Analysis of Sustainablity patterns of stair stepped villages in northwest Iran Case study: Totakhaneh, the wonderful village

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Abstract— *Various factors impact on residential complexes as well as villages. These are called economic, sociocultural and environmental factors. Sustainable residential complexes have balanced among these factors. This paper is studying the stair stepped village named Totakhaneh located in east Azerbaijan, Iran. The paper is to answer the question - are mentioned factors balanced in formation process of village texture? Is Totakhaneh a sustainable residential complex? The investigation method is descriptive-analytic; data and information collected through fieldwork and library study. Finally, it was concluded that although nature has meaningfully affected on the formation of the village; however sociocultural and livelihood issues have been influential on major and minor decision-making processes and the village has been assumed a sustainable residential complex before accession to the modern life.*

Keywords— sustainability, village, rural housing, sustainable residential complexes, Bonab.

I. INTRODUCTION

Concept of sustainability has been highly regarded in recent years, and many developed countries have tried to approach successful models of sustainable development. A glance on vernacular architecture in different areas of Iran suggests our ancestors' prudence and wisdom in selection of material and form of building to save energy by constructing sustainable building. They have used minimum facilities to provide the most suitable existing conditions; to overcome unfavorable climatic and environmental conditions and to meet principles and fundamentals of sustainable design which is focused nowadays by architects and urban designers.

This paper is scientifically studying a wonderful village named Totakhaneh in east Azerbaijan, Iran. It is geographically located in an impassable mountain range overlooking a valley with original features of vernacular architecture; Totakhaneh has formed gradually in coordination with climate and vernacular properties. This paper is going to analyze influencing factors on formation of Totakhaneh, to evaluate its texture and skeleton rate of amenability to environmental and socioeconomic factors. Required information on Totakhaneh collected through fieldwork and library study. First part of this paper is introducing influencing factors on village formation. And then sustainability principles are studied; and finally, influencing factors on texture of the village are reviewed. According to the primary principles, in sustainable complex socioeconomic and environmental conditions of human life are focused.

This paper is going to answer the following questions: Except natural factors, are socioeconomic and cultural factors influencing on village formation? Have the three mentioned factors been balanced in formation process of village texture? According to the current definitions of sustainability, is Totakhaneh a sustainable residential complex? Objective of this paper is to achieve sustainability models of Totakhaneh for the development and reconstruction as well as development and reconstruction of other villages in Bonab area.

II. DIFFERENT VIEWS ABOUT INFLUENCING FACTORS ON FORMATION OF RURAL HOUSING

There are different influencing factors on rural housing formation. Also pundits have given different views in this regard. Those who believe on the effect of environmental factor have chosen a superior factor as the main framework; then they have described various types. The most important follower of this method is environmental determinisms. They recount natural environment as the most important formation factor of rural housing depending on exposed conditions of natural environment; and human being is trying to find solutions in order to cope or adapt with natural environment. Although they may assume other influencing factors in the process but non-environmental factors have very trivial effects on the process. For instance, on classification of different types of rural housing in Iran, there are many types of housing in geographical domains that include climatic domains as a variety substrate of different types of housing with tolerance. (Ghazal Raheb, 2015)

Amos Rapoport observed that climate is one of the influencing factors on housing formation, and house formation is a complex process that is not just dependent to one factor but many different ones, the complexity is comprehensible when effects of maximum number of variables are considered. (Rapoport, 1969) he believes that early man built housing as a shelter to protect himself against climate conditions and it is very important. also he observed that sociocultural factors play decisive role in formation of a house, then he said that for primary and farmer communities, house builders have specific needs and habits that are not rational in terms of climate such as religious believes; ritual necessities; self-glorification; social class and so forth. He gave various examples on areas with the same climate conditions where sociocultural factors have been resulted in many various forms of housing. Therefore, we cannot just assume the role of a decisive index in formation process of housing. On materials and construction methods of housing, he believed that people gradually mastered the techniques and methods of construction. According to another view, social factors and social norms are the most important classification operant of housing typology. Uni emphasized that house is a social concept and its nature is different based on social class; religion and concerning area. Based on comparative observations in India he observed that geographical factors have no crucial effects on type of house. He believes that sense of needs and requirements inside the house and outside of it is very different; then he observes that different sections of a house have specific social concept based on nature of people; social needs; and how to use it. (K.R.Uni, 1965)

Another approach considers livelihood of residents as main classification factor of housing typology. For instance, housing typology is classified in different types of housing such as agronomic housing, husbandry housing and farming housing and so on. But according to the problem solving approach, settlement selection is an important housing formation problem solving guideline that includes all skeletal and non-skeletal aspects influencing the human existence. Chosen solutions amended by mankind are original. This approach is routed in man's collective unconscious; and then the solutions are transformed to tacit knowledge or archetype that deeply influence on the collective unconscious. Hassan Fathi interprets this solution as tradition. He believes that this architectural pattern is more than just a specific architectural style while comprehensive and accurate architecture comes from a living tradition which is practically resulted from experience of several generation with a single problem. (Fathi, 1993)

He declares that the tradition is a way to release from many decision makings; and establishment of new traditions along with former ones prevents them to fade away; rural communities must necessarily protect the traditions as villagers' cultural guard. He believes that the villagers cannot evaluate unfamiliar styles. If they neglect tradition it may be disastrous. Intentional collapse of tradition in a rural community is a cultural murder and the architect is obliged to respect concerning tradition.(Fathi, 1993) although his view to concept of pattern is somewhat historical and process based. He believes that recognition of old architecture is helpful for restoration of a powerful tradition exudates from villagers' local inspiration; while the employers and skilled craftsmen must cooperate in this regard; he believes that the new project must transform plans of every house for compatible living style of residents. Their diverse transformation plans must indeed be purposeful. (Fathi,1993)Also, Christopher Alexander frankly observed that pattern is desirable for problem solving; he believes that pattern is objective in the world; it is an integrated combination of activity and space frequently repeated in anywhere and every time it seems slightly different. He believes that architecture has a pattern language; there are two sets like other systems; Patterns or symbols and combination rules of symbols. Patterns have a structure that demonstrates they are a combination of smaller ones. Rules are at the heat of patterns and explain that how they are created.(Alexander, 2002) Residence is a relationship with man 's Purposeful and conscious activity and vital functions such as livelihood requiremens, social behavior and personal life.

The relationship manifests fundamental concepts such as domain; and personally defendable space that require interference in environment and space development. (Lang, 2002) Despite multiple difficulties in the development of a similar system of influencing factors and impressed features of skeletal texture of villages we may consider natural and socioeconomic factors; including diverse secondary factors for explaining formation process and evolution of skeletal features of villages. Diagram 1 represents affecting factors on skeleton of villages.

Sustainable architecture challenge is related with finding a comprehensive solution for environmental consideration, meanwhile it is to achieve life quality and cultural; socioeconomic and comfort values. (WGSC,2004) we may search on objectives of sustainable architecture in relation to environment and energy: sensitive buildings to vernacular needs must be created; energy consumption must be reduced to the minimum level; indeed we must necessarily consider vernacular sociocultural content for implementation of environmental technology. Sustainability needs a continues progressive effort. It is impossible to improve and modify constructed environment without peoples' participation. Sustainability requires

compatible rules and regulations; consequently, it needs participation of communities through effective management of resources by focusing on equity. (Munier, 2005,5)

DIAGRAM 1- AFFECTING FACTORS ON SKELETON OF VILLAGES

III. SUSTAINABLE ARCHITECTURE

Concept of sustainable development is the result of increased awareness of global connections; increasing environmental problems, socioeconomic issues; poverty; inequality; and concerns about a healthy future for mankind. Sustainable development links socioeconomic and environmental issues strongly. (Hopwood et al, 2005:38-39)

Sustainable development emphasizes on environmental issues that is one of the three important domains. The task of architects is very serious and sensitive because they are up to 75% responsible for climate change either directly or indirectly.(Rogers,2005) Therefore, the architects must encroach the environment very cautiously. Sustainable architecture is proceeding for decades; and the architects have developed and proposed many solutions for crises and problems of sustainable architecture. (Gorji, 2010,92) thus, it is necessary to study old sustainable residential complexes. Previously we referred to influencing factors on formation of village skeleton; environmental, sociocultural and economic issues. All pundits mentioned their views on important factors of skeleton formation of village; according to the definitions, sustainable residential complexes must balance among environmental and socioeconomic factors. Diagram 2 has studied objectives of sustainable architecture and environmental issues.

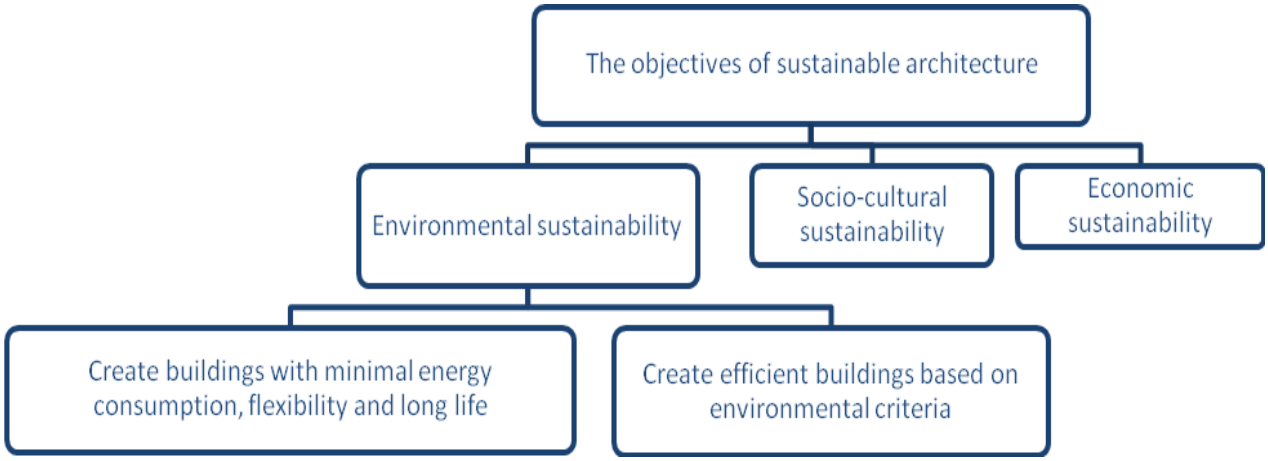


DIAGRAM 2- OBJECTIVES OF SUSTAINABLE DEVELOPMENT

IV. INTRODUCTION OF TOTAKHANEH, THE CASE STUDY VILLAGE

Totakhaneh is a sector of Bonab, the county in east Azerbaijan. The village is naturally surrounded by mountains and valleys. General slope of the village is from the east to the west and from the north to the south ; valley is located at the south of village. Buildings are constructed in reddish staire stepped structure compatible to the topography and red color of the area. (majnouni, 2014) all stair stepped villages of the area are similar to Totakhaneh and obtained investigation results are generalized to stair stepped villages of the same area.

FIG.1.TEXTURE AND ARCHITECTURE OF THE VILLAGE

V. CLIMATE OF TOTAKHANEH

We concluded that Bonab and Totakhaneh are classified as long season cold areas; mild and short summers where atmospheric fallout is higher than the national average. (Kasmaei, 1993) mountainous location of the village resulted in different climate condition according to reports of aerology stations in Bonab county.

Daily wind direction is from south to the north, and southwest to the northeast ; but during the night its direction is from north and the northeast to the valley. In summer, wind flow with evaporation of river water leads to ventilation and cooling of the village, therefore, the village is cooler than the Bonab county in summer. But in winter, the wind intensify the cold climate and it is very cold in winter. Generally, winters are very cold but summers are mild in this village.

TABLE 1
INTRODUCTION OF TOTAKHANEH

Location	Rural natural position	climate	Locations of buildings	The slope direction of the village	Wind direction
Bonab, East Azabayjan, Iran	Mountainous	Mild summers, very cold winters(kasmaei,1993)	On the hillside overlooking the South East	From north to soutn and from west to east	During the day from south to north and in the evening, from north to south

VI. TEXTURE AND ARCHITECTURE OF THE VILLAGE

General texture of Totakhaneh has the following features

- The village is located on hillside toward southeast.
- Its texture is very compact; the stair stepped village is harmonious with the slope.
- Most houses are sunk into the ground from the west and north and it is possible for them to be exposed to light from the east and south.
- At the northern parts of village, the houses are elongated toward north-south and in lower parts of the village are elongated from northeast to the southwest.
- Roofs are yard of neighbors' house.

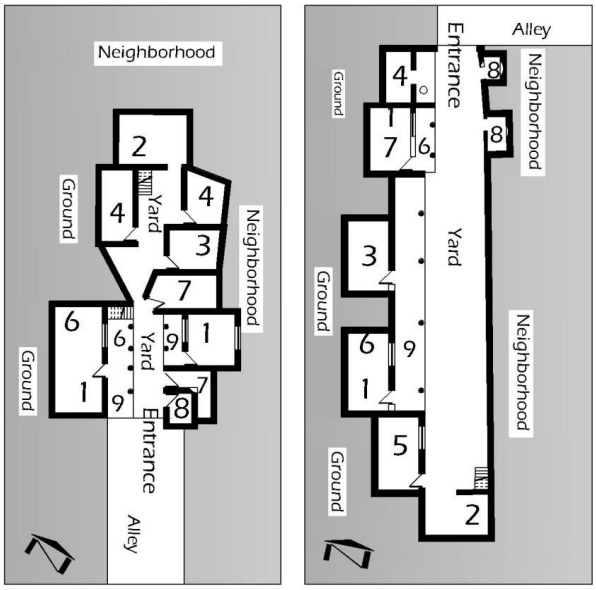
TABLE 2
SPACES OF TOOTAKHANE HOUSES

Living spaces include

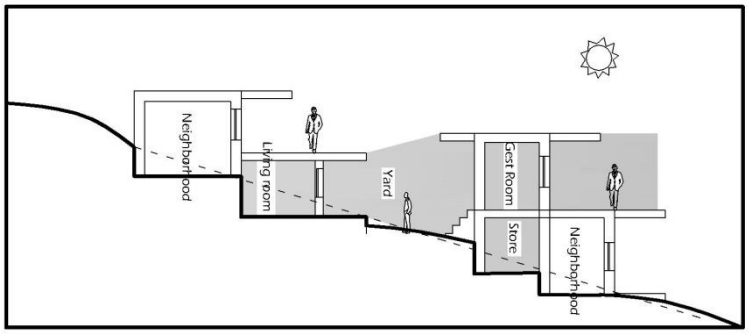
1. Living room; where there is an indoor cylindrical clay oven for heating of the living room in winter.
2. reception room: traditionally, people of the village are hospitable; family members work and live closely together in living room and usually, the reception room is located at the second floor to keep it neat and clean for uninvited guests.

Service delivery spaces include:

1. Stable
2. Hay loft, firewood storroom for wood heater
3. Carpet weaving workshop
4. Semi-outdoor and indoor rooms for cylindrical clay ovens for bread cooking.
5. Kitchen and dairy for storage and processing of animal products because in villages, the kitchens are not used just for cooking but for producing dairy and food products.
6. Bathroom and W.C
7. The Porch is for storing materials and goods in winter but for living in summer



Above Plans of two of the village houses



Above : The east-west section of one of the houses of the village, Gray colour in section shows territory belonging to a house.

VII. CHARACTERISTICS OF BUILDINGS OF THE VILLAGE

- Almost all houses have a central courtyard; the courtyards are elongated toward north-south or northeast-southwest depending to the houses; they are narrow and long.
- Porches are 2 meters deep for two reasons; views are inclined towards east and west; and the deep porch prevents light entrance to the building in summer; secondly, the deep porch prevents snowfall to the courtyard in winter when it is snowing heavily.
- Majority of buildings are one story in Totakhaneh; just reception rooms are built on the second floor on warehouse and service spaces.
- Rooms are linked to other interior spaces and land from the three sides. Majority of rooms are adjacent to outdoor spaces through ceiling and a view.
- Rural people have close working and living relationships; their living and working system is different from those of burgher. They subsist by keeping livestock, farming, husbandry and weaving carpets. Their working and living places are close together.

VIII. A SURVEY ON INSTANCES OF SUSTAINABILITY IN TOTAKHANEH

8.1. Impact Of Environmental Factors On Village Texture

Environmental sustainability is the most important aspect of residential complexes; diagram 2 indicates that environmental sustainability includes two important aspects, namely construction of efficient buildings based on environmental regulations and construction of buildings with minimized energy consumption; flexibility and long life. Figure 3 illustrates a section of rural building that is built compatible to the slope of the area with minimum change in rural nature; Table 3 represents cooling and heating procedure of the buildings of village before gas entrance to the urban area. Rural people of Totakhaneh used passive methods for thermal comfort.

TABLE 3
PASSIVE METHODS FOR THERMAL COMFORT IN TOOTAKHANE

Passive Heating Methods of Tootakhane Village					
Ground source heating helps to heating of the building due to the mass effect[2]	Alongate in north-east to south-west direction compatible to mountain slope for best use of sunlight	Use of high thermal mass materials in buildings[3]	Prevent heat loss by creating two-skin ceilings, and small windows	living room is adjacent with insulation spaces such as animal stable and wood store	Use the heat of cylindrical bread cooking oven for heating the living room in winter[2]
Passive Cooling Methods of Tootakhane Village					
Ground source heating helps to cooling of the building due to the mass effect [2]	South wind is used for cooling the buildings during the day	Use of high thermal mass materials in buildings[3]	Transfering of activities from inside to outside porches	Avoiding sunlight to inside the rooms via deep porches	Wetting down the yard in summer for cooling the house via evaporation cooling

TABLE 4
IS TO STUDY IMPACT OF NATURAL FACTORS ON VILLAGE TEXTURE

factors	Effective variable		The way of dealing with enviromental variables
Enviromental Factors	Flood		Formation of village on the hillside to prevent flooding
	Water sources		There are three water fountains in the village one for drinking , the others for livestock watering and agriculture
	Heavy snow		Orientation of the passages and yards along north-south direction let to sun light to melt the snow covered them, although low width of yard and deep porches prevent heavy snow fall to the yard
	Wind Direction		During hot days the wind flow from the bottom of the valley to the village with the river water evaporation help the cooling of houses and during the night the air is cold. wind flow is from mountain to the valley and doesn't involve buildings
	Slope of the village	the direction of village Slope	due to the slope of the village the houses in northern part of village are alongated in north-south direction but in the southern part the houses are alongated in north-east to south-west direction which is suitable for sunlight gain
		Create Perspective	Create tiered perspective
		Contact with the ground	because of the village slope the buildings are sunk into the ground and use the ground source cooling in summer and ground source heating in winters To create comfort conditions
		Maximum use of the land	some of the spaces like stores are sunk completely in the ground and their entrance is on the ceiling, due to the mass effect of the ground they have mild climate in summer and winter
		The effect of the Earth's slope on the spaces lay out	In the houses of the village, bathroom and w.c are situated down the slope for easy disposal of the waste and the reception room is situated at the top of the slope in second floor far Away from the noise and pollution from animal waste.
	Materials of the area		Native materials of the village are used in rural architecture, walls constructed with stone and thatch are plastered with red material obtained from surrounding mountains

8.2. Impact of sociocultural and economic factors on the texture of village

Not only climatic and environmental factors but also socioeconomic factors impact on the texture of village. Table five illustrates impact of sociocultural variables on the texture of village such as; religious factors and mosque; lodgment manner of different tribes and neighborhood and etc. Also impacts of economic variables on the village texture are generally analyzed. For example agriculture and horticulture impact on positioning of the village and formation of houses.

TABLE 5
IS ILLUSTRATING THE IMPACT OF NATURAL AND SOCIOECONOMIC FACTORS ON THE TEXTURE OF VILLAGE.

Factors	Effective variable		The way of dealing with socio-cultural and economicall variables
Sociocultural factors	relegion		placement of mosque in the main core of village and on the main route through the village for easy access of rural residents and foreign visitors to the mosque
	The way of tribes establishment		the village texture are divided to four zone because there are four tribes in the village which house in the zones
	Neighborhoods		.neibourhood connection is via ceiling to the yard because of stair stepped form of the village
	Locating public places such as schools and health centers and etc.		social places such as school and ... are placed in southern part of the village which has mild slope and near to the main road to easily access for the employees who come from out
	Interest in public life		even though there are numerous rooms in the houses of villagers, there are rarely personal bed room in the houses because of social life culture of the people.
	hospitality		due to hospitility of the village people, despite living the family in one room, in most of the village houses one or two room allocated to the gests.
	Weman's veil		Because the yards are in the view of neighbours, the village women have always veil.
	Rituals		Because of the high slope of the village, social events are held in the south of the village which has no slope.
Economical Factors	Rural jobs	farming	Because of the importance of livestock in the household economy, stables and animals food store are located near living spaces and act as thermal insulation for living spaces and animal waste are used for heating and fertilizer. animal crossing passages and the entrance of houses have been made with high width for crossing animals.
		agronomic	the village is located on the slope of mountain and the fertile land of the valley is used for agriculture and gardening and also food stocks positioned inside residential houses act as thermal insulation for living spaces.
		Carpet weaving	because of the employment of most of the families to carpet weaving, there is a allocated room to carpet weaving in most of the houses.
		Supplies of bread and food at home	bread and food preparing at home by villagers has caused formation of cylindrical bread oven and product maintenance spaces

CONCLUSION

Sustainable residential complex balances among environmental and socioeconomic factors. Before emergence of modern living, villages were considered as sustainable residential complexes because they were compatible to the environmental conditions of the area through trial and error; and there were intelligent solutions for confronting environmental incompatibility. Old people respected and protected the nature. This paper is introducing a sample of stepped structure villages named Totakhaneh that is located in Bonab in east Azerbaijan. According to the diagram 5, in formation of the village, environmental issues such as accessibility to the water resources; avoidance and prevention of flooding; construction of sloped structures for utilization of sunlight; usage of regional potentials for passive heating and cooling have been very effective. Not only environmental issues but also social issues, and religious beliefs; relationship of residing people are effective in the village formation and layout of internal spaces of the houses.

On the other hand, economic issues; sources of villagers' income and their subsistence have increased diversity of indoor spaces and have impacted the texture of village. Generally, we may conclude that texture and architecture of Totakhaneh are highly flexible for gradual construction of various spaces; all peoples' living requirements are considered. Namely, it is a sustainable residential complex and foretime experiences are regarded and used for future development project of the village.

POSTSCRIPT

[1]Passive methods do not use mechanical energy and fossil fuels for heating and cooling. (Leckner,2006)

[2]High mass of the ground creates time lag. Average impact of summer heat and winter cold at about 6 meters depth ground is equal to constant temperature in steady state. Almost it is equal to the average annual temperature of the concerning climate. Accordingly, earth is cooler in summer and hotter in winter than the surrounding air.

[3]Walls of Totakhaneh are constructed by available materials in the village; there is 20 cm stone at the middle of wall covered with 10cm thatch on both sides and finally covered with plaster. According to a research by Pourdeihimi and Gosili , stone walls are more efficient and their potential is higher for outdoor walls in cold climate; and they are appropriate for such climates (Pourdeihimi and Gosili, 2015)

Winters are very cold in Totakhaneh; first way for keeping the interior warm is to prevent entrance of cold air to the house and exit hot air from the house. Majority of indoor areas of the houses are adjacent to the ground and other indoor spaces; they lead to courtyard from one side; heat loss is just from ceiling and leading wall to the courtyard. Windows are relatively small and only there is one or two windows to the courtyard or valley. Rooms are ventilated through loophole on the roof.

[4]Fossil fuel is used to heat living room and reception room; previously they used oil heater for reception room because they used it whenever they had guest but there was a cylindrical clay oven in a corner of the living room for bread cooking in winter. When firing the oven the loophole is opened to let the smoke exit the room.

Summer cylindrical clay oven is located in a semi-outdoor space but winter cylindrical clay oven is located in a corner of living room to warm it in winter. In the past they backed bread two or three days per week; and they heated their living room with the heat of oven for several days; they put a large table, a stool-like frame on the cylindrical clay oven and covered it with a thick quilt to heat themselves. Hot air was pleasant for the family members gathered surrounding it. Nowadays every family member prefers private room thus they use gas heater to heat the private room instead and they use lot of energy for heating.

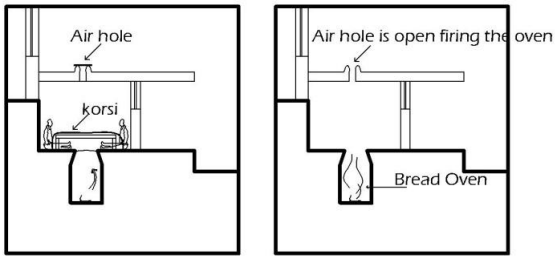


FIGURE. USAGE OF CYLINDRICAL CLAY OVEN IN WINTER TO HEAT THE LIVING ROOM

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