



INDICATORS OF SUSTAINABILITY IN VERNACULAR SETTLEMENTS HOT DRY REGION OF IRAN, [CASE STUDY: KERMAN-MEYMAND]

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ABSTRACT

Nowadays, sustainable development theory is one of the most challenging subjects in urbanism field. Old settlements have strong relationship with their environment. Vernacular settlement can provide suitable patterns of sustainable existence, which has been created from generations' experiences completion. It has the lowest damage to natural system by intelligent usage of natural presents. Warm and dry areas have special climatic features. settlement of such areas were positioned and constructed based on special principals which were consistent with environmental features and ecological capabilities. These settlements are consistent with natural texture and site ecology and capabilities. It not only imposed no destruction on their environment, but also beyond that, play it's role as a perfection reaching agent for material. the goal of this paper is investigation of persistence indexes of vernacular settlement in warm and dry area. This paper first has a brief review on persistence concepts and following that on sustainable urbanism and urban persistence indexes and after that describe climatic and geographical features of Iran's warm and dry areas, after that Meymand (as a case study) is analyzed with morphological approach.

Keywords: Underground settlement, Vernacular, Sustainability, Morphology, Hot-dry area, Meymand.

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Contribution/ Originality

The paper contributes the first morphological analysis of vernacular settlement in hot- dry area to reach sustainable indicates.

1. INTRODUCTION

Human being has faced different problems such as increased environmental pollution and destruction of natural resources of the city and farness from nature. During evolution of human settlements, there was balance between human and nature by the nature itself. In the primary stages of city dwelling, the man refused to change and destroy nature because he regarded that resource as his survival origin. This balance has lasted for long time until he lost his balance with rapid progress of technology and consequently increases of city dwelling. For this purpose, we can achieve effective strategy for solving this problem by recognizing concept of sustainability and indices of a sustainable city.

1.1. Compilation of Basic Concepts until Formation of Indices Meaning of Sustainability

Sustainability generally means a set of conditions which lasts over time and sustainable development means a route in which welfare and life quality optimization doesn't lead to decrease of welfare for the future generation (Navabakhsh and Arjomandsiahpush, 2010).

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Definition of sustainable development by Bertland Commission can be accepted as comprehensive definition. On this basis, humanity has ability to make his development sustainable meaning that he can meet his urgent needs without damaging ability of the future generation to meet his needs (Navabakhsh and Arjomandsiahpush, 2010).

Sustainable development means fulfillment of essential needs, improvement and promotion of life quality and management of biosystem. For this purpose, the following principles shall be observed in order to achieve it:

- Applying and making recyclable resources sustainable or those which are recyclable
- Optimizing use of unrecyclable resources or minimizing consumption of natural resources with regard to their natural growth
- Minimum production of wastes and pollutions which can be absorbed in local and global scale and capacity.
- Creating a sound environment for the future generation and fulfillment of essential needs of the human being and society

With regard to these views, sustainable development can be studied in three aspects of sustainability in natural resources, social sustainability and economic sustainability (MofidiShemirani, 2009). One of the ways which can be raised in ecological sustainability is morphological recognition of the city and we can make judgment about its sustainability by studying morphological constituent parts.

1.2. Sustainable City

In fact, sustainable city is harmonious with nature and we regard it as part of nature which is developed on the basis of nature. Sustainable development is an ecosystem, a dynamic and complex place which can't violate different natural and unnatural laws (Tabibian, 2009). A city will reach sustainability when its environment is not damaged and its limited resources are not destroyed (Navabakhsh and Arjomandsiahpush, 2010).

2. MORPHOLOGICAL STUDY AND ANALYSIS

As mentioned above, one of the ways of studying ecological sustainability of settlement is its morphological study. Urban morphology is study of form of the biological complexes. Morphologists show that biological complexes can be studied in terms of some key elements (Caremona *et al.*, 2010).

Conzen, father of Anglo-Saxon urban morphology classifies parts of urban morphological systems as follows:

- 1- Plan of the city (including site, streets, and accesses and plot pattern of blocks)
- 2- Building texture (three-dimensional form)
- 3- Use of land and building

2.1. Sustainability Indices

Cities need a series of indices in order to achieve ecological sustainability so that we can indicate their sustainability while comparing them. Any city has indices with regard to its power and ecological bed capacity which is the most important and we should notice its essential indices. These indices can be mentioned as follows with regard to morphological division of Conzen :

Main plan of the city (including site, streets and accesses, plot pattern of blocks)

- Site (respecting for bed and topographical lines of the land, organic texture, environmental considerations, safety considerations)
- Access (respecting access hierarchy, access, encouragement to implement the plan, decrease of route, design of movement routes in order decrease environmental effects)
- Plot pattern (increase of social interactions, design of parts for decreasing environmental effects, failure to break social classes)
- Building texture (protecting historical buildings, use of recyclable energies, attention to human scales)
- Land use (compacted urban texture, variety of land use)

2.2. Specifications of Hot and Dry Climate

Iran is located between 25 and 40° in northern latitude in hot region and total height of the sea level is below 475 m which constitutes limited percentage of total country. On the basis of Coupon method, Iran has been divided into four climatic regions:

Moderate and humid climate (southern coasts of Caspian Sea), cold climate (western mountains), hot and dry climate (central plateau), hot and humid climate of southern coasts)

In this climate, these winds lose most of their humidity while passing large continents due to wind blowing from southwest to northwest. In addition, air is hot and dry due to movement from upper parts of atmosphere.

Direct sunshine in these regions is severe and produces 700 to 800 kilocalories of energy in each hour in square meter. At most times, year is cloudless but mist and dust are produced in the afternoons due to hotness and movement of air layer close to the earth. Low humidity and lack of cloud in sky causes to increase temperature changes range in these regions and reach 15°C (Kasmai, 2007).

- Low rainfall and humidity
- Very low vegetation
- High temperature difference between day and night
- Winds with dust (Tavasoli, 2002).

3. INTRODUCTION OF MEYMAND SETTLEMENT

All over the world are different underground settlement which has manifested one of the best examples of sustainability in terms of sustainability and harmony with nature. Ancient biological centers can be identified as example of these sustainable settlements which have survived for long term. Meymand is located in hot and dry climate as underground settlements. Main structure of this settlement is based on rock architecture. Its buildings are located in underground. Meymand settlement with area exceeding 420 sq km is located in 35 km of northeast of Shahre Babak in Kerman Province (National Geography Organization of Iran, 2000) (Fig1) This village is located in semi-desert region and has hot and dry climate. This highland village has created a suitable place inside the mountain due to its surrounding by the mountains.

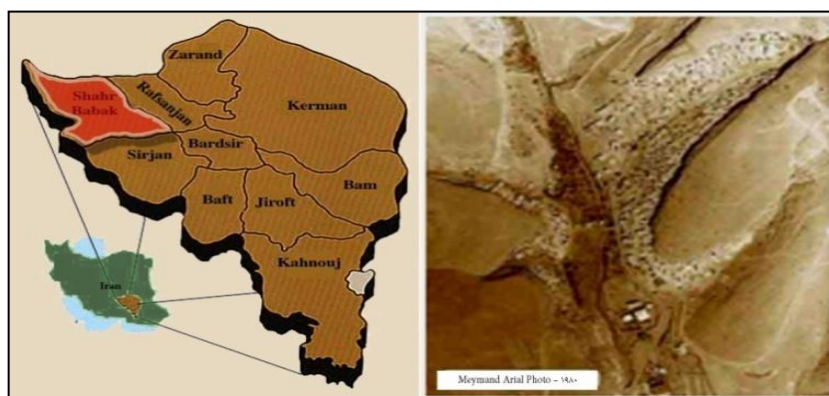


Figure-1. Location of Meymand in Iran

Source: NGOI (1995)

3.1. Morphological Study and Analysis of Meymand

With regard to classification of three urban plans branches and models of separating blocks, building texture and body, land use and their relationship with sustainability, we study morphology of Meymand village and sustainability of its elements:

3.2. Urban Plan

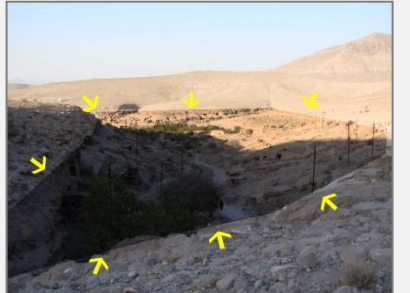
The primary general plan is expression of city and support of urban texture and its gradual formation indicates site and history of city. Although it is changing, it is regarded as one of the most sustainable urban form elements (Allain, 2010). In any city, there are two plans, general plan which manifests major lines of the city and partial plan which is analyzed in district scale (Allain, 2010).

3.3. Site

Of the determining factors of spontaneous sites formation are requirements and limitations of the site. Site is an important part of main form of the city (Allain, 2010). Sites which face restrictions help the human being imagine and reach valuable adjustments and compatibilities which cause identity and benefit of a district or a city. Sites are regarded as sustainable and determining element with regard to natural status, running and stagnant waters and vegetation of plants. On the other hand, site can indirectly determine major lines of urban texture.

In Meymand village, the primary settlement has resided in mountain range due to natural position of the region and special form of ruggedness. Surrounding rocks of this village have fitted buildings of this village in 4 or 5 levels as bedrock. Following the topography of the region, location in two sides of the valley and enclosure by the surrounding mountains caused to decrease undesirable climatic effects of the region on texture of the village. On the other hand, location of buildings in the mountain causes to minimize the penetrating heat with help of more thermal capacity of the earth and high internal volume in comparison to the surface exposed to shining and decrease thermal exchange between the inside and outside with use of the earth average thermal conditions and location in the earth (Shakibamanesh and Ghorbanian, 2010).

Table-1. Analyze of Meymand Site

| | Analyze | picture |
|------|--|---|
| Site | <ul style="list-style-type: none"> -Surrounding by the mountains for control of undesirable climate conditions -Appropriate orientation for decrease undesirable climatic effects -Following the topography of the region -location of buildings in the mountain for minimize the penetrating heat with help of more thermal capacity of the earth |  |

Source: written by authors

3.4. Accesses

Urban plans are affected by access axes. These axes are affected by highlands and lowlands and surface waters (Allain, 2010). Specifications of these highlands and lowlands determine direction of the roads (parallel or vertical roads in order to prevent erosion and water drainage) (Allain, 2010).

Movement system of Meymand village is based on two roadway and way axes. Roadway system has no role in the village and Pedestrian way system has more dominant role. In Meymand, passage routes have been gradually formed on the basis of passage of the habitants and road way is located in direction of texture extension (Northern and Southern). pedestrian way is studied in two surfaces of public and semi-private pedestrian ways. Public pedestrian way has been formed in levels of range and in direction of topographic lines of the ground and plays role of directing running waters and undesirable wind out of the texture. This route is harmonious with the texture and coordinates itself with the texture conditions and has been formed as public space in order to have access to levels and classes. Second level includes pedestrian ways of semi-private and semi-open routes opposite to houses which are called alley. Width of the alley is about 1 m and its length is about 9 m and width of the end of alley which is

linked to hall is about 2.5 m (Shahshahani and Rouhi, 1996). These dimensions have been embedded vertical to lines of the ground level in order to penetration of undesirable wind and have access to suitable height. In study of general texture, the number of alleys decreases gradually by moving from main direction of the texture to upper direction of the range and few alleys are found in joint place. (Fig 2).



Figure-2. Location of Alley (kiche) in Meymand

Source: Taken by authors

Table-2. Analyze of Meymand accesses

| | | Analyze | Picture |
|----------------|---|--|---------|
| Road way | | Orientation to the original structure of texture Direction South to North | |
| pedestrian way | 1 | Direction to topographic lines of the ground Directing running waters Directing undesirable wind out of the texture Used as public space | |
| | 2 | Observance of human proportions Climate considerations Element to achieve the proper height located vertically to topographic lines of the ground | |

Source: Written by authors

3.5. Plot Pattern

Plot pattern is result of land separation in small and large plots for construction and urban development and indicates personal ownership and socio-economic structure of the period (Allain, 2010). Position of the building, relations and its size and specifications and even type of material and construction techniques may be affected by social dignity and position (Haji, 1996). On the other hand, pedestrian ways are affected by topography and direct distribution of plots. These plots are vertical to the route and lead evolution of urban development (Allain, 2010). Plot pattern is durable but it can change over time (Caremona et al., 2010).

In Meymand village, all houses are private and about 2 meter of the alley (Kiche) belongs to residents. With regard to living and residence style, social organization and social kinship are part of rural society. Rural societies were composed of master, headman of village, agent, farmers, and squatter. In this village, house of the headman is

larger and more distinct than other rural houses in terms of location, access to water, suitable landscape, and even security and size (Allain, 2010). Due to limitations of the village development and limited population of the village, there is no such plot pattern in this village. In Meymand village, there are different tribes each with special districts and naming of this village is due to reliance on geographical place and tribes in which they lived. These districts include:

- 1- Kalaghiha district (Hossein Ahmadi) in southwest of the village ,
- 2- Geda district (Khalil) in west of the village ,
- 3- Kahoor Boneh district in southwest of the building ,
- 4- Zeinodini district in north of the village ,
- 5- Patgh district in northeast of the village ,
- 6- Meymand in northern part of the village ,
- 7- Posht Kamar in northern side of Meymand.

Plot pattern of houses in this settlement is located vertically to topographic lines of the ground and this direction prevents penetration of rain and confrontation with undesirable winds. These houses are located adjacent to each other to form compacted texture. This location decreases heat loss and temperature fluctuations.

4. BUILDING STRUCTURE

City includes plan and a volume of buildings and public and private spaces which have been known or unknown. Building structure consists of the buildings which are specified with antiquity, style and height as well and empty urban spaces or public spaces (squares, parks, gardens etc). Building texture (full) consists of all kinds of residential or functional houses which can be identified through their architecture.

4.1. Relationship between Mass - Space Places

Relationship between the made and unmade surfaces, relative order of the volumes and their distance are of the key variables of the urban view (Mngali, 2006). Empty and full spaces of Meymand with such architecture are not distinguished because architecture has no specified border and limit due to full spaces and Meymand can be regarded as full space from which spaces have been reduced (Allain, 2010). (fig 3)

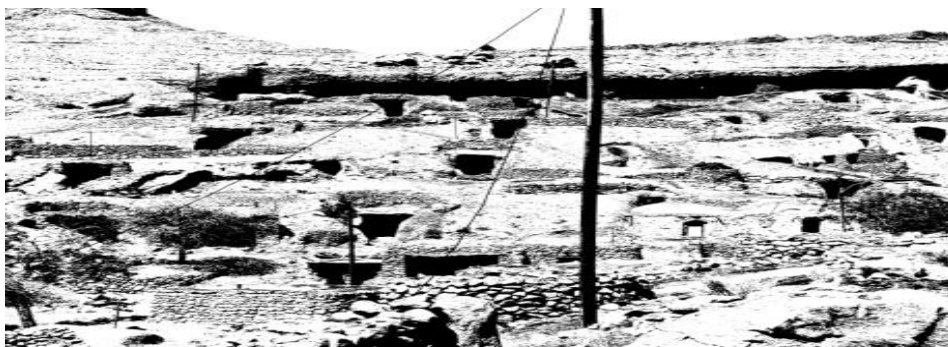


Figure-3. mass - space elevation

Source: Taken by authors

4.2. Urban Silhouette

urban silhouette is created due to average height of the buildings which form a carpet of the ceilings (Allain, 2010). This village is harmonious with topography of the region due to its special location. Generally, these buildings are located in 4 to 5 levels in one story and in mountain range. This harmony between buildings caused to form a compacted and integrated texture and extended skyline which is in harmony with its surrounding environment. (fig 4)



Figure-4. silhouette

Source: Taken by authors

4.3. Historical Monuments

Urban texture is spotted with public buildings. The buildings are specified in terms of size, landscape and function and have infinite variety. Monuments help identity of the city and have effect on the adjacent texture. In addition to rock houses, bathroom, school, Hoseinieh, temple and water mill are found in Meymand. These buildings have been handmade and have architectural specifications of the rocks. Some of these buildings have lost their efficiency due to bathroom and temple due to antiquity or loss of the past functional value and are regarded as museum. Of the spaces which are used as monuments and urban spaces are mosque and Hoseinieh which are located in middle of the village.



Figure-5. Historical Monuments

Source: Taken by authors

4.4. Building System

Buildings of the cities reflect geographical variety of small regions. Set of elements (structure, shell, walls, ceiling, material, etc) and their sequence have special combination which determines type of architecture (Bariassoulis, 1994).

In this settlement, roof of a house is floor of the upper story due to static issues. Alley and upper story units are not in the same direction with their lower units. In most houses of Meymand, openings are shorter than 5 m and the longer ones are found in some houses and mosques and Hoseinieh. In houses with short opening, ceiling of the houses has no arch or has low creep. This creep creates propulsive force which is repulsed by thick rock tides. Height of these buildings is at most 2.5 m. decrease of height in houses of Meymand decreases moment of some forces in the building. In some places such as bathroom, rock columns in middle of the ceiling due to its long opening help transfer dead load of the ceiling to the ground. But in some places such as bathroom, main courtyard of the bathroom has arched ceiling which has been created inside the mountain. Constituent materials of the house are gravels which have been brought there from the surrounding. Meymand village has one view with regard to

location of building in the mountain and compaction of the texture. Portal of the house is regarded as the only entrance door of the buildings and the space receives its light from this door and there is no window for ventilation. (fig 6)



Figure-6. Building system

Source: Taken by authors

4.5. Use of Land and Building

Land use is affected by two components, firstly: needs of the human being and secondly: biological specifications and processes. Land use is the method in which the human being started using the land and its resources for the related purposes (Caremona *et al.*, 2010). Sustainable land use is raised for supporting natural resources and maintaining resources for the present and future with optimal use of the land and incurring the least damages on unrecyclable resources. Uses relate to elements which are rarely modified but they are temporary in comparison to other buildings uses and change over time (Ebrahimi, 1996).

Land uses in Meymand settlement include residential and trading, religious and administrative uses. Its dominant use is residential. These land uses are located on the basis of gardens and farmlands. Religious land use in Meymand is limited to mosque, Hoseinieh and temple. Location of mosque and Hoseinieh adjacent to each other and in center of the texture gives identity to texture and public place in it. One of the other dominant uses is Meymand old bathroom and function of this bathroom is in district scale and all principles of design and spaces in this scale have been observed in terms of design structure (Haji, 1996) In study of compaction, Meymand settlement has compacted and fine texture and this compacted texture helps confront with the harmful winds and minimize thermal exchange between the internal and external space of the buildings (Haji, 1996). (fig 7)

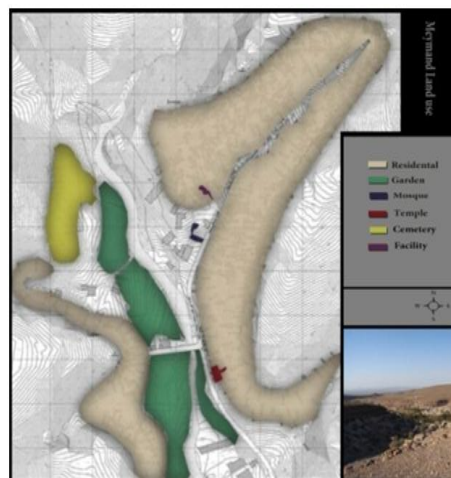


Figure-7. Meymand land use

Source: Mngali (2006)

5. CONCLUSION

Table-3. Meymand morphological analyses based on sustainable Indicators

| Morphology indicators (Conzen) | | Ecology sustainable Indicators | Morphology Analyze of Meymand |
|--------------------------------|---------------------|--|---|
| Urban plan | Site | -Orientation to the original structure of texture -Organic texture -Environmental consideration - Security consideration | -Settlements located in the hillside -Surrounding by the mountains for control of undesirable climate conditions -Located in 4 to 5 levels in mountain range -High internal volume to surface exposed to sun light |
| | Access | -Respect the hierarchy of access -Encourage pedestrian -Reducing the path length Path design to reduce the effects of climate | -The dominant role of pedestrian way Direction running waters with access |
| | Block Pattern | -Increased social interaction -Block design to reduce the effect of desirable climate -Association between social classes | -Sustainable block pattern -Private property -The same social classes -Appropriate orientation of block pattern -Composition of the continuous block |
| Building structure | silhouette | | Extend silhouette |
| | Historical monument | -Protect historical monument | -Protect historical monument such as bathroom, mosque, Hoseinieh, temple |
| | Building structure | -Observance of human proportions Use native material -Use renewable energy | -Small window and low high Meymand homes due to structural consideration and the environmental conditions -Use rocks and mountain masses Meymand as base of houses -Dimensions of the door with respect to the human scale -Use the base of mountain to reduce heat exchange |
| Land use | Density | Density texture | Density texture in Meymand |
| | Land use | Variety land use | -Protect traditional texture -Appropriate distribution residential and agricultural use -Com ability between adjacent land use -Emphasis on remarkable places in the center of texture |

Source: Written by authors

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