UNIVERSITY OF ZIELONA GÓRA

CEER CIVIL AND ENVIRONMENTAL ENGINEERING REPORTS

CIVIL AND ENVIRONMENTAL ENGINEERING REPORTS

E-ISSN 2450-8594

CEER 2025; 35 (2): 0091-0113
DOI: 10.59440/ceer/202238
Original Research Article

FORMULATING GUIDELINES AND REQUIREMENTS FOR CONTEXT-BASED RURAL HOUSING DESIGN, CASE STUDY: RURAL HOUSING IN SISTAN, IRAN

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Abstract

The Sistan area in eastern Iran was one of the areas that experienced a flood in the early 1990s, and many of its rural houses were destroyed. For immediate accommodation of flood victims, the government accumulated different villages in residential towns. The design priority in the creation of these towns was the houses' strengths against flood, and the rich indigenous architecture that was shaped based on the environment and attention to context was ignored. Thus, inattention to the environment and design context in the design process of rural houses after the crisis has made villagers not accept these houses. This paper aims to formulate regulations for designing rural housing by studying and examining the indigenous housing of the zone to help improve the quality of rural housing. The research method is based on the examination and field survey of 22 selected rural houses in this area based on the Geographic Information System (GIS), which is done through the descriptive-analytical method. The results of this study have resulted in formulation or advice and requirements within four parts of functional recommendations, climatic, physical identity, and spatial relations, which observation of these requirements can contribute to the improvement of rural housing quality. This method has been done based on the design field and area and can assist housing scope policymakers in the areas prone to natural disasters, so they can formulate the housing design after the crisis based on the attention to the design field and area.

Keywords: rural housing, context, post-accident design, formulating design guidelines and requirements, Sistan

1. INTRODUCTION

Now, the policy of consolidating villages and rural housing design in various countries is subject to policies and rules made by governors of that country [1]. These policies can be successful when they are along with multidisciplinary sustainability-based environmental studies [2, 3], sustainable managerial planning and strategies, and public participation [4-8] play a key role in these policies [9,

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10]. There is a potential for changing the appearance of rural housing in countries with moderate or high-income economies, such as China, Russia, and Turkey due to the economic development of a middle class of society and their entrance to rural areas [11-15]. However, many rural environment renovation projects have faced some challenges due to long-term planning and investigation adopted by policymakers in the rural housing field [16-18], and governments have preferred urban development instead [19, 20] resulting in the degradation of rural areas worldwide [21]. Compared to urban housing, rural housing is more physically vulnerable during crises such as natural disasters, and each country adopts its own policy, strategy, and post-crisis design in response to these damages. These strategies even may affect the health [22] and culture of occupants [23, 24]. In the post-crisis renovation process, most countries construct new houses for rapid accommodation without considering the context, so these houses are incompatible with the climate, culture, and behaviour of villagers. The post-crisis design of rural housing is done based on modern techniques to reinforce rural housing, but it should not hurt the identity of rural housing. Inattention to the mental and behavioural aspects of villagers in the rural houses' design process has led to a strange appearance of rural houses, so villagers do not accept and welcome the houses constructed by rural housing institutions and practitioners. However, the identification and application of context effect on the joint creation processes and subsequent challenges such as stakeholders' participation [25] can enhance the acceptance and use rate of rural spaces [26-31] and result in socially accepted place-based solutions that contribute to transfer and evolve the sustainability [25, 32].

Various decisions have always been made for developing rural areas in Iran [33]. As mentioned, Sistan is one of the areas that was flooded in the early 1990s. Many villages were destroyed by this flood and Governors' policy for the accommodation of flood victims included the construction of towns and the gathering of several flooded villages in these towns. Construction of houses in these towns was based on the house's strength against flood, and the rich indigenous architecture of the area was ignored. These towns gradually led to residents' dissatisfaction due to a mismatch with the climate and culture of residents living in that zone. Many of the new houses were extensively changed by residents without considering the required principles, which led to a mess in the rural landscape. Since more than half of the residents in the Sistan area live in villages, it is necessary to pay attention to the quality of villagers' living space. The field studies show that the quality of Sistan's indigenous housing was matched with the environment before flood occurrence, and residents were satisfied with living in the indigenous housing [34]. Therefore, this paper offers some regulations and criteria based on the field assessment and sampling from the selected vernacular houses, which can improve the housing quality in new constructions. It also helps the world housing policymakers in the areas prone to natural disasters to improve housing quality after the crisis inspired by the vernacular architecture of each area and based on local participation.

1.1. Rural vernacular housing in Sistan

Vernacular architecture reminds villagers of the soul and landscapes of the house [35, 36]. Vernacular architecture in Sistan can be named as architecture influenced by the climate and culture of the area and shaped based on wind engineering [37-40]. The winds blowing in this area highly regulate the hot weather and affect the orientation of Sistan's settlements in a way that allows wind flow into the residential houses [41-43]. The domed shape of these houses' ceilings provides shading decreasing the heat in the building [44]. Therefore, the positive use of nature is seen in the vernacular architecture of Sistan, so the context and climatic conditions have received great attention in people's lives (Fig. 1).

Fig. 1. Vernacular rural architecture in Sistan

1.2. Post-crisis rural house constructed in Sistan by the government

Development of the sural areas in different aspects has been always considered by the researchers of less-developed communities. These studies have directed the governments towards decisions and projects related to rural area management (as a policy or strategy) based on their viewpoint on development issues [33]. Renovation of rural housing by the government often focuses on the quantity and speed of civil engineering projects without paying sufficient attention to the local landscape of the rural areas, which results in the construction of uniform houses [45, 46].

A prominent sample of this policy is seen in the project of consolidating flooded villages in the Sistan area and accommodating the victim villagers in the towns with monotonous architecture. According to field observations, the construction of this housing has made people dissatisfied due to inattention to their needs, demands, and culture. Following are some physical or structural challenges of this kind of housing:

- Construction of housings with the same type and shape for various households has led to considerable changes in residential houses after the settlement of residents or remained empty and unwelcomed.

- Inattention to the climate in selecting materials and openings of the houses constructed by the government has led to energy loss.

- Inattention to the livestock space in the housing plan has made some occupants integrate living and livestock spaces.

- An incomplete copy of urban housing in some housings has led to the improper appearance of these settlements (Table 1).

Table 1. Main problems of post-crisis housing constructed by the government

		
A considerable part of housings has remained empty.	Blockage or downsize windows in the sun-facing front by occupants	Blocking windows in wind-facing front by occupants
		
Using a glass-made façade that causes high energy loss	Incomplete copy of urban housing that causes high energy loss	Using materials with high heat transfer rate that causes high energy loss

Investigation of the housing constructed after the flood crisis by the government indicates that villagers' settlement projects have failed due to numerous social, cultural, and structural problems, as well as incomplete copies of the urban housing. It seems that this kind of housing has not been fully accepted by the residents because the vernacular architecture and texture of the area have not been considered. Hence, principles and regulations of rural housing projects must be formulated in this area to improve rural housing in the Sistan area regarding the context and indigenous knowledge, so that governors can construct housing during the crisis by referring to these principles and regulations.

2. CONSIDERING CONTEXT AND PLAN PLATFORM AS A LIVING LAB

The concept of the living lab (LL) is used in collaborative planning and design of various fields of sustainability, environmental management, preservations, and plan platforms [47]. The LL concept these days points to empirical research approaches, including real-life [48, 49]. The real-life' empirical context provides the field for design based on the cooperation between stakeholders, which is based on identifying problems, discovering solutions, and applying them [59, 50]. There are two approaches in this case: first, an actual texture or fabric can be a physical texture like a city, rural area, or a neighbourhood [48, 49] its internal specifications include social-economic, cultural, and political dimensions, and governmental structure, living labs, and are mainly defined as certain context or area [26, 51]. Second, the context of real life has been used based on the plan platform and local solutions [48, 52].

As mentioned above, a collaborative approach is often used in an LL to find solution options for a given problem in the LL. This collaboration becomes successful when it matches with the context it is imposed, involves the relevant stakeholders, and increases admission of solutions. Because LLs are embodied in the real-life context under the effect of various cultural, social, and economic contexts, inattention to context effect on the plan may lead to identity-less plans. Therefore, the plan and context must receive greater attention in the design of rural housing, which pursues the purpose of this study.

3. MATERIAL AND METHODS

3.1. Study area

Sistan area is located in the east of Iran (Fig. 2) and is known through three features: climate particularly the 120-day winds, history, and archeology [39, 53, 54], and Hamun Lake. Sistan is one of the windiest environments in the world [55, 56]. Sistan Wind blowing from central Asia to the northern coast of the Oman Sea is known as the 120-day wind due to its average blowing time from May to September [57-61], and its dominant direction is from northwest to southeast [44, 62, 63]. Sistan’s climate is desert based on the Ghosen's, is dry and very hot with dry summer based on the Köppen method, and is a climate with very low precipitation, hot, and dry based on the cluster analysis technique [37]. The average annual precipitation rate of Sistan is around 50mm, high average annual temperature, and about 4820mm of annual evaporation [64, 65]. Another specification of Sistan is the presence of Hamun Lake in this area. This lake is located northwest of Sistan’s settlements, so on rainy days, wind blew from the lake to these settlements lowering the temperature. Climate change has led to lake dryness causing more dust concentration during 120-day winds blowing in this area [66].

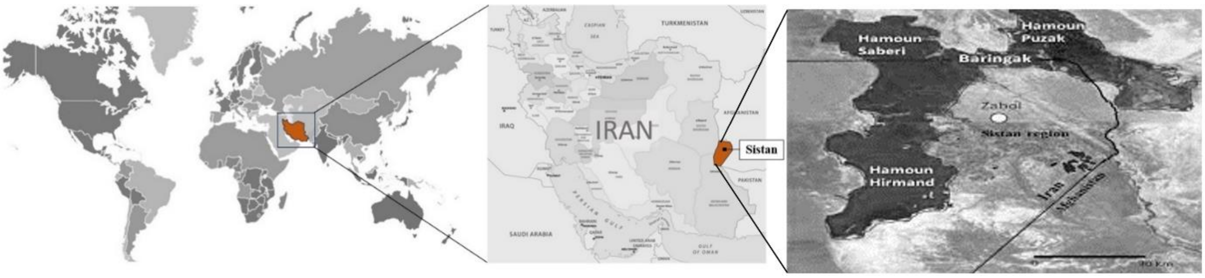


Fig. 2. Location of Sistan zone in the world and Iran

3.2. Data sources and methods

There are 1037 villages in Sistan, so the high number and dispersion of these villages have led to the first step of this research for choosing selected villages. This step has been taken through purposive sampling and geographic information system (GIS) software. The GIS-based indicators are widely used at all levels of spatial policy [67]. Various components, including population, employment, texture, and topography have affected the selection of villages. several sublayers have been defined for each component. These sublayers have been identified and layered through GIS software. Population is divided into two sublayers, including less than 20 households and more than 20 households; employment is divided into four sublayers agriculture-service, agriculture, husbandry, and fishery. Texture is divided into three sublayers dense, semi-dense, and scattered sublayers, and topography is divided into two sublayers plain and foothills. After the data were inserted into the GIS and information sublayers obtained for each effective component in selecting a village, villages with less than 20 households were deleted. According to the available data in the second step, 11 villages were selected on behalf of the 1037 villages in the Sistan area. To formulate guidelines and solutions for architectural design to improve rural housing status in selected villages, 2 housings were selected for field study and analysis (Table 2 and Fig. 3 & 4).

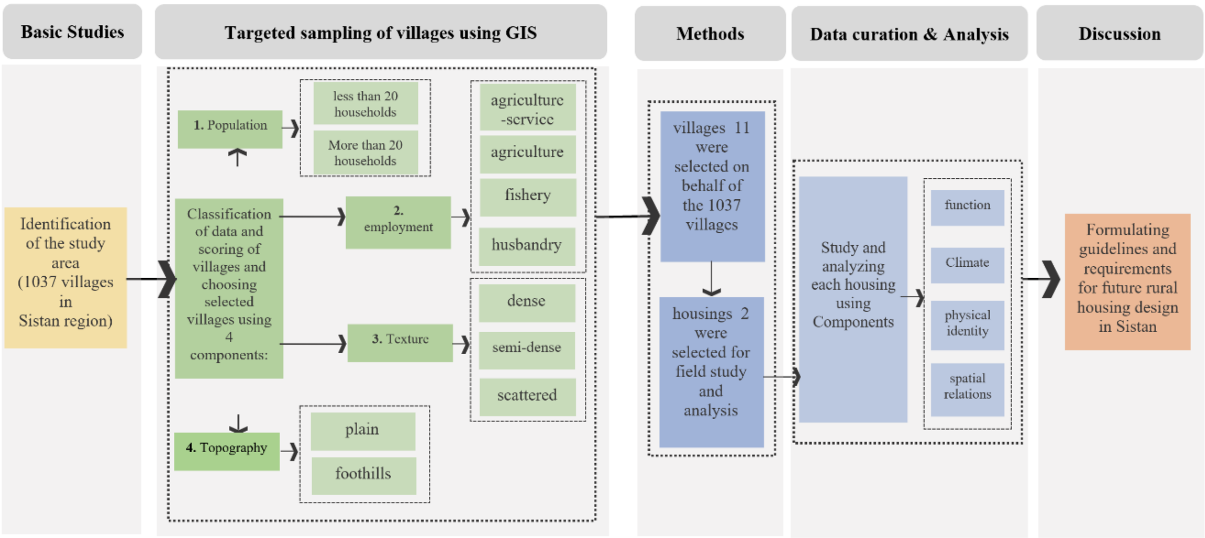


Fig. 3. Research Process

Table 2. Selected villages of Sistan region and effective sublayers in their selection

Row	Name of village	Population	Employment	Texture	Topography
1	Jaleei	1156	Agriculture-service	Semi-dense	Plain
2	Karbasak	1409	Agriculture-service	Semi-dense	Plain
3	Gori	822	Agriculture	Dense	Plain
4	Qale no	1452	Agriculture	Dense	Foothill
5	Sefidabeh	3685	Husbandry	Dense	Foothill
6	Palgi Bazzi	253	Husbandry	Scattered	Plain
7	Loorge Bagh	263	Fishery	Semi-dense	Plain
8	Sekoohe	444	Agriculture	Dense	Foothill
9	Loutak	1049	Agriculture	Dense	Plain
10	Gamshad	484	Agriculture	Scattered	Plain
11	Milak	1917	Agriculture	Semi-dense	Plain

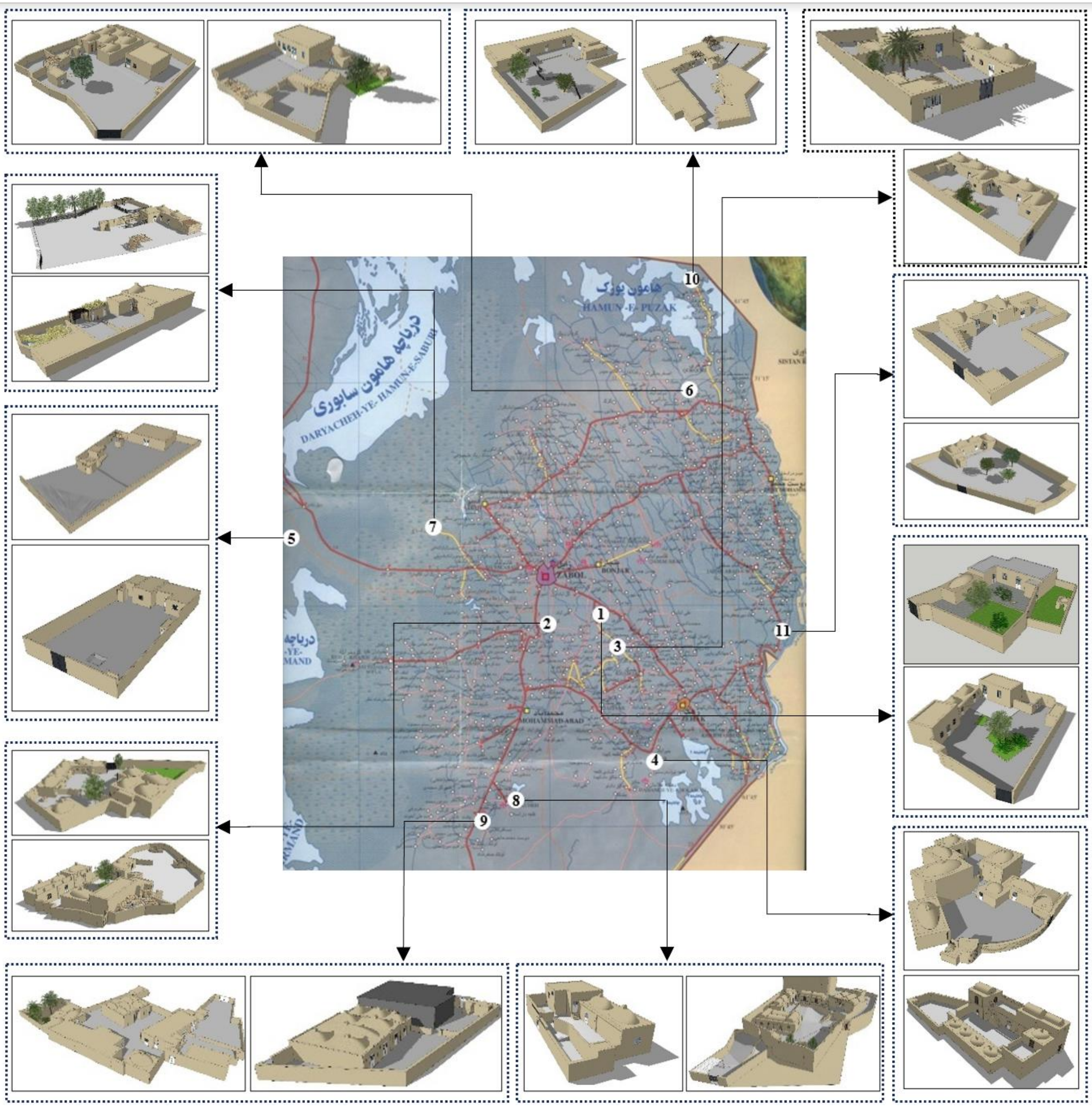


Fig. 4. Perspective of selected housings in each village

4. RESULTS

Since 11 villages were selected, 2 housings were chosen from each village and 22 housings were chosen. In the field study on each selected housing, the following cases were examined while expressing an architectural description of the building: number of households, type of livelihood, the shape of building and deployment of Mass and space, land's area, deployment of the housing in the land, housing orientation and occupation surface (%), number of floors, number of room and performance of each room, type of structure and materials used in the building, outstanding architectural elements, openings' dimensions and situations, interior ornaments, façade, spaces' height, and investigation of executive details of each housing. Fig. 4 depicts the perspectives of selected housings based on the village and housings.

After the field studies were done, the selected housings were analyzed based on 4 items to formulate guidelines and solutions for architectural design.

4.1. Analysis of space function in selected types

According to the information gathered from this area and selected residential types and the research process of functions required for buildings, all functional components can be studied generally. These functions are classified into three residential (living), service, and livelihood groups as reported below (Table 3).

Table 3. Space function in the types selected in Sistan

Function	Space	Definition of space	Image
Living space	Room (Khona)	Rooms are the most important parts of living spaces that often have a separate door and direct access to the courtyard, and this door is against the direction of the dominant wind of the area. The private life space of each household is shaped into one or more rooms in which, many functions occur. Field studies indicate that the width of these rooms in this area is around 3m, and the rooms must be carpeted since the people of this area believe that rooms must be covered by a carpet.	
	Kitchen	The cooking space in most villages of this area is inside a room where family members spend time. The kitchen is not just used for cooking and washing but most kitchens are carpeted and used as a sitting room at different times.	
	Dining room (Khoneh Outagh)	The dining room is the most important room that is larger than other spaces. This space has been decorated with khameh-Doozi (a kind of sewing) curtains, carpet, cushions, and furniture based on the financial power of the owner to respect the guests. The culture of this area is based on having many guests in ceremonies; hence, guest rooms provide various functions, such as a place for gathering together, spreading a table, and a place for guests to rest.	
	Mahtabi	It is a closed space without a roof, which is surrounded by rooms. The Mahtabi is used in those rural houses of Sistan that have a living space on the upper floor and livestock space on the lower floor. This space is mainly used for taking rest afternoons and sleeping at night. This space is a pleasant and desired place for a higher yield of wind energy.	
	Dakoncha	In those rural houses where livestock space is not located beneath the living space, the living space has been implemented in the land surface at about 60cm distance from the ground. In this case, Dakoncha is defined as the open space in front of living spaces that is separated from the courtyard with surrounded living space with about 60cm height difference or a wall with this height. Dakoncha is indeed the Mahtabi that is deployed on the ground floor.	
	Courtyard	Courtyards are enclosed spaces and each house has a separate courtyard. Some spaces and elements, such as the faucet, WC, bathroom, the entrance gate of the living space separated from private spaces, etc. exist in the courtyard. The livelihood function of the courtyard includes the maintenance of livestock and birds, cereals (wheat and barley), garden, and trees that are in the courtyard. Some performances such as washing clothes and dishes, parking cars, taking rest, and sitting occur in the courtyard.	

Livelihood spaces	**Barband (summer barn)**	A barband is defined as an enclosed space without a roof to keep livestock, including cows, sheep, and goats that is located in the corner of the courtyard. Since the 120-day winds of Sistan blow from northwest to southeast, the Barband space has been built in the south and southeast direction of vernacular housing to prevent any bad smell and noise to living space, which is mainly located in north and northeast fronts. The fence of Barband is made of clay wall covered with Tamarisk branches.	
	Stable (winter barn)	In rural housing of this area, a roofed space covered with tree branches and leaves is built in Barband to keep livestock during winter, so livestock is protected against the winter cold. This space is mainly seen in most rural houses of this area.	
	Hennery	Poultry and livestock are inseparable parts of villagers' lives. Some closed spaces called Kooleh are used to keep livestock and poultry during winter.	
	Garden (Kort)	Garden or croft exist in most studied rural housing types in this area. Some crops such as wheat, barley, alfalfa, and trees like palms and berries are planted to create landscape and shade.	
Service space	**Entrance gate**	The entrance gate provides access from outside to inside and vice versa. Entrance gates are mainly two-part doors made of wood or iron. The gates are sometimes roofed to become more practical and provide a better visual perspective. Entrance gates have simple shapes and reach the courtyard in many residential units.	
	Warehouse	Warehouse is one of the needs in all housings. This space is used to store food, products, and other equipment in each house. This space is used to protect the living spaces or provide livelihood functions. Each house has some warehouses to store crops and livestock products.	
	WC	WC is the hydergine space of the house with a small area assigned to it. these spaces are mainly located in corners of the courtyard far from living spaces to prevent any bad smell and noise in living spaces.	
	Bathroom	Bathroom space is used next to the WC for taking showers in most rural houses of this area due to the water piping system and increased hygiene per capita.	
	garage	The garage is a roofed space located in the service part of the courtyard near the entrance gate. This space has a door in garages where agriculture vehicles and devices are kept.	
	Oven house (Tandour)	The oven house is one of the important elements used in rural housing in Sistan, which has a unique architecture with a half-ceiling roof back to the wind blow preventing the oven fire from going out. The clay materials are used in the construction of the Sistani Oven, and which its architectural feature is highly matched with the climate of Sistan (120-day winds).	

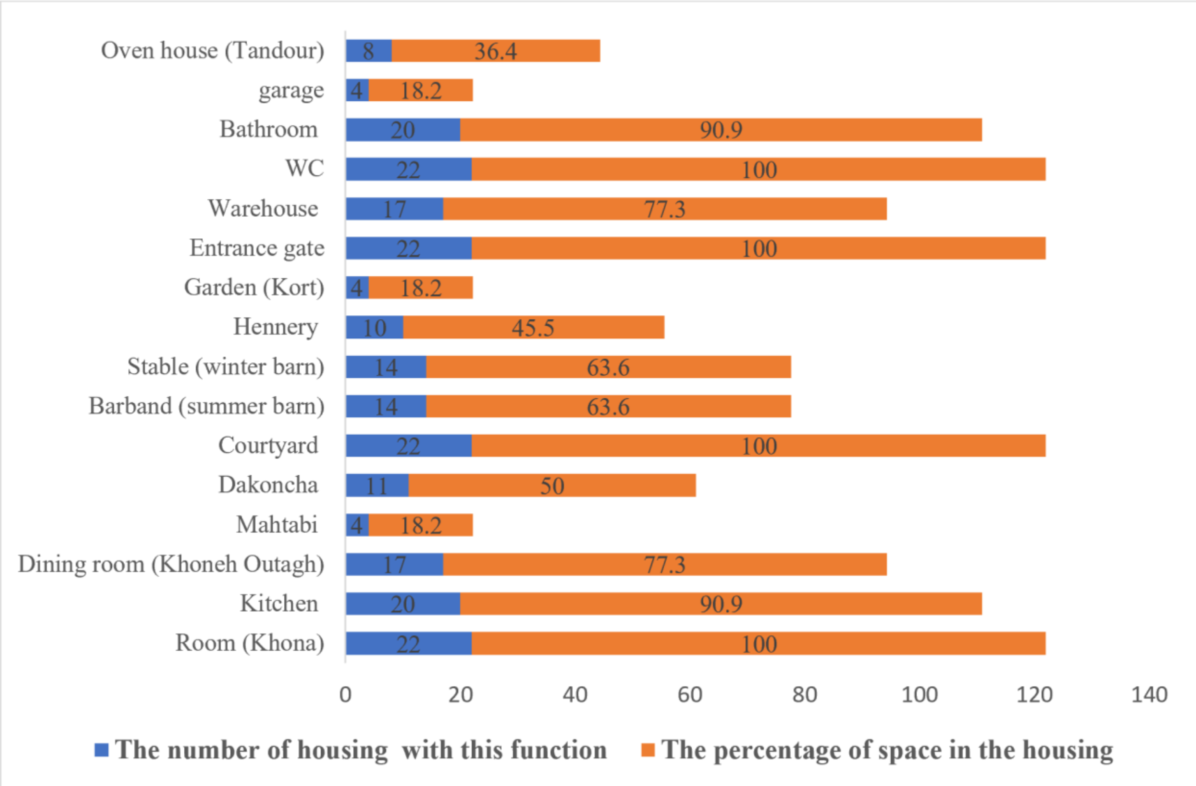


Fig. 5. Frequency (%) of spaces in selected residential types

Fig. 5 shows that room (Khona), entrance gate, courtyard, and WC are seen in all selected residential units followed by the kitchen and bathroom in living spaces and barn and stable with the highest frequency among service spaces.

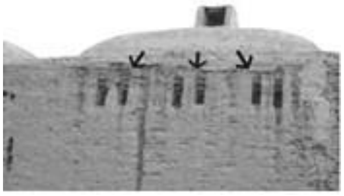
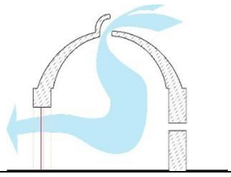
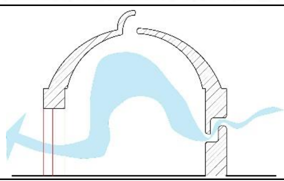
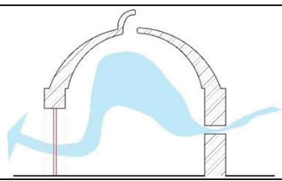
4.2. Climate analysis

Wind energy use, being protected against severe cold winds in winter, and shading in summer are the most important concerns of villagers living in this area demanding thermal comfort in the house [38]. This kind of housing depends on the natural conditions regarding the construction materials and architectural style, so they are constructed using natural materials available for the local people of Sistan considering the climatic requirements of the area, especially the wind [68]. Clay and mud are the materials used in the vernacular architecture of Sistan. According to the field studies on 22 housing types in the Sistan area, the most significant and effective issues in the climate of this area include using wind energy for ventilation, building Orientation, materials, and openings' position in the main directions.

4.2.1. The key architectural elements to use wind energy in selected housing types

Desired winds are used as a substantial solution to cope with severe hot weather in the area and cooling the indoor space [69]. Table 4 reports the key elements of Sistan's vernacular housing affecting the natural indoor ventilation of the house.

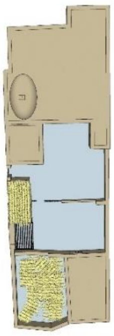
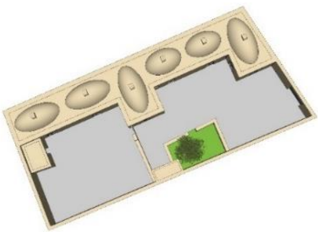
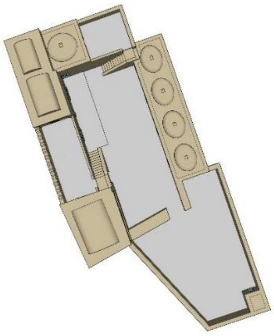
Table 4. Key architectural elements for natural ventilation in selected housing types [70, 71]

Kolak	**Sourak**	**Dorchah**
Kolak is the local term used for vernacular windcatcher in Sistan. Kolak is a rectangular protrusion built in the middle and upper part of the wind-facing dome: after the wind enters the Kolak and redirects inside it enters to indoor space of the house through a 20*20cm gate providing desirable ventilation due to the dome form of ceiling.	It is a kind of air conditioner with a 20cm width and 30cm height deployed in the wall of the northwest front. In this technique, an entry and exit airway is installed with a certain angle in the wall to break the wind force and enter the air into the indoor space reducing dust by decreasing the wind speed. The height of the Sourak gate from the internal floor of the room varies between 1 and 1.5m.	Dorchah is used in the wall of the northwest front to direct the wind flow directly from the outside to inside the room. This element plays a significant role in temperature reduction during summer. The dominant size of the Dorchah equals 20*20cm, and the bottommost Dorchah is placed within 60cm height from the room floor, so the wind contacts the human body in the best way when they are sitting.
		
		

4.2.2. Building Orientation

Building Orientation is one of the most important factors affecting the creation of housing thermal comfort. Table 5 reports the frequency (%) of building Orientation directions. The field data extracted from 22 selected types in this area indicate that building Orientation includes three north-south, northeast-southwest, and northwest-southeast directions among which, northeast-southwest Orientation has had the highest ratio with 73% frequency. This Orientation provides maximum use of wind energy is provided for most rooms existing in the house.

Table 5. Building Orientation frequency (%) in selected types

Building's Orientation	**North-south**	**Northeast-southwest**	**Northwest-southeast**
Frequency (%)	9	73	18
Image			

4.2.3. Construction Materials

In Sistan, construction materials are selected that are sufficiently resistant and match the climate of this area. In the vernacular architecture of this area, thick clay-made walls are used due to the low heat transfer rate of the clay that is proper for regulating the environmental conditions and preventing the cold and heat created in the space due to the long delay of these materials. However, field studies on selected types in this area indicate that mixed brick-clay materials have been widely used (82%) in these buildings. Moreover, clay-made materials were used in 9% of selected houses and brick-made materials were used in another 9% of houses because brick is more resistant rather than clay. Also, the final coverage of selected housing types in this area is thatch coating, which is a suitable material for thermal insulation in the climate of this area.

4.2.4. Location, number, and percentage of windows in selected types

The type of windows, their location, size, and materials are the most important and effective elements in adjusting the environmental conditions of the room. According to field studies on 22 rural housing types in Sistan, the highest frequency (41.5%) belongs to the windows deployed in the southeast front, which indicates the use of natural light to provide housing light. Also, the northwest front has the second rank of window frequency (38.9%); since the dominant wind of the area blows from the northwest, the mentioned statistics indicate that constructors of the selected housing types in this area have considered the use of wind energy for natural ventilation. It is worth noting that small windows with dorchah shapes have been used in the northwest front to prevent wind intensity (Table 6).

Table 6. Number and percentage of windows in selected types

Window's location	North	West	Northwest	Northeast	Northwest	Southwest
Number of windows	3	1	30	7	32	4
Percent	3.9	1.4	38.9	9.1	41.5	5.2

4.3. Analyzing the physical identity of types

In rural housing, house identity consists of some concepts and signs, such as color, texture, materials, dimension and size, form, indoor space relations, façade, mass and space, openings, etc [72]. There are some features and elements in the vernacular housing of this area that define its architectural identity distinguishing it from other areas. The domed ceilings and prominent elements, including the Mahtabi and Dakoncha have distinguished the physical identity of rural architecture in this area. Other elements that make the identity of the vernacular housing body of this area include color, furniture, geometry, and rhythm [73](Table 7).

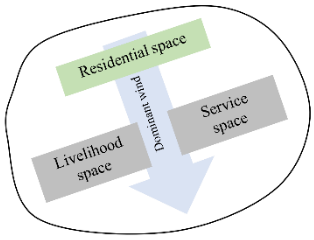
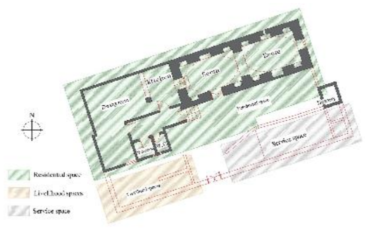
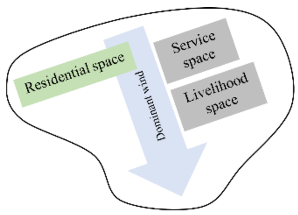
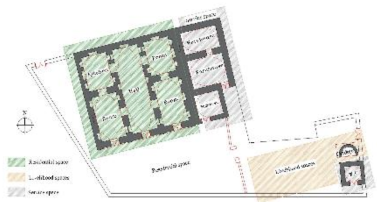
Table 7. The features and elements in the vernacular housing of this area

Color	The color of spaces' constituents determines the space quality in this area. The color can be seen in the additional elements, furniture, and decorations used in the housing of this area. The decorative elements are mainly seen as additional ones with diverse and bright colors in the housing of this area. Interior ornaments are more seen in the furniture, carpet, motifs on the curtain, and patterned colored pillows; these ornaments are inspired by geometric motifs, birds, flowers, and plants.	
Furniture	Spaces have simple and flexible furniture. In this area, carpet must be used in the space, so that the size of rooms depends on the carpet's size. In most rooms particularly in the guest room, hand-woven carpets of Sistan with diverse colors are used to carpet spaces, and cylindrical pillows and soft mats are used around the room for guests to lean on the pillow. The sewed curtains are used in front of wall windows.	
Geometry	In single-space scale, geometry is affected by the Sistani ceiling construction, size, and number of carpets. In the villages that experienced floods and earthquakes, the houses had prepared maps and a plan with certain geometric shapes; in contrast, in vernacular buildings in which space re gradually shaped regarding the power and need of the owner over time, the house has organic mode and general rule of wind energy use is considered.	
Rhythm	Rhythm appears when elements are repeated in the housing of this area; rhythm can be seen in elements of the ceiling, edge of the Dakonchah shelter, Mahtabi, and cymatium of buildings.	

4.4. Analyzing spatial relations of types

Deployment and connection between residential, service, and livelihood realms are substantial cases used in analyzing the spatial relations of the selected types. In Sistan, 120-day winds have a considerable effect on forming the body of the rural residential units in this area [34]. These winds blow into the residential unity, pass through the living realm, and provide requirements for wind energy use to create natural ventilation in the living realm[68]. In studies, types, deployment, and connection between residential, service, and livelihood realms included two different types (Table 8). In 64% of selected residential types, living realms are deployed in the north front of service and livelihood reals regarding the wind direction. In the remaining 36% of types, living, livelihood, and service realms are located next to each other concerning the dominant wind of the area. In some types, living, service, and livelihood realms are deployed on two floors (the living realm on the upper floor and the service and livelihood reams on the bottom floor).

Table 8. Deployment of residential, service, and livelihood realms in the vernacular housing of Sistan

Row	**Descriptive expression**	**Frequency (%)**	**Graphic expression**	**Case study**
1	Regarding the importance of using the 120-day winds of Sistan, the living realm is deployed in line with the dominant wind, and service and livelihood realms are deployed next to each other under the living space.	64		
2	In this case, living, livelihood, and service realms are deployed next to each other in line with the dominant wind, and in some other types, the living realm is located on the upper floor above the service and livelihood realms.	36		

Since living spaces are the most important realms in rural housing, it is necessary to analyze the relations between living spaces in these buildings. Regarding the field observations and examinations done on 22 housing types in Sistan, three types of arrangements are seen in living or biological space, which are reported in Table 9. According to this table, the highest frequency belongs to those types in which, rooms are reaching the courtyard through a middle room despite the direct connection from some rooms to the courtyard.

Table 9. Diversity in the connection between living spaces

Row	Descriptive expression	Frequency (%)	Case study
1	In this type, living rooms do not have an internal connection but are connected through the courtyard. According to field studies, this kind of living space connection is just seen in the vernacular housing of Sistan and mainly for linear and L-shaped types.	18	
2	In this type, rooms have a door that directly reaches the courtyard and sometimes, two rooms have an internal connection, so energy loss is less in such housing types rather than in the first type. Field studies show that the highest frequency belongs to this type.	59	
3	This housing type often includes the selected newly-built houses that have a direct space called a hall in the door of other rooms that are opened to this space. In most housing types of this type, the dining room has a direct connection with the courtyard in addition to its internal connection through the hall to create privacy.	23	

5. DISCUSSION

This study considers the post-crisis reconstructions in the Sistan area. the comparison between this study and post-crisis renovation samples in other areas shows that post-crisis housing reconstruction has been successful in some places and unsuccessful in other areas.

A severe earthquake in the in northeastern Peru destroyed more than 3000 houses in 1990. For reconstruction, the improved Indigenous quincha technology was selected as a resistant strategy against earthquakes. All reconstructed houses remained undamaged in the next earthquakes. This reconstruction was successful due to improved indigenous technology in construction and public participation in the reconstruction process [74].

The Gujarat earthquake in 2001 was one of the most destructive earthquakes in India, which led to extensive destruction, and two approaches were used in its reconstruction. The owner-driven Reconstruction approach was relatively more successful because it allowed residents to construct their houses based on their needs, native knowledge, and cultural identity. On the contrary, Contractor-Driven Reconstruction, which was implemented by foreign organizations was less successful because imposed the climatic features and lifestyle of local people, modern housing, and urbanism patterns. This case led

to social non-acceptance, exploitation challenges, and even reduced structural sustainability in some cases [75].
In 2004, a tsunami caused widespread destruction in the coastal communities of Tamil Nadu, India. However, many vernacular houses that were demolished and replaced were actually repairable, environmentally sustainable, affordable, and more comfortable than the new houses built by external agencies. The reconstruction in this region is considered unsuccessful due to the lack of understanding of the socio-cultural and environmental context [76].

Reconstruction after the 2006 earthquake in Lorestan, Iran that led to 100% destruction in many villages was along with major changes in the structure and materials of housing. In this process, the roofs of Indigenous houses that were usually constructed flat with wooden beams and thatch coating and were appropriate insulation for housing were replaced with gable ceilings with metal coating. In addition to climate inconsistency, these roofs changed the appearance of villages. These changes not only destroyed the identity of indigenous architecture but also led to the incompatibility of new buildings with the climate and local lifestyle [77].

Examination of these four cases indicates that successful reconstructions have been based the local participation, the use of indigenous materials, and understanding the social and climatic needs, while unsuccessful reconstructions have occurred due to imposed non-native models, inattention to traditional knowledge, and noncooperative approaches. Reconstruction experiences after the flood in Sistan confirm that inattention to indigenous knowledge, and public participation in construction have made villagers not accept the house, so some measures must be taken to enhance the quality of life regarding the indigenous architecture of the area. Thus, this paper has formulated design regulations and requirements in rural housing to improve the living space by studying indigenous architecture. These requirements are presented in four parts herein.

5.1. Results of analyzed function of spaces

Following are the results obtained from the analysis of spaces' function in Sistan:

- Room (Khona) provides various functions and is functionally flexible in rural housing of Sistan.
- Culture is one of the important factors affecting the space architecture, so Qibla is perpendicular to one of the wall surfaces in the selected housing types, and the deployment of WC space, dining room, and ornaments used in the housing follows the culture of occupants.
- Courtyard exists in the form of an enclosed space with a certain and defined entrance gate in all (100 percent) selected types.
- Mahtabi or Dakonchah space exists in more than half (68.2 percent) of selected housing types. These spaces are highly important in housing, so they are considered significant spaces for vernacular architecture in this area.
- The space designed for guests is highly substantial and often has a door independent from outside in addition to its internal access.
- WC and bathroom are mainly constructed in the courtyard far from the living rooms and outside it.
- Many structural elements are seen in the courtyard or surrounding environment of the housing, including the warehouse (77.3 percent), Barband (63.6 percent), Oven House (36.4 percent), garden (18.2 percent), Hennery (45.5 percent), and roofed stable (63.6 percent).

5.2. Results of analyzed climate conditions

According to the observations and examinations of the vernacular housing in this area, it is concluded that:

- Wind energy is considerably used in the vernacular housing of Sistan more than other climatic factors.
- Window size varies in different walls based on the climate of the area. Most windows are deployed in the southeast front of the area (41.5 percent). Those windows deployed in the northwest front (the direction of the dominant wind of the area) are small to achieve higher efficiency and yield of wind energy. These windows are fully closed during winter.
- The thatch coating is the final coating of selected housing types in this area since it is a proper material for thermal insulation in the climate of this area. The materials used in the walls and ceiling included clay in the past, while new materials such as brick are now used in combination with clay due to the higher strength and numerosity of brick (In 82 percent of rural housing).
- The Orientation direction of buildings is often (73 percent) northeast-southwest, and its main front is southeast-facing. Regarding the 120-day winds blowing from the northwest, the rooms' doors are deployed in a wind shelter which is mainly located in the southeast front.

5.3. Results of analyzed physical identity of types

Elements that make the physical identity of buildings located in Sistan mainly comprise color, furniture, geometry, and rhythm. The results of this analysis are reported herein:

- Hot and bright colors are common in the culture and architecture of this area.
- Indoor furniture in the rural housing of Sistan is seen in different forms of indigenous carpets of Sistan, cylindrical pillows, and sewed curtains.
- Geometric discipline in the plan of rural housing in this area by consideration of the carpet module and the regularity in the furniture arrangement, and more importantly the order seen in the thatch façades are the most prominent signs of the housing types in this area, which create harmony in the overall appearance of the villages in Sistan.
- The rhythm used in the housing types of this area is seen in elements of the ceiling, edge of the Dakonchah shelter, Mahtabi, and cymatium of buildings.

5.4. Results of analyzed spatial relations of types

Following are the results of analyzed spatial relations in the housing types of Sistan:

- Livelihood and economic conditions have a direct effect on the quality of housing. It means that the quality of the buildings, size, number of spaces, and quality of materials are higher in the areas with better economic status.
- In terms of living, livelihood, and service area adjacency, the living area has been located in the northwest or north of the residential unit in all (100 percent) selected types. The service and living areas are deployed in a way that pollution of these spaces does not cause any disturbance in the living area.
- In 77 percent of housing types, the rooms not only have internal connections with each other but also have separate access to the courtyard. In the new housing types, however, the mass arrangement has been used and the rooms' doors are opened to the sitting room or hall, which plays the role of division space.

6. CONCLUSIONS

This study showed that rural housing in the Sistan area these days does not originate from the context and the decisions made on rural housing by the government have only considered the strength regardless of other cultural and social aspects in housing design. This study conducts field investigation on 22 different rural housing types in this area and also analyses four items of space function, climate, physical identity, and spatial relations of the types based on the descriptive-analytical method. The results of this study contribute to guidelines and requirements of architectural design, which improves the quality of rural housing in the Sistan area. This method has been done on the plan platform and context, so can improve rural housing in other similar climates. The Architectural design criteria and requirements for rural houses in Sistan region have been mentioned herein:

• Functional criteria and requirements:

- Since mass space is located in the northwest part of the land in all studied cases (100%) in the Sistan climate, mass space must be placed in the northwest of the land and a courtyard must deployed in the southwest part to construct new rural houses in empty lands to keep the mass and space fabrics of the village.

- To revive prominent vernacular elements, the important indigenous spaces such as Mahtabi and Dakancha that existed in 68.2% of studied houses must be also used in the design of new housing.

- Since the guest room had a separate door towards the courtyard in 100% of studied cases due to the culture of guest welcoming in this area, this principle must be also considered in the design of new houses.

- It was observed in the studied cases that the dominant culture of people living in this area is the design of WC and bathrooms in the yards of houses; therefore, toilets and bathrooms must also be built in the yards of residential units in new rural houses.

• Climatic criteria and requirements:

- To use wind energy for natural ventilation in the hot climate of Sistan, the building elongation must be northeast-southwest so all rooms can benefit the wind energy because the dominant wind in the Sistan area has directions from northwest to southeast. In 73% of studied cases, rural houses had northeast-southwest elongation.

- Windows deployed in the north of rural housings (north, northeast, and northwest) that are directed towards winds of the area have small sizes and their average size equals 20*20cm according to the field observations.

- Because furnaces exist in this area and the emphasis is on using indigenous materials in sustainable and climate-friendly architecture, brick materials must be used in new houses due to their strength rather than clay.

- Vernacular architecture elements applied in the past to use wind energy can be revived in the new rural housing.

- Regarding the dry climate of the area, proper vegetation that is matched with the climate can be used in the open space of the courtyard to create moisture and shading.

- Only in 1.4% of studied houses, the window is located in the western front; therefore, it is not recommended to build a window on the west side due to annoying light.

- The thatch coating can be used for the external façade because it has a bright color and absorbs less heat.

● Physical identity criteria and requirements:

- Regarding the importance of physical identity in buildings of this area, living spaces square-shaped or rectangular can be carpeted.
- It should be implemented to use rhythmic elements adopted from vernacular architecture in new constructions and on the edge of shelters (Dakonchah, Mahtabi, and cymatium).
- As indigenous decorations and bright colors are seen in the physical identity of villagers in this area, these elements can be used in the interior architecture of buildings.
- It is required to pay attention to the beauty of the façade in rural houses especially aesthetical indigenous and vernacular criteria in housing design.

● Spatial relations' criteria and requirements:

- Since living arenas existed in the northern front of land in 64% of sampled cases, the living arena must be deployed in the northern scope in the design of new housing in terms of adjacency of residential living, and service arenas in one piece of residential land due to 120-days winds blowing in Sistan. This deployment prevents pollution in service and living areas from disturbing residential areas.
- In 77% of studied houses, every room has direct access to the courtyard which is rooted in the culture of residents living in the Sistan area. Therefore, rooms must have direct access to the courtyard as much as possible in the design of new rural houses.

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