houses, they are frequently so shallow that they cannot be used for sitting on. The builder may not even provide a path to the door. When one is provided, the path may run from the driveway to the door; rather than from the sidewalk, if there is one. If the garage door has, in fact, become the functional door of the house, then the portable home in a park, with its direct relationship between carport, or pad and the front door, is functionally equivalent to the relationship found in the house. The sitting of double-wide units, however, retains the traditional front door arrangement, even though units located in parks are not subject to the setback requirements which had institutionalized the definition of the front yard and supported, in turn, the maintenance of the front door display. Advantages of Portable Homes

- The requirements for scaffolding, shuttering and formwork are reduced because ready-made self-supporting components are used in the designing of these houses.
- There are more chances of getting investment capital because the homes are completed sooner due to faster on-site construction.
- On-site congestion and construction is reduced.
- Quality control is much better in a factory assembly line setting than in a construction site setting.
- The designing and development of portable and movable homes can be carried out easily where skilled labor is readily available. It also reduces the cost of overhead, space, materials, power, and labor.
- Material waste is reduced in a production line setting.

- Advanced materials such as sandwich-structured composite can be easily used, improving thermal and sound insulation and air tightness.

Disadvantages of Portable Homes

- There is a need for proper and careful handling of the fabricated components such as glass, steel panels, or concrete panels.
- There could be more failures and leaks at joints in the fabricated components so there is need to pay close attention to connection methods.
- Depending on design, there may be a need for heavy-duty cranes and precision measurement to place components in the correct position.

Models of Industrialization in the Integration of the Portable Home

Specific strategies of integration are guided by models which define the function of the artifact in a variety of contexts. For example, if the artifact (i.e. dwelling) is seen as a form of investment, then the model helps to organize action to treat it in that capacity. The basic models of industrialized housing, introduced earlier, are: housing as product, housing as service and housing as process. In the previous chapter, the relationship of these models to the development of the house trailer was discussed. These models continue to operate in the portable home era, but they are further elaborated by the evolution of the artifact from a house trailer into a portable home. The model of housing as product is often conveyed in the image of the house-as-car. If housing is seen as a car, then it should be manufactured like a car, marketed like a car and used like a car (i.e. with the expectation that stylistic and technological changes will promote a cycle of obsolescence). The industrialized production of consumer goods usually means factory assembly.

The advantages of such assembly of housing are given as: controlled environment (free of the vicissitudes of weather), yearlong production, improved tolerances in assembly and a rationalized sequence of assembly supporting mass production. While these benefits exist in portable home production, they are not fully realized. The sale of portable homes, like conventional housing, is seasonal. Since dealers cannot afford to hold excessive inventory on their lots, and manufacturers find stockpiling units expensive, the seasonal character of sales produces a corresponding cycle of production (Bernhardt, 1980). Factory production should result in better tolerances of assembly, but portable homes, like conventional construction, suffer from low tolerances. The passage of the portable home construction standards (1976) assures the soundness of units and, to a limited extent, promotes standardization. High tolerances, however, are only necessary when standardization is applied to the production of interchangeable parts. In the case of the portable home, it is the unit as a whole which constitutes the component of housing. The critical point of interchangeability is where the unit must hook up to the tow vehicle, and where it must be connected to site utilities. Part of the economy achieved by portable home production stems from the use of rationalized assembly; which supports mass production. Components (e.g. wall sections, kitchen cabinets, etc.) are sub-assembled and brought onto the assembly line when required. The same kind of rationalized assembly, however, can be achieved in on-site construction with the use of serialized production.

Indeed, the degrees to which mechanical techniques are used to assemble units in the factory are not significantly greater than those utilized in large scale housing developments. Perhaps this means that the serialized housing site is a factory, but that it is not perceived as such because the process is not enclosed in a building. The same

observation can be applied to highly industrialized agriculture. The image of the housing factory, then, may be limited by a too literal interpretation of what a factory is. In developing housing as a product, the manufacturers have acted as if the product were the unit and not the unit/site ensemble. To be sure, their associations have suggested standards for park design, and at times have offered design services, but few manufacturers have engaged in park development. The park is to the unit as highways are to the car. Each is dependent on the other, but car manufacturers, like portable home manufacturers, do not take direct responsibility for developing this support system. Some dealers and park developers have attempted to tighten this interface, but the result is often the creation of a "closed" park. The very notion of a closed park and the legal response (e.g. those consumers should be protected against such parks) reinforces the identification of the unit itself as a product.

Frame Construction

"Stick built" architecture is a colloquial term for buildings of 2 x 4 frame construction (typically platform framing).The walls are light and, until the recent concern over energy, hollow. Such construction is an early and significant American contribution to the industrialization of building. Developed in Chicago in 1833, it made it possible for relatively unskilled labor to erect a structure in an incredibly short period of time. Contemporary descriptions of Chicago marveled at the speed with which buildings were erected (Boorstin, 1965). Despite the lightness of the frame and the frequent indifference in joining members, the final structure was remarkably strong. This strength results, in part, from the application of the wood cladding which encloses the frame and also acts as a structural membrane; creating a true "skin and bones" architecture.

The thin walled construction is not meant to endure unchanged through the decades; but to quickly return the investment made in them, and then to be extended or demolished as new needs arise. Here, then, is the basis for a disposable architecture; one which is cheap enough to promote the idea that it may be more economical to demolish a building than to engage in extensive maintenance and upgrading. It is also a structural system which provides the basis for a relatively flexible architecture. It is a simple task to add a shed extension onto the core structure when needed. Indeed, the "lived-in" form of such structures is a core house, often square, with a series of shed additions successively tacked onto the back. Structural thinness has been regarded by many modern advocates of industrialization as an essential property of industrialized housing. R. Buckminster Fuller asks the question-"how much does your building weigh?"-to underscore the importance of weight as a consideration when units or components must be transported from the factory. Fuller speaks of the technological evolution of buildings in terms of structural ephemeralization: the trend toward developing ever lighter, yet more efficient structures. In comparison with its predecessors, stick built architecture is lighter and stronger. Moreover, its individual structural members are small enough and light enough to facilitate transportation and fabrication.

Gropius and Wachsmann (1961), in the General Panel System, have basically extended and rationalized the fabrication of stick built structures. Whereas in on-site construction, the frames for individual walls are fabricated on the ground and then raised into place and sheathed; in the general Panel System, they are fabricated and sheathed at the factory and simply joined at the site. Stick built construction, then, may serve as the basis for more sophisticated forms of industrialization. It is not difficult to identify the

literal thinness of the mobile home. While this is often regarded as a sign of flimsiness (frequently with justification), it is not so inherently. The mobile home is essentially a stick built structure, both in terms of its fabrication and type of construction. The construction of a mobile home begins with the fabrication of the floor frame.

Ducts, wiring and plumbing are installed along with the insulation and subflooring. The completed frame is then bolted to the metal chassis. Before the 1976 HUD standards, the entire floor might be covered with a single sheet of vinyl floor covering or carpeting. Large plumbing fixtures, such as the tub and toilet, are usually installed first on the finished frame. Kitchen sinks in self standing cabinets may also be introduced. Each wall frame is then constructed as a unit with its interior plywood sheathing. They are bolted through the flooring or strapped to the frame. Batt insulation is applied to the exterior walls, once in place. The roof is assembled as a single unit. Acoustical ceiling tiles are attached to it, and then the entire roof section is fastened to the walls. Aluminum sheathing is then taken off of a long roll and wrapped around the exterior. Window openings are cut through the sheathing and prefabricated windows and storm sashes fastened to the frame. A single sheet of aluminum is drawn over the roof. Once the basic shell of the unit is complete, cabinets and closets are installed and, finally, furnishings are added. This entire process of fabrication will consume some 250 person hours of labor (less than a quarter of that which goes into a site built house), and the unit will roll out of the factory on the same day that it rolled in. No other form of industrialized housing can match this record of speed.

Figurative Architecture

The need for building quickly and cheaply, which served as a motivation for the diffusion of stick built architecture, resulted not only in structures which were literally thin, but figuratively thin as well. Figurative thinness has to do with the way meanings are related to the features and form of a structure. Meanings are applied to and associated with form as signs and signals, rather than forms serving as indicators. The figurative thinness of stick built architecture is most simply expressed in what Venturi, Brown and Izenour (1977) call the "decorated shed." The decorated shed occurs "where systems of space and structure are directly at the service of program, and ornamentation is applied independently of them" (p. 85). The appliques of the shed may consist of expensive materials or they may be painted on. They may suggest a monumental scale while hiding a modest structure.

While associationism in the Nineteenth Century is tied to particular movements and styles (e.g. romanticism, exoticism and the picturesque), the general idea of associationism provides one of the fundamental approaches to the understanding of meaning in architecture and all other areas of human communications. Associationism may be understood in terms of the structure of significant features. The significant feature, it will be recalled, consists of some discriminable aspect of an artifact (i.e. a feature) and an expectation (i.e. significance) related to that aspect. There are at least two types of bonds joining features and expectations. These bonds can be distinguished as associational and identificatory; arbitrary and necessary; conventional and natural. This distinction in bonds corresponds to the distinction made in semiotics ("the science which studies the life of signs within society" Bonta, 1979, p. 26), between signal and

indicators. Indicators are features spontaneously produced in the course of an action which come to stand for a particular aspect or expectation resulting from that action. A signal is a feature intentionally introduced or singled out of a situation in order to communicate something about that situation.

Methodology

Research Design

The purpose of this study was to determine a suitable solution to the housing insufficiencies in Mithi, Tharparkar. Since information from quantitative, experimental studies is sparse, a qualitative research method was chosen in order to provide an understanding of the current situation and the various options available. Qualitative research methods enabled the understanding of the context of the problem and allowed case study analysis to determine the significance of the research problem with respect to a certain area or population group (Schoenborn, 2012). A systematic analysis of the previous literature and case study analysis on the topic was also conducted. Information about the research problem was gathered using academic papers that were selected by applying fine criteria for search tools. Surveys were deemed inconclusive in this study since the decision makers are not the poor homeless, but rather those in government positions. Direct communication with government officials was the most effective way to find the needed information on which to base decisions as to the feasibility of providing housing.

Information Search

The literature study on the topic was an exploratory process to gather the information to determine the feasibility of the design and implementation of portable homes in desert areas. The research articles for evaluating the topic of the study were retrieved from EBSCOhost, Proquest and Web of Science databases. Those particular research articles and case studies were selected in which the moveable home designs were tested on desert regions. The first theme of this qualitative research study intended

to determine the barriers and constraints faced by modern home designs in dealing with the climatic and ecological conditions in desert regions. In the second theme, the study evaluated the effect of building materials used in movable houses in desert areas with respect to their heat consumption. The third theme of this qualitative research was to evaluate the already developed models of portable houses that are ecologically sustainable and could be used over a period of 10 years without any need of mending.

Information Collection

Those research articles were included in which the movable homes in desert areas are discussed specifically. Those research articles were included that discussed architectural techniques focused on portable homes to be designed and built in extremely hot and humid environments. The studies were included in which the ecological sustainability and economic feasibility of portable housing is determined.

In addition to the published literature, information was needed about infrastructure and materials available in Tharparkar and what the political and cultural requirements would be for that area. The specifications of the design of these portable homes and how they can be setup would depend on these factors. In order to find this information 20 questions were created for the government officials in different departments and ministries who communicated with via telephone to get the information required for the successful implementation of these homes in Mithi,Tharparkar. The following government officials were contacted in order to get the needed information:

- Chief Executive Officer from the Water and Power Development Authority Hyderabad Division (WAPDA, HESCO) was contacted to get answers for water and power related questions.

- General Manager of Projects and Construction at the Sui Southern Gas Company (SSGC) was contacted to seek answers to gas related issues.
- The Personal Assistant to the Chief Minister, Sindh (PA,CM) answered the questions related to leasing, infrastructure, logistics and transportation .
- Regional Director from Sindh Bilding Control Authority (SBCA) answered the questions on how these shelters can be used as a permanent housing solution.
- Assistant Superintendent of Police (Anti-Encroachment Force) (ASP) provided the answers related to security.

The design specifications were then determined after taking the cultural aspects into consideration of the locality. The 20 questions are provided below:

Infrastructure / Government Assessment for “Chelson Shelters”:

1. What electricity sources are in the area?
2. How reliable is the electric service?
3. Is there natural gas, propane or some other fuel source available?
4. Is sewer service available in the area? If so how much capacity does the system have? Would grey water be needed for proper function of the waste system?
5. Is water available in the area? Are there pipes that the units could be hooked to or is there a system in place where water can be filled into the unit's tanks at a regular interval? If no such system is available, how close is the nearest well or water source?

6. Is the soil in the area stable?
7. Is the area prone to floods, heavy winds, earthquakes or other inclement conditions?
8. Are roads to the area sufficient to carry trucks to deliver the units? The weight of each unit is less than two tons fully loaded. If there are no reliable roads, is the ground generally suitable to carry these loads?
9. Is there equipment in the area that can be used to level ground and/or lift the units from trucks. (A backhoe, trackhoe, or any lifting equipment that can handle up to 2 tons would be adequate. If not available, can a backhoe be transported to the site and used?
10. Can these units be placed on land that can be utilized by the occupants without harassment?
11. Is there space available for gardens?
12. What permits or permissions are required to transport and assemble the units?
13. What fees are required to establish the units in the area?
14. Would the units we required to be relocated in a set time period?
15. Are the intended occupants of the units to be considered temporary residents in the area or will the units serve as a more permanent housing solution?
16. Are there educational facilities in the area?
17. Are there medical facilities in the area?
18. What would the government's role in the process be?

19. Are there any building codes or regulations concerning the establishment of these units that would need to be met?
20. Is the area generally secure? Are police forces available to protect the units and the materials (such as solar panels) from theft or destruction?

Information Analysis

Descriptive content analysis was performed on the selected research articles to find out the economical usefulness and ecological sustainability of the portable home architecture. Besides that, the current situation of the Tharparkar Desert and how the portable homes might bring betterment to the life of people living in Tharparkar were considered. This research also explored different strategies and tactics to improve the current situation through the results of this thesis.

The results of this study will be presented to the federal and provincial governments of Pakistan so the movable home concept would be applicable in the Tharparkar desert region. The design requirements, however, and configured for the specific conditions in Mithi.

Findings and Discussion

The information gathered from different resources highlighted the current situation and living standards of the people living in the Tharparkar Desert of Pakistan. The findings of the collected information provided a brief overview of the lifestyle of these people. This is the basis on which the feasibility of the portable homes in Tharparkar Desert area was decided.

1. The sources of electricity in Tharparkar district are very few; coal based power projects are constructed in the area for providing electricity to residents of Tharparkar. Furthermore, it was discussed that the coal based power projects need time to be constructed as there are international barriers imposed on the project (Chief Executive Officer HESCO WAPDA).
2. The electricity services in the Tharparkar are not efficient, currently there is a 5 hour supply of electricity in the region each day. However, the government, along with some other companies such as Tharparkar Engro Coal Power Project, is building power projects in the area to fulfill the need of electricity in the region (Cheif Executive Officer HESCO WAPDA).
3. Tharparkar has plenty of coal sources that are being utilized by the government for generating power, and natural gas reserves are also available in some areas of Tharparkar dessert (General Manager of Projects and Construction SSGC).
4. The sewerage and sanitation systems in Tharparkar Desert are not properly developed; there is no pipelines or proper system for sewage and people dig pits for sewage purposes. However, some projects have been started by NGOs from

UK and USA for the betterment of people (Chief Executive Officer HESCO WAPDA).

5. One of the biggest problems of Tharparkar and its surrounding areas is the water shortage because there is no availability of safe ground water in the area. The ground water available in the area contains minerals and a high concentration of salts which is not good for humans. There is no proper water system available in the area. However water for the units can be transported using water tankers from Badin which is the closest water station. Due to the shortage of water and the tankers in the region, it can only be provided once every 15 days (Chief Executive Officer HESCO WAPDA).
6. The soil of the desert is prone to wind, and it remains dry for much of the year. The wind of the desert is not stable and the high velocity wind can easily blow the soil from the desert (P.A. CM Sindh).
7. One of the good things about the Tharparkar Desert is that it is not prone to natural disasters such as the earthquake and floods (P.A. CM Sindh).
8. The road and transport infrastructures are not good at the desert; however, the government of Pakistan has carried out some projects to provide basic facilities such as transport, road, water, sanitation and health to people of the area (P.A CM Sindh).
9. There is no proper equipment to level the area, but machinery is available in Pakistan which can be used by engineers to level the surface for building units.
10. Yes, these units can be placed on land and it is also essential to train people of Tharparkar for building and maintaining these shelters.

11. Yes, small gardens can be constructed in front of each unit in order to make the environment of the desert clean. There are fertilizer factories around the area which can provide fertilizers to make soil fertile which will help the residents grow vegetables and fruits for themselves.
12. The companies which are constructing or developing different projects in Tharparkar must require permits and permission from the government in the same way the permission of the government is required for constructing houses (P.A. CM Sindh).
13. It is difficult to decide exact fees for the units; however, a significant amount of money may be required to place portable homes in the area.
14. As the proposed idea is considered to be a relatively permanent living solution with all the basic necessities included, government allows a time frame of ten years for such projects. Units may be relocated after the given set of time period but not necessarily. If the project is able to build a community in the area they may stay at the same location (Regional Director, SBCA).
15. Units may serve as the permanent housing solution for the residents. However, if the resident doesn't like the homes, they have the freedom to change.
16. There are very few or only basic educational facilities in the area. Only Urdu medium primary schools are available in the area that serve students up to the 5th grade.
17. No proper health or medical facilities are available in the area. NGOs and some welfare organizations make efforts to provide basic healthcare services to people in case of emergency.

18. Government can facilitate the process by subsidizing rates on materials and other logistics-related matters for building houses in the region (P.A. CM Sindh).
19. Every country has their own and regulations for building houses or other infrastructure. Likewise, Pakistan also has rules which must be fulfilled by the constructing organization.
20. Currently, there is no police available in the area; however, once the construction is started, police must be enforced there for security reasons (ASP Anti Encroachment Police).

Through the investigative research, it was found that there are a lot of "loopholes" in the governmental system of Pakistan which leads to corruption. This is a prominent reason that the government welcomes refugees and then makes money by exacting fees from those agencies who must provide sustenance and shelter for the refugees. Money will need to be allocated for "smoothing the process" so that the shelters may transported and built in communities where they are needed. These "fees" cannot be accurately assessed since they are not officially declared policies but rather a cultural system in the bureaucracy.

Results:

After going through all the literature review and communicating with the concerned government officials on the 20 questions that were developed based on the current conditions in the Tharparkar region, it became possible to determine the design specifications for the homes that would be most suitable for the region in terms of cost, sanitation, security, culture and environment.

The basic idea is to provide a shelter that is cost effective, environmentally friendly, and able to deal with the security and sanitation issues for the occupants. A core unit will be designed that contains a toilet and bathing facilities in one corner and a kitchen would be attached to it on the same wall that would provide a sink to wash dishes. Initially, the idea was to provide a cooking top along with the sink, but after getting to know the culture of the region it was suggested that an empty ground space should be left for cooking, as people in Tharparkar prefer stoves on the ground for cooking. A water tank would also be provided with the core unit which can hold water for up to 15 days for 5 occupants. Keeping the spatial and sanitation issues in mind, a folding toilet and detachable waste tanks for “black water” and “grey water” would be used. The "black water" or human waste is to be decomposed and used as soil amendment. Grey water could be used to grow vegetables and fruits in the front or the backyard of the shelter.

The core unit would be transported to the place where it is set in place, having adjustable pads on each corner of the unit to level it on the ground, 6 straps would be drilled in the ground which will help make it secure from high winds and natural disasters such as earthquakes or floods. Depending on the size of the shelter, adjustable floor panels, wall panels, and a roof would be attached to the core using straps to ensure safety. Each unit would have a door and a window and an additional vent in the kitchen. Folding beds and tables would be attached to the shelter so occupants could move in and start enjoying the benefits immediately. Attaching wall panels, roof tops, beds and tables is to be an easy task which doesn’t require heavy tools and could be done within a day.

Depending on the family size more rooms could be attached to the shelter by adding more panels.

The main idea of the "Chelson Shelter" is to provide the people of Mithi with better housing where they can live with a sense of security, cleanliness, and a better lifestyle. Based on the information available it is known that there are not many resources available in the region. While designing the shelters, it is important to concentrate on the maximum utilization of scarce resources; water and electricity. Atomizing showers, which require less water but still supply high pressure water that provides effective cleaning and avoids wastage of water, are to be used if possible. The sink will have a set amount of water for cleaning dishes. A water pressurizing pump, electrical outlets, LED lights, and pedestal fans would be provided for better lighting that can operate from electricity produced from solar panels on the roof top. Batteries with enough capacity to run a LED, ventilation fan and water pump are preferred if electricity is not available. Compressed natural gas (CNG) cylinders (Sui gas) would be used for cooking purposes, heating of water, and for ventilation in the house depending on the climatic conditions. Insulated floor, wall and roof panels would be used to provide a controlled reasonable temperature inside the shelter that is efficient and cheap. Local materials would be used for assembling the unit in a way that would reuse and recycle resources and reduce waste.

Specifications:

The follow are the specifications for the shelters for the people in the Mithi area:

- Core Unit: 4feet deep, 10 feet high 10 feet wide.
- Wall thickness: 4 inches average 6 inches floor and ceilings.
- Basic room size: 10’10’8’

- Footing pads: 16 inches, adjustable plates-12 inches.
- Sloped ceilings towards the core unit for proper ventilation flow. Windows and vents for increased ventilation.
- Folding toilet (squatter) with showers on top, to utilize the space. Shower water drains into grey water tank for reuse and toilets are cleaned automatically by high pressure water to ensure sanitation when folded in the wall.
- Kitchen: Sink to wash dishes, 2 feet counter space, cupboards and cabinets to store food and an empty space for ground stove for cooking.
- Folding dining tables and beds attached to the walls.
- 800-1000 liter water tank provided for each unit. Clean water is provided every 15 days.
- Waste tank, when filled, can be emptied for gardening purposes.
- Pertal, Keal, Safeda or Neem wood wall panels are be used with a Styrofoam core for insulation. (Wood panels ranging from $1.10-$4.00 per cubic foot, depending on what wood to be used).
- Efficient solar panels to fit on roof for use in day and to charge batteries. Batteries can be charged for 12 hours of use with 2 hours of electricity when available.

Conclusion

Tharparkar, Sindh, is one of the most arid deserts in Pakistan. Looking at the governmental, ministerial, cultural, and environmental conditions, there were certain characteristics that had to be met. Because of the extreme temperatures and lack of resources, so the conclusion of this study is that these shelters following the prescribed specifications could meet the needs of these people. These mobile shelters could provide the displaced people of Tharparkar with a permanent housing solution by providing and establishing a complete portable home community, a revolution on the mobile home park.

The research provided answers to the three research questions:

Q1) Are modular portable homes a suitable housing solution for Mithi, Tharparkar?

Currently, people living there have no proper housing, sanitation, security or any other system. The researcher found that there is a huge need of not only providing these people with houses but building a community so they can support an effective society. Some of the most concerning issues connected with this project which could be addressed with proper housing in a community setting are illiteracy, due to lack of schools; high fatality rate and sicknesses, which are connected with the shortage of medical centers and hospitals and the lack of water.

Q2) Can these homes be used as a permanent housing solution?

Concerned governmental officials stated that these shelters could be set there for at least ten years - and contingent upon the shelters helping to build the community, the government would allow them to stay there as a permanent solution. Taking into consideration all of these issues, and in conjunction with information from government ministerial officials, the specifications for the homes appear to provide an effective

solution for the area and efficient in resource utilization. The homes can be easily set up in less than a day without any heavy equipment or machinery required. The core unit would be transported to the chosen area where they would be set up with the help of local people who would be trained so that they can build the houses on their own and can start supporting themselves through this work. Schools, hospitals, and small workshops to build these shelters are also the part of plan. The researcher concluded that the portable home could accommodate housing as a better process and feasible if it were made up of modular components that are interchangeable.

Q3) What would be the requirements or specifications for such homes designed for the Mithi situation?

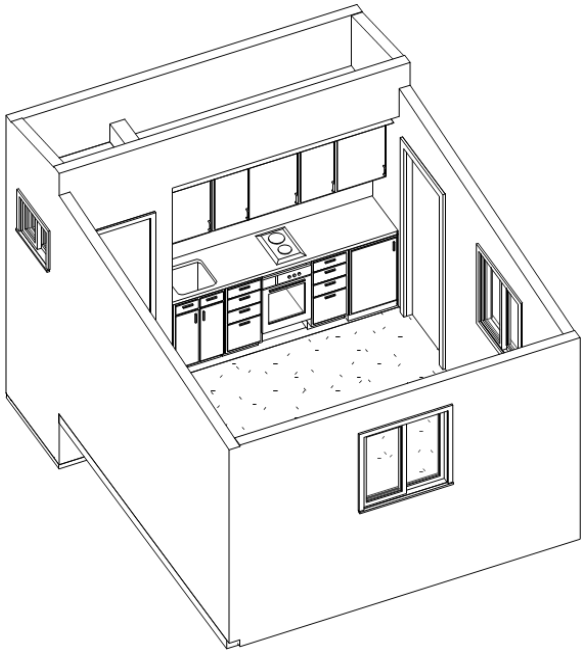
This question is answered in the specifications section on pages 36 and 37. These findings support the development of a plan for the precise design of the shelters and supply chain logistics for these shelters in the Mithi area of Tharparkar. It is also anticipated that these shelter communities should be feasible throughout the Tharparker desert area, providing the indigenous poor with housing that would provide sanitary living conditions and foster a sense of safety and ownership.

Future work is recommended: a business plan that will delineate requirements, responsibilities, design and build the components and ship these components to Mithi, Tharparkar, Sindh Province. A presentation to the Sindh Provence ministry, to NGOs which participate in humanitarian projects and USAID should be included in the plan. The groundwork has been laid for this plan to be developed. The researcher found enthusiasm for the project among local and regional government officials, indicating a reasonable expectation of project implementation success.

Appendix A

Chelson Shelter Overview

The Chelson shelter meets the security, sanitation and environmental protection needs of the occupants in an environmentally sustainable manner. The core unit contains toilet and bathing facilities in a small room and a kitchen countertop with a sink and cooking surface. The core contains water tanks that hold enough water for a week for a family. The toilet is a folding unit that is self-cleaning and uses very little water. The waste is dropped into a "black water" tank that is designed to maintain optimal oxygen levels, temperature and moisture content to ensure rapid decomposition of the waste. The "grey water" is stored in a separate tank that can be used for gardening or recycled for use in the shelter. Fans, filters, heaters and other mechanical and electrical needs are all contained in the core.



The core is brought to a location and placed on ground that is fairly level. Pads in each corner are adjusted to bring the unit to level and plumb. Straps are drilled into the ground and attached that secure it from uplift against wind or earthquakes. No footings or additional ground preparation are required. A floor system is either folded down from the core unit or assembled from panels shipped with the core. It is secured on adjustable footings and beams which are also strapped to the ground. Wall panels and a roof are

placed to complete the house. The exterior and interior surfaces of the floors, walls and ceilings are finished and require no expensive tools to assemble on the site. Each unit has doors and windows and additional vents to aid in cooling. Beds and tables can be attached to the walls so a family could move into the shelter and be able to bathe, cook food, sleep and live securely in less than a day. When needed the units can be shipped such that they can be set up in less than a few hours. Several rooms can be attached to a core unit so that the unit can be used for a few people or a larger family.

The principle functions are designed to use resources efficiently. The shower is low flow and designed to minimize waste. The kitchen sink delivers clean and heated water but the flow metered so that it is hard to waste it. Electricity is used to run ventilation fans and water pumps and can be used for cooking. Electrical outlets are placed sparsely and lights are LED. A solar panel on the roof should supply the basic requirements for the unit. If electricity is available then more conveniences can be added. If propane or gas is available they can be used for cooking, water heating and space heating. The floor, wall and ceiling panel are well insulated for the environment so that space temperature control is efficient and inexpensive. The unit is adapted to the local environment and the resources available in it but is designed to use resources economically and with little maintenance. By design, the occupants reduce waste, re-use material and resources and recycle what cannot be re-used.

The shelter is quickly assembled and disassembled as needed but is ideally not placed on wheels. The concept is to make a home that feels permanent and secure rather than make the occupants feel nomadic and unsure of where they will be. These are best suited for situations where they will be used for over six months since they are designed to help

the occupants feel control over their environment by taking care of themselves, growing a small garden and being part of a community. They are designed with a planned life span of over 20 years so could be used as a permanent solution in some situations. They are modular but because they are shipped in panels there is less shipping costs and four of these units could be shipped in the space of one comparable pre-assemble unit.

Specifications for Chelson Shelters:

- Core unit: 4 deep, 12 wide, 11 feet high (including tanks and 'footing pads'.
- Wall thickness varies depending on local insulation and strength requirements. Typical thickness would be 3.5" for walls and 6" for floor and ceiling. A basic room would be 12 x 12 x 7 to 8 feet high (sloped ceiling.) Additional rooms may be added as needed.
- The footing pads are 16" round adjustable plates. Beams are used for the floor system and placed on 12" round adjustable plates.
- The ceiling is sloped up from the front of the living area toward the core unit to aid in ventilation. Windows and vents are placed to increase air flow.
- The toilet folds into the wall when not in use so that the room can be used for showering or bathing. A drain directs shower/bathing water to the grey water tank. The toilet is cleaned by a jet of water when folded into the wall to ensure sanitation. Biodegradable soaps are supplied in the unit.
- The kitchen contains a sink and cook surface. Counter space is provided along with cabinets and cupboards to food and kitchen needs.
- A table may be folded from one of the wall panels as could beds with mattresses.

- The waste tank, when filled, is pushed to a holding area under the unit where the decomposition process is controlled. When decomposition is completed, the temperature is raised to 140 degrees to kill unwanted microbes and then the contents are taken from under the unit and emptied into a field or garden.
- Water can be added to the internal tanks when available or at low flow rates. If reliable water sources are available, the unit can be hooked directly to the pipes and the tanks may be omitted. If sewer service is available the black water and/or grey water waste may be piped directly into the sewer lines and the tanks omitted.
- The interior wall surfaces are to be washable and durable with a natural feel to them. The exterior surfaces finished and any element in contact or near earth are metal coated or water and rot-resistant material such as pressure treated wood, plastic, vinyl or fiberglass.

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