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The Analysis of Environmental Sustainability for Rural Housing Using Fuzzy Interference Systems (Case Study: Rural Areas in Marivan County)

Bahram Imani [1]*- Asghar Pashazadeh [2]- Seyyed Hadi Karimi [3]
1- Assistant Prof. in Geography and Rural Planning, Mohaghegh Ardabili University, Ardabil, Iran.
2- Ph.D. Candidate in Geography and Urban Planning, Mohaghegh Ardabili University, Ardabil, Iran.
3- Ph.D. Candidate in Geography and Rural Planning, Tehran University, Tehran, Iran.

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Abstract
Purpose- Housing has been one of the basic needs of the human beings, and the settlements have also been considered as the basic needs in terms of human communities. In order to satisfy such needs appropriately, traditionally human beings have intended to supply such needs as dealing with their surrounding environment. The current research intends to define the indices of housing sustainability in order to investigate the sustainability of environment for rural housing in Marivan County.
Design/methodology/approach- The required data was collected using documentary methods and field studies together with questionnaires. First, the environmental variables of sustainable housing for rural areas were defined. Next, using hierarchical sampling method together with Cochran formula, 295 rural households were selected as the sample of the study. The tool for collecting the data was a questionnaire with an acceptable reliability endorsed using pre-test, data analysis, and the calculation of Cronbach's alpha coefficient. Finally, in order to analyze the data, fuzzy interference system (FIS) was used within the MATLAB software. For mixing the results obtained from measuring the elements of environmental sustainability, the gamma fuzzy was used together with FIS.
Findings- The results indicated that the environmental sustainability of rural housing in the current research included the values of 0.9, 0.7, and 0.5 for gamma fuzzy which respectively included 0.09, 0.22, and 0.52. This indicates that the environmental sustainability of rural housing is not desirable for the areas investigated in this study.
Research limitations/implications- The most important problem with the current research was that the household heads in the rural areas could not be easily accessed for data collection.
Practical implications- With respect to the results, it is recommended that the economic, cultural, and social conditions of the rural areas and the subsistence of their native residents should be in line with the climatic and geographical conditions of the areas.
Originality/value- The results of the current research can pave the way for studying the sustainability of the rural housing, especially in the area which has been studied.
Keywords- Rural housing, Environmental sustainability, FIS, Gamma fuzzy, Marivan County
Paper type- Scientific & Research.

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**** Corresponding Author:***
Imani, Bahram, Ph.D.
Address: Department of Geography, Faculty of Letters & Humanities, Mohaghegh Ardabili University, Ardabil, Iran.
Tel: +98914 154 0629
E-mail: bahram_imani60@yahoo.com

1. Introduction

Traditionally, housing has been considered as one of the most important factors of living for human beings. Having a secure shelter has also been regarded as one of the oldest wishes of the human beings, and they have managed to use different kinds of methods and technologies in order to enhance the quality and quantity of housing. The importance of housing contributed to new plans on housing. However, choosing correct plans has helped development in terms of housing in many countries (Afrakhteh & Havasi, 2011). Clearly, housing is fundamentally important in terms of progress for human beings. In its universal declaration of human rights, the United Nations contends that all individuals are entitled to achieve an appropriate standard level of living for their health and well-being. According to the UN, this appropriate standard for living includes food, clothing, housing, healthcare, and social services (Choguill, 2007). During all periods of human life, especially through the recent decades experiencing population growth with high speed, housing has been regarded as one of the most important issues in terms of social and economic issues. Therefore, having access to appropriate housing for all rural and urban households, especially for the poor groups and those who are faced with social damages, have been the most important challenges which the governments and policy makers experience. Brandt's (1987) final report demonstrates that housing is one of the key needs across the developing countries. The results indicate that almost 20% of the global population lack good housing. According to the estimations, probably more than half of the population of the developing countries lives in substandard housing, while either the governments of these countries have not tended to supply higher standardized housing for their people or they cannot afford to supply such houses (Hakimi et al., 2011).

The housing plans were mostly focused on cities and what has been written on rural housing generally considered the architectures of the rural housing. However, in Iran, a higher percentage of the population live across the villages.

On the other hand, with regard to the increasing urban population and the immigration of the rural individuals towards cities, it seems necessary that the policy makers and planners focus more on rural development. Rural housing, which is one of the most important needs of the villagers and their development, should be sublimed within different plans of national development as one of the special projects.

One of the problems which has attracted the attentions of many experts has been housing and its sustainable development together with the human development. For such strategy, optimal using of the sources should be regarded. One of the important points which have been concentrated through the documents of the second meeting on human settlement was the importance of sustainable settlement and supplying good housing for people toward their development. Then, sustainable rural housing could be regarded as one of the important indicators in terms of rural development and civilization. Therefore, identification of the features for rural housing together with methods for supplying them has been highlighted (Chaparli, 2007). In other words, sustainable housing refers to those houses which are appropriate in terms of economic issues, acceptable with regard to social issues, feasible in terms of technical and physical structures and adoptable to the environment (Charles, 2007). With regard to comprehensiveness of sustainable development, the basic condition for its emergence is the issue of sustainable development. Thus, the important point is that each of the individual parts should be equally considered. For instance, the quantitative items should not solely be regarded in terms of sustainable housing. However, all of the basic developments and issues as related with human beings, nature, culture, environment and their interactions should necessarily be investigated (Taghizadeh, 2001). One of the recommendations by the promotors and missionaries on sustainable development has been regarding ecology or stressing on technology and native methods or materials toward development. Also, the possibility of spiritual growth and perfection for human being should be provided. The sustainable housing plays more important role in terms of family sustainability, social and economic growth and enhancing security of the individuals, especially in terms of enhancing cultural values together with providing emotional tranquility of the family members (Asayesh, 1996). One of the

important approaches with regard to information on sustainable housing is to use the indicators of housing sustainability. These indicators demonstrate the qualitative and quantitative conditions of the rural housing together with improving housing plans for long term (Lotfi et al., 2009).

Therefore, here, investigation on identifying and defining factors and causes of environmental sustainability for rural housing has been done as a necessary issue. Also, some recommendations will be provided on modifying the methods together with improving the affairs. So, the current research intends to reach the following objectives:

- Evaluation and definition of the indicators for sustainable rural housing in different rural areas.
- Introduction of the level for environmental sustainability of the rural housing.
- According to these objectives, the current research also intended to answer the following questions:
- How is the level of sustainability for rural housing according to the indicators of environmental sustainability?
- In terms of the situations of sustainability for rural housing, which recommendations and solutions could be provided to improve them?

2. Research Theoretical Literature

2.1. Definitions and concepts

Housing is considered as a complex and extensive concept. It has various aspects, so a unique definition could not be provided. House is regarded as a physical place and as a shelter for satisfying the basic needs of the households in which, some of the basic needs including foods, resting and protection against weather conditions is supplied (Pourmohammad et al., 2007). While housing involves physical place, it also contains the residential setting which include all the necessary services and facilities in order to help families live in wellbeing together with having some plans on employment, education and health for the individuals. In fact, the definition and concept for "housing" is not generally related with a residential unit, but it involves the entire housing environment (Mokhber, 1983). In most cases, the most important factors influencing on individuals' satisfaction of housing in neighbors, include the conditions of housing and environment (Westaway, 2006).

The rural housing is a location where the biological methods, subsistence approaches and finally the forces influencing on environment and economic and social trends emerge (Saeidi, 1994). Rural housing is different from urban housing in various aspects. The most important aspects include the functions and patterns of rural housing against the urban houses. Unlike the urban houses, the rural houses mainly have living functions with different types of functions together with many living outcomes. These houses provide the rural residence with necessary setting in terms of living, work, product storing, and protection of cattle, information, communication and holding customs. Therefore, different functions of rural houses generally include three classes: living functions, productive, subsistence and economic functions and arrangement functions. Each of the functions demand their own faces. However, it should be noted that, in all of the cases, the functions of different spaces for rural houses totally differ from each other. For instance, the living room might have living function as its major performance. Together with some productive activities like carpet weaving are performed there. In this case, the function of the space includes a living-economic one.

In consequence, it should be acknowledged that development has been based on such aspects in balance together with providing special importance for environmental, social and economic aspects. For housing, establishing balance between residential needs of the households and the necessities in terms of social and economic developments require recognition of qualitative and quantitative aspects together with perceiving their flexible natures. Housing, in terms of social and economic development, is vitally important for employment, attracting extra productive capacity, increased value added and promoted economy basis (Chaparli, 2007). A systematic perspective on the rural houses and their structures with respect to those elements building the settlements and houses in order to better identify them contributes to formation of physical and rural development which vitally influence on housing (Gray, 2004).

The theme "sustainability, planning and deepening of stable locations" has recently been

regarded in architecture literature. In terms of theory, many concepts and thoughts have been provided by scientific and academic institutes (Pourmohammad et al., 2007). Many scholars believe that sustainability requires development of thinking together with a fundamental change in thinking and practice. However, few scholars went forward and didn't closely regarded the features of such developments. Sustainable housing doesn't mean the house will remain forever, but it means that materials, energy, water will help sustainability of human economy and its structures (White, 2002). The kind of housing which can satisfy the living needs of the current generation based on the effectiveness of energy sources and provides secure neighborhoods in terms of economic, cultural and ecological problems (Edwards & Turrent, 2000). So, sustainability is not solely linked with physical problems. However, it involves extensive, social, aesthetical and economic aspects which regard such problems as air quality, reducing chemical materials, coordination between housing and natural perspective, participation of the users in designing, housing management, variety, protection of the existing settlements instead of destroying them. One of the recommendations provided by the promoters and missionaries on sustainable development is ecology or stressing on the technology and materials with ecological methods for development (Taghizadeh, 2001).

Sustainable housing should have best interaction with its environmental bed while having less influence on environment. Interaction of housing with environmental bed is considered as one of the most important factors for protecting environment, sources and energy. Also, it should be corresponded with culture, methods, traditions and economic conditions of the residence.

In addition, sustainable housing should be built using ecological materials which are compatible with climate and could be recycled. Furthermore, using good technology, security and its standards, it could be improved (Mahmoudi & Nikghadam, 2008).

Sustainability is considered as a process which involves improvements in terms of sustainability. Sustainable housing should consider five areas: protection of natural sources (earth, energy, water), logical utilization of human made sources, protection of system and its reviving potentials, justice between production, human being and classifications, prediction of health, security and safety (Edwards & Turrent, 2000).

One of the important ways of being informed of housing condition for rural sustainability is to use housing indicators (Azizi, 2004). On the one hand, these indicators demonstrate the qualitative and quantitative features of the rural housing in each individual interval and on the other hand, they provide effective guideline for improving future plans. In fact, the indicators include the measurement tools for housing sustainability and its development together with calibrating its success and materialization of housing policies. Therefore, in addition to evaluating the situation, it is applied the formulating quantitative objectives for plans (Hekmatnia, 2006). These indicators could be divided in terms of their nature and theme. For nature, they are classified in two groups including qualitative and quantitative one. And for theme, they are classified into four parts including economic, social, physical and environmental ones.

Here, with respect to the indicators in terms of the experiences obtained in Iran and across the globe, according to the environmental conditions for housing and their residence at the study area, the factors and items for measuring environmental sustainability of rural housing have been provided within questionnaires on rural households which include a five level Likert scale "very low, low, a little, high, very high). Since the data was analyzed using FIS and within the MATLAB software, it should be noted that, with respect to work overload in terms of defining data bases, a twelve items fuzzy rule was developed in order to measure environmental sustainability of rural houses. Through four factors which they divided evenly (Table 2).

2.2. Research background:

According to research literature and the history on research problems, one of the main steps for starting a typical research is literature review, because the information from such investigation complements the results of the research. Many investigations have been done on rural housing. Table one summarizes some of the researches:

Table 1. a summary of background on researches for sustainability of rural housing
(Source: Research findings, 2017)

Row	Subject	Authors	Date	Results
1	Housing policy in Nigeria	Vinsinteg o et al	2001	The role of housing policies, housing access, housing infrastructures, construction regulations, construction materials and housing-related industries have been investigated by emphasizing on increasing the role of the private sector.
2	Upper roof, qualitative assessment of rural housing services in India	Gopta et al	2009	In a study conducted in the villages of India, they achieved the following results: rural housing in India faces many challenges, including lack of land, the poor rural population, and the inability to use good materials for housing and lack of awareness from up-to-date technologies in housing construction which requires more attention from the government and authorities.
3	Rapid recovery of rural areas against reducing land use policy in Chinese villages	Lee et al		This paper examines the reduction in land use policy adopted by the Chinese government. The results of this paper indicate that the reconstruction of rural housing in China is a hybrid process involving the reconstruction of housing in European countries, which is distinctly different from the political, social, and cultural fields of China.
4	Sustainable development of rural construction structures based on local identity	Sarfaraz et al	2013	MCDM is used as a new hybrid model in this research. First, SWARA is used for weight criteria, and then COPRAS is used to evaluate the five selected structures in the climatic conditions of these areas. The authors suggest that this research can be useful as a framework for use elsewhere around the world.
5	Study of sustainable housing indices in rural areas	Shayan et al	2014	The results of statistical analysis in SPSS show that five factors - amenities, economics, constructing power, productivity and environmental compatibility - can explain about 82% of variance of research variables. Considering these factors is essential in the planning of applicable housing.
6	Assessing sustainable housing development in a developing country	Yigitcanl ar et al	2015	The results show that policymakers, planners, development agencies, and researchers support further studies on local sustainability and emphasize the need for collective efforts and an effective process to achieve local sustainability and form sustainable settlement.
7	Sustainable city development and housing	Moham mad Taghizad eh	2001	Considering the basic issues related to human, nature, culture, environment, and their impact on each other for sustainable urban development and housing is necessary and put forward results for moving towards sustainable urban development and housing.
8	Sustainable Rural Housing Pattern in Gilan Plain	Adeli Gilani	2005	The sustainable pattern of rural housing in Gilan should be designed according to cultural, economic, social and natural factors.
9	Study of informal housing indices in Iran	Hatami nejhad et al	2006	Although the characteristics of informal settlements in Iran are lower than official settlements, they are better than other countries because of basic services.
10	Indicators and Components Essential in Rural Housing Planning and Policy-making in Iran	Lotfi et al	2009	Recognition and application of rural housing indices in the long term will transform rural housing, which will lead to the provision of a suitable and developed rural housing model in the country.
11	An analysis of the role of housing loan in rural development	Afrakhte h et al	2011	The results of this paper indicate that rural housing loan policy has not been successful, as it is not presented in the framework of systematic and comprehensive rural development planning in line with the objectives of empowerment.
12	The continuation of rural housing architecture with the motivation of sustainable rural development	Zandiyeh et al	2012	With industrial advances, population growth and the expansion of traffic between towns and villages, we are faced with the construction of contemporary rural buildings that subject to a variety of disorganizations in the design, selection of building systems, organs, and so on.

Table 1.

Row	Subject	Authors	Date	Results
13	Analysis and evaluation of housing sustainability indicators in rural areas	Barghi et al	2016	Five factors of amenities - welfare, economic, building strength, efficiency and environmental compatibility are able to explain about 72% of the variance of research variables and paying attention to these factors seems necessary in the planning of sustainable housing.
14	Rural housing sustainability based on mutual information analysis	Mohammadi-Yeganeh et al	2017	The results of the statistical analysis show that the social dimension is sustainable, physical and economic dimensions are somewhat sustainable conditions, and environmental and architecture dimensions are unsustainable. Also, the results of mutual information analysis method showed that Social dimension has the highest level of influence and impressionable among the indicators.

According to previous investigations, it could be said that a lot of research has been done on housing sustainability. But, for the villages at Marivan County, no research has yet been done. Finally, the current research is a complementary research for previous investigations while the author of the research sought to design appropriate indicators for environmental sustainability of rural housing and considering the degree of stability of the indicators in villages.

3. Research Methodology

3.1 Geographical Scope of the Research

Marivan County is located in Kurdistan province of Iran, 46º, 8' eastern longitude and 33' northern latitude and height of 1476m from the sea level at western Kurdistan. According to Iran's latest political divisions, the county has been divided into three areas including Khav and Mirabad, Sarshiv and Markazi. Khav and Mirabad include a rural district which has gotten the same name. Sarshiv has been divided into villages including Sarshiv and Golchidar and Markazi (central area) has been divided into three villages including Zarivar, Sarkal and Komasi (figure 1).

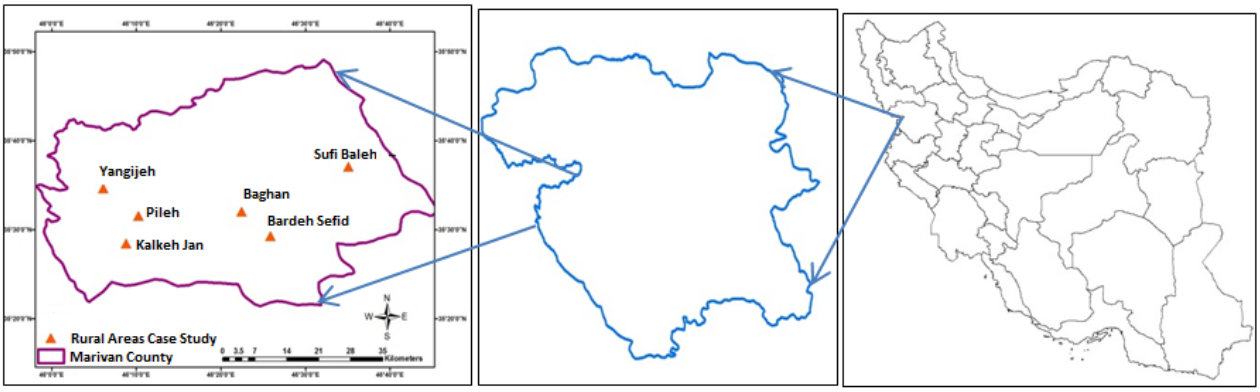

Figure 1. Spatial representation of the villages at current research
(Source: Research findings, 2017)

3.2. Methodology

In terms of objective, the current research uses an applied method because, in order to develop applied knowledge (rural development for housing sustainability of villages), clearly, the results can be used for planning. The dominant approach in terms of nature is survey which utilizes an analytical, descriptive method. However, the documentary and field observations have been used for collecting data. For description, the data and information have been obtained through using the documentary and field methods.

Therefore, the domestic and international sources including box, articles and thesis involved the desk research method. For field observation, direct observation and interview based on questionnaires completed by household heads, were considered for studying the villages. For

data analysis, fuzzy inference system (FIS) was used.

The statistical community of the research included the villages of Marivan county which were selected using a clustered method for the individual villages as the representatives of their respective villages (village Yangijeh from the village Khav and Mirabad, village Bardeh Sefid from the rural district of Komasi, village Pileh from the rural district of Sarkal and village Baghan from the rural district of Sarshiv, village Kalkeh Jan from the rural district of Zarivar and village Tazehabad Sufi Baleh from the rural district of Golchidar).

In order to determine the sample size, the Cochran formula was used and 295 household heads were obtained. For sampling, the randomly hierarchical method was applied. It means, according to the size of the households, they were randomly selected. It should be noted that total population of villages at Marivan County involves 59514 individuals (295 villages) of whom 1575 live in those villages selected as the sample of the current research. Finally, reliability of the questionnaire was measured using Cornbach alpha for which a value of 0.89 was obtained and this indicates reliability of the research tools.

Table 2. The villages of the study area and their selected samples
(Source: Statistics Centre of Iran, 2011)

Village name	Population number (person)	Number of household	Sample size
Yangijeh	385	80	66
Bardeh Sefid	333	70	59
Pileh	277	62	53
Baghan	252	61	53
Kalkeh Jan	194	42	37
Tazehabad Sufi Baleh	134	30	27
Sum	1575	345	295

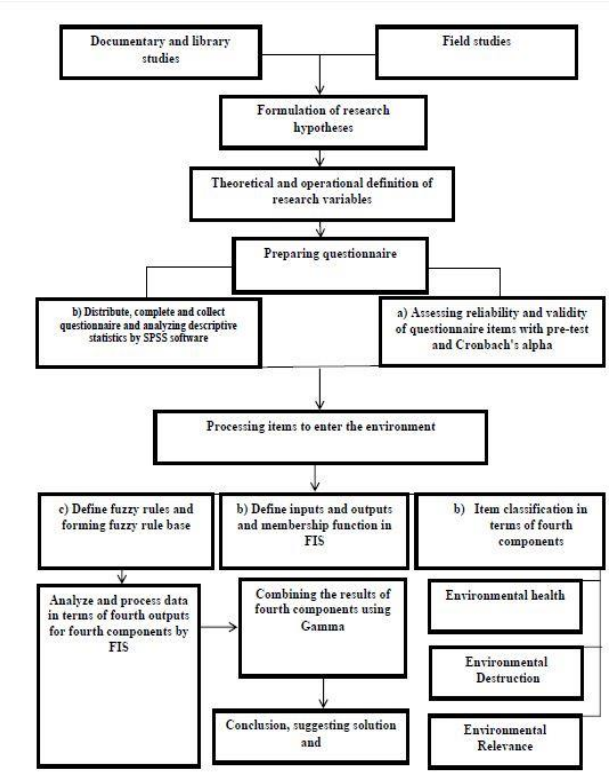

Figure 2. Research process
(Source: Research findings, 2017)

3.3. Variables and indicators of research

With respect to the indicators provided in terms of the Iranian and international experiences, the items and factors for evaluating and measuring environmental sustainability of rural housing were provided within questionnaires for rural households through a five points Likert scale (very low, low, a little, high and very high) with regarding the environmental conditions of the houses and residence at the area under study. Since the data was analyzed using FIS within MATLAB software, it should be noted that, with respect to overload in terms of defining the data base for twelve items fuzzy rules were designed in order to measure the environmental sustainability of rural housing with regarding four factors (table 3).

Table 3. Dimensions, factors and items of questionnaires provided to the households for measuring environmental sustainability of rural housing

(Source: Research findings, 2017)

Factor	Items	Item orientation	Number of items
Environmental destruction	To what extent did your housing construction cause the destruction of agricultural land and land use change?	-	3
	To what extent has your housing construction been eroded grasslands?		
	How much wood do you use to consume fuel (cooking, heating, etc.)?		
Environmental health	To what extent do you consider suitable sewage system (absorption well) in your housing?	+	3
	How satisfied are you with the health of your village passages?		
	How satisfied are you with the health of drinking water in the village?		
Environmental relevance(1)	How satisfied are you with the distance your home has with flood right of way?	+	3
	How satisfied are you with the slope of your home?		
	How satisfied are you with natural lightning and daylight illumination throughout the day?		
Environmental relevance(2)	To what extent your housing design and the type of materials used in it can cause to save energy?	+	3
	To what extent native materials have been used to build your home?		
	How satisfied are you with the calmness your home provides against crowd and noise?		

4. Research Findings

Data analyzing, measuring, and assessing environmental stability level of rural houses in the region under study were carried out using fussy inferential system (FIS) in Matlab. Finally, theoretical foundation results and field findings analysis of the study were summarized and recommendations toward improvement of environmental stability of rural houses and the houses in the region under study in particular were proposed. Since the study relies on FIS for data analyses, a short explanation about the system is due. Afterward the results of analyses are represented. Fuzzy sets were first introduced by Prof. Lotfizadeh (1965) for situations that more than one probability is expected. In definite sets, one member is either a member of the set or not. Therefore, the membership value is either 1 or 0. However, in fuzzy sets, each element may be assigned with any number between 0 and 1. Fuzzy logic can use indefinite functions “AND / OR” for illogical aspects of the variables and differences of fuzzy sets. In FIS, “IF and THEN” are used to combine knowledge base and connect input fuzzy variables and output variables (Ross, 2010, p 28). FIS is the most common type of fuzzy inferential method where each fuzzy rule is the minimum membership level for the condition represented by the rule. Only the regions covered by the rule are taken into account. Fuzzy inferential method was utilized here. The stages of the method is as follows: determining a set of fuzzy rules; converting inputs into fuzzy value using fuzzy membership functions; combining fuzzy inputs using the rules; combining outputs using the rules for developing output distribution; defuzzification of output distribution (into definite values). Following steps were followed to implement FIS:

1- Classification and defining the variables: As mentioned earlier, measuring environmental stability of rural houses in the regions was done based on rural family questionnaire and based on 12 statements designed based on Likert's five-point scale. Since data analyses were done using FIS in Matlab and given the large volume of analysis work throughout defining fuzzy rules base, the 12 statements designed to measures environmental stability of the rural houses were categorized into 4 elements (Table 3).
2-Memberships function type was determined and the range of the values was limited to Likert's five-point scale (1-5): Each statement was ranked from -1 to +6 based on triangle members function and membership level was categorized into good, moderate, and bad (poor) categories. (Figure 3)

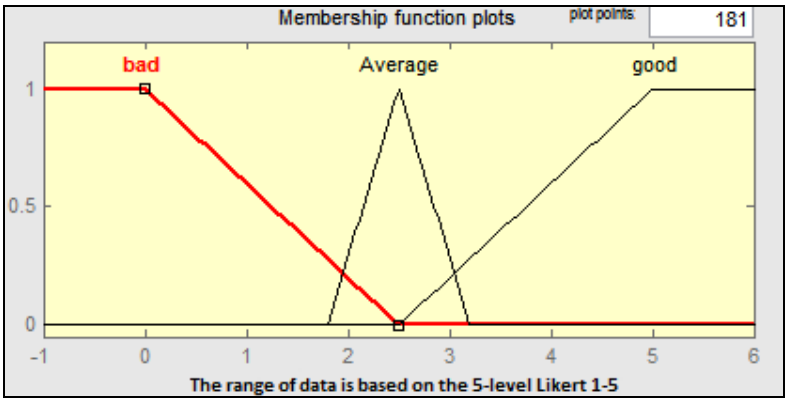

Figure 3. An example triangle fuzzy membership function for the research elements
(Source: Research findings, 2017)

A notable point at this stage is the lack of correlation between the elements of environmental stability measure. That is, there is a direct and positive relationship between the four elements of study and the three elements of environmental health, environmental relevance (1), and environmental relevance (2) based on the questionnaire designed based on Likert's five-point scale (1= very low, 2= low, 3 = relatively, 4= high; very high = 5). However, the elements of environmental destruction were negative and inverse. Therefore, the definition of values range and the triple modes (good, average, and bad) in FIS for this element is as follows (fig.4):

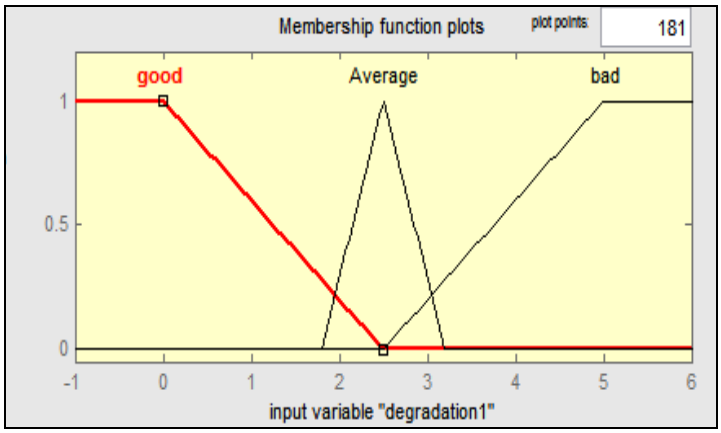

Figure 4. An example of triangle fuzzy membership function for environmental destruction element
(Source: Research findings, 2017)

3- Defining fuzzy rules and developing fuzzy rules base: At this stage and given the large number of possible combination for the statements of each element and based on If-Then rule, the rules were defined and a fuzzy rule base was created. Taking into account that each element contains three statements, and given the number of permutation in the triple combination of the statements and the elements of the system at none mode, 55 rules were defined for each element and for the four elements of environmental, environmental destruction, environmental health, environmental relevance (1) and environmental relevance (2), totally 220 fuzzy rules were defined. An example of the fuzzy rule base is shown in figures 5 and 6.

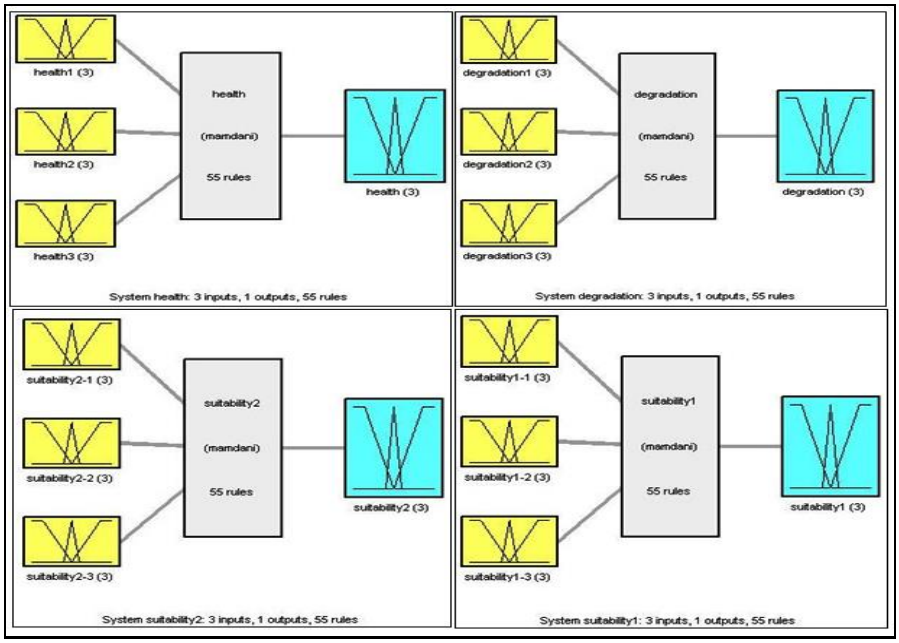

Figure 5. A general schematic view of inputs, outputs and number of rules defined in FIS
(Source: Research findings, 2017)

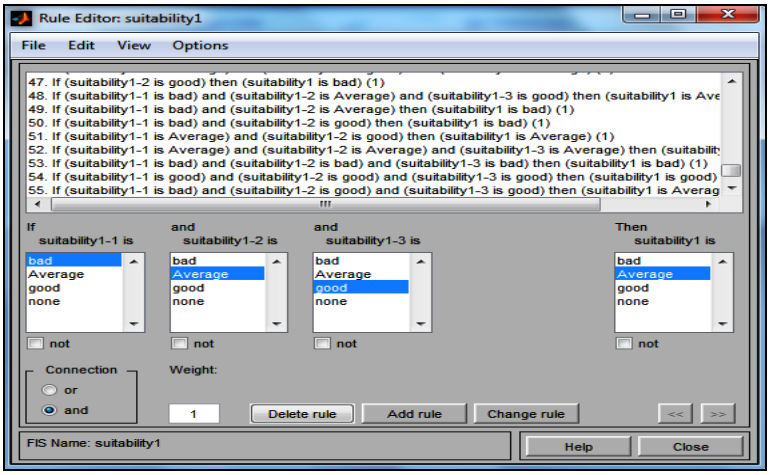

Figure 6. A schematic view of inserting rules to create fuzzy rules base in MATLAB
(Source: Research findings, 2017)

4- Combining the obtained outputs for each one of the fuzzy rules and assessment of the four elements: The obtained results from data assessment based on fuzzy rules base for each statement and the mean score of 295 questionnaires for each statement and each element are illustrated in Table 4.

Table 4. Membership rank of the four elements of rural house environmental stability
(Source: Research findings, 2017)

Membership rank of the four elements of rural house environmental stability			
destruction	**Environmental health**	**Relevance**	**Relevance**
0/27	0/31	0/35	0/37

5- Combining the results of analyzing the four elements using fuzzy GAMA: Since the membership values were combined using AND operant, which combines the sets, the minimum membership value for the elements are extracted. Minimum function and overlapping were also used by the operant and the equivalent of Intersect was defined (eq. 1). Consequently, to have more logical results, fuzzy GAMA operant was used, which is defined as in equation 2.

$$\mu_c(x) = \min \{\mu_1(x), \mu_2(x), \ldots, \mu_n(x)\} \quad (1)$$

μcombination=(fuzzy algebraic sum)^{y} * (fuzzy algebraic product)$^{1-y}$ (2)

Therefore, fuzzy algebra multiplication and fuzzy algebra sum were used to combined the results for AND operant. Fuzzy multiplication is as follows:

$$\mu = \prod_{i=i}^{i=n} \mu_i \quad (3)$$

Where, μi represents membership value of ith element. All the obtained values were multiplied. Due to the nature of values between 0 and 1 – i.e. membership level of the element of fuzzy set- the operator makes the small figures converge toward 0. Thus, fewer number of pixels are categorized in very good class. Therefore, the operator is featured with high sensitivity in positioning. That is:

= 0.011 × (environmental fitness1 × 0.370) × (environmental fitness2 × 0/352) × (environmental health × 0/313) × (environmental destruction × 0/273)

Fuzzy sum operant is defined as follows.

$$\mu = 1 - \prod_{i=1}^{i=n} (1 - \mu_i) \quad (4)$$

Where, μi stands for membership value of the statement of ith element. The operator computes the addition of multiplied addition of all sets.
Therefore, the output, despite the fuzzy algebraic multiplication, increases the value of pixels toward 1. Consequently, more pixels are categorized in "very good" class. The final values are increased, which means the factors amplify each other and combining the results has an incremental effect. Therefore, the operator is less sensitive to positioning.

((1 -) + (1 - 0/313) + (1 - 0/352) + (1 - 0/370))
1 -0/273

⇩

1 - (0/727 × 0/687 × 0/648 × 0/630) = -0/796

Finally and as noted, fuzzy GAMA value is obtained through multiplying fuzzy sum by fuzzy algebraic sum. Here, 0.5, 0.7, and 0.9 are taken as the values of fuzzy GAMA and the obtained results are listed below.

μ Combination = $(xsum)^{0/7}*(xprod)^{1-0/7}$ = 0/22
μ Combination = $(xsum)^{0/9}*(xprod)^{1-0/9}$ = 0/52

μ Combination = $(xsum)^{0/5}*(xprod)^{1-0/5}$ = 0/09

- In order to measure environmental sustainability of rural houses in villages Kalkeh Jan, Bardeh Sefid, Tazehabad Sufi Baleh, Yangijeh, Baghan and Pileh in Marivan county, such factors as environmental destruction, environmental health and environmental fitness were used as according with the appropriate method for analyzing the results. For combination of the results from

these factors measured by FIS, Gamma Fuzzy was applied. The results indicated that the environmental sustainability of the rural houses, in terms of Gamma Fuzzy values of 0.5, 0.7 and 0.9 are 0.09, 0.22 and 0.52, respectively. This demonstrates that the environmental sustainability of the rural houses has not been desirable. The results on instability of rural houses are consistent with those obtained by Gopta et al (2009) and Mohammadi Yeganeh et al (2017). The results showed that the instability was mostly occurred due to environmental destruction so that the rural houses were not built according to their surrounding environment. This contributed to destruction of farm lands and changes in land use. Therefore, in order to improve the situation with regarding the results from measuring the factors of environmental sustainability of the rural houses including destruction, environmental health and fitness, some guidelines and recommendations have been provided**:**

- The rural housing is subjected to subsistence, economic, cultural and social situations of the native people and is accorded with the climatic and geographical situations of the region. Due to closeness to Marivan county, this has less been seen in villages Yangijeh and Kalkeh Jan as compared to other villages**.**
- A well-developed sewage system should be established for the residential units in the villages simultaneously when rebuilding and reinforcement is done **.**
- With respect to the results indicating that housing plays a vital role in terms of producing extra additional materials in villages and the produced garbage materials aren't collected, recycle bins should be provided in appropriate places. Also, these garbage materials are collected by garbage trucks, especially in villages Kalkeh Jan, Yangijeh and Baghan which have lower health conditions as compared with other villages**.**
- Application of ecological facilities, tools and materials for building rural houses **.**
- Application of people's active participation for implementing and managing construction of housing units and rural buildings
- Formulation and development of construction rules and regulations for updating living conditions according to the culture and climate of the rural area
- Providing the villagers, researchers, designers and constructors with patterns for objective operation. The patterns should be presented in such a manner that they are not complementary uniform when modifying the design process and the villagers shouldn't be forced to follow a similar architectural plan**.**
- Given the fact that the villages Tazehabad Sufi Baleh and Bardeh Sefid are susceptible to damages due to landslide and flood, strong materials should be used for building the rural houses**.**
- Good designing and planning for villages located at inappropriate beds and removing physical problems in terms of paths, good distribution of services and improving health conditions for villagers
- Promotion and education of safety and retrofitting for rural houses**.**
- Promotion and education of providing health on rural areas through producing healthy houses (enhancement of health level in rural houses which have been studied).

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تحلیل پایداری محیطی مسکن روستایی با استفاده از روش استنتاج فازی (مطالعهٔ موردی: نواحی روستایی شهرستان مریوان)

بهرام ایمانی[1*] - اصغر پاشازاده[2] - سیّدهادی کریمی[3]

۱- استادیار جغرافیا و برنامه ریزی روستایی دانشگاه محقق اردبیلی، اردبیل، ایران.
۲- دانشجوی دکترای جغرافیا و برنامه‌ریزی شهری، دانشگاه محقق اردبیلی، اردبیل، ایران.
۳- دکترای جغرافیا و برنامه‌ریزی روستایی، دانشگاه تهران، تهران، ایران.

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چکیده مبسوط

۱. مقدمه

یکی از مسائلی که به شدت توجه همگان را به خود معطوف داشته، مسکن و توسعه پایدار آن و همگام با آن توسعه انسانی است. مسکن پایدار از نقش با اهمیت‌تری در ثبات خانواده، رشد اقتصادی و اجتماعی و بالا بردن ضریب ایمنی افراد و خصوصا ارتقای فرهنگی و آرامش روحی اعضای خانواده دارد و در کل سیستم نیز تاثیر می گذارد. یکی از راههای مهم آگاهی از وضعیت مسکن پایدار استفاده از شاخص های پایداری مسکن می باشد. این شاخص ها بیانگر وضعیت کمی و کیفی مسکن روستایی از یک طرف و بهبود بخشی برنامه ریزی مسکن از سوی دیگر برای یک افق بلند مدت است. لذا انجام پژوهش در خصوص شناسایی و تبیین عوامل و دلایل پایداری محیطی مسکن روستایی در محدوده مورد مطالعه و ارائه پیشنهاداتی در این بخش با هدف اصلاح روشها و بهبود امور بعنوان یک ضرورت مطرح است. بنابراین ما در این مقاله سعی داریم به اهداف زیر دست یابیم:

ارزیابی و تبیین شاخصها و نماگرهای مسکن روستایی پایدار در نواحی مختلف روستایی؛

شناسایی سطح پایداری محیطی مساکن روستایی؛

و متناظر با این اهداف، ما در این تحقیق به دنبال پاسخگویی به این سوألات هستیم:

پایداری مساکن روستایی در روستاهای مورد مطالعه بر اساس شاخص‌های پایداری محیطی در چه سطحی است؟

با توجه به وضعیت پایداری مساکن روستایی چه پیشنهادات و راهکارهایی برای بهبود آن می‌توان ارائه کرد؟

۲. روش تحقیق

تحقیق حاضر بر مبنای هدف از نوع تحقیقات کاربردی می‌باشد زیرا به منظور توسعه دانش کاربردی (توسعه روستایی از طریق پایداری مسکن روستاها) می‌باشد، بدون تردید نتایج حاصله از آن می‌تواند در برنامه‌ریزی‌ها قابل استفاده باشد. جامعه آماری این تحقیق روستاهای شهرستان مریوان می باشد که به صورت تصادفی ساده تعداد ۶ به عنوان نمونه تحقیق انتخاب گردید. برای تعیین حجم نمونه افراد نیز از فرمول کوکران استفاده شد که تعداد نمونه سرپرستان خانوار ۲۹۵ بدست آمد و برای نمونه برداری از روش طبقه‌بندی تصادفی استفاده شد. یعنی براساس میزان جمعیت (تعداد خانوار) و به صورت تصادفی ساده انتخاب شدند. لازم بدست بذکر است که پایایی پرسشنامه به روش آلفای کورنباخ، ۰/۸۹ که نشان از قابل اطمینان بودن ابزار تحقیق می باشد.

۳. یافته‌های تحقیق

در این تحقیق با استفاده از روش استنتاج فازی(FIS) در محیط نرم-افزار Matlab به تحلیل داده‌ها و سنجش و ارزیابی سطح پایداری محیطی مساکن روستایی در محدوده مورد مطالعه پرداخته شده

*. نویسندهٔ مسئول:
دکتر بهرام ایمانی
آدرس: گروه جغرافیا، دانشکده ادبیات و علوم انسانی، دانشگاه محقق اردبیلی، اردبیل، ایران.
پست الکترونیکی: Email: bahram_imani60@yahoo.com

است. مراحل و نتایج روش استنتاج فازی این تحقیق به این شرح می‌باشد:

۱) دسته‌بندی و تعریف متغیرها: از آنجا که تحلیل داده‌ها به روش استنتاج فازی و در محیط Matlab صورت می‌گیرد و با توجه به بالا بودن حجم کار در مرحله تعریف پایگاه قواعد فازی ۱۲ گویه طراحی شده بود در نتیجه جهت سنجش پایداری محیطی مسکن روستایی ۴ مولفه به صورت همگن تقسیم‌بندی شده است.

۲) تعیین نوع تابع عضویت و تعریف دامنه‌ی مقادیر بر اساس طیف پنج سطحی لیکرت (از ۱ تا ۵): در این مرحله برای هر یک از گویه-های تحقیق دامنه‌ای از ۱- تا ۶+ در قالب تابع عضویت مثلثی تعیین شده و درجه عضویت نیز با سه حالت خوب، متوسط و بد(ضعیف) دسته‌بندی شده است.

۳) تعریف قوانین فازی و تشکیل پایگاه قواعد فازی: در این مرحله با توجه به تعداد حالات ترکیبی ممکن برای گویه‌های هر یک از مولفه-ها و بر مبنای قاعده «اگر – آن گاه» (if-then) اقدام به تعریف قوانین و تشکیل پایگاه قواعد فازی شد که با توجه به اینکه هر مولفه حاوی ۳ گویه بود نهایتاً با توجه به تعداد جایگشت ممکن در ترکیب سه گانه‌ی این گویه‌ها و محدودیت سیستم در حالت none (پوچ) ۵۵ قانون برای هر مولفه تعریف شد که در مجموع برای مولفه‌های چهارگانه‌ی محیطی، تخریب محیطی، بهداشت محیطی، تناسب محیطی (۱) و تناسب محیطی (۲)، ۲۲۰ قانون فازی تعریف شده است.

۴) ترکیب خروجی‌های حاصل از هر یک از قوانین فازی و ارزیابی مولفه‌های چهارگانه: در این مرحله نتایج حاصل از ارزیابی داده‌ها بر مبنای پایگاه قواعد فازی که در مراحل قبل تشکیل شده بود برای هر گویه محاسبه شد و میانگین حاصل از ۲۹۵ پرسشنامه برای هر گویه و نهایتاً هر مولفه محاسبه گردید. بگونه ای که این مقدار برای تخریب محیطی، بهداشت محیطی، تناسب محیطی (۱) و تناسب محیطی (۲) به ترتیب ۰/۲۷۳، ۰/۳۱۳، ۰/۳۷۰ و ۰/۳۵۲ به دست آمده است.

۵) ترکیب نتایج حاصل از تحلیل مولفه‌های چهارگانه با استفاده از گامای فازی: از آنجا که ما برای ترکیب مقادیر عضویت از عملگر «و» فازی استفاده شده و این عملگر اشتراک مجموعه‌هاست. بدین معنی که حداقل درجه عضویت اعضا را استخراج می کند و از تابع مینیمم در همپوشانی استفاده می‌کند و معادل اشتراک (Intersect) تعریف می‌گردد. نتایج این مرحله هم که از طریق ضرب نتایج حاصل از ضرب جمع فازی در جمع جبر فازی بر اساس رابطه‌ای مربوطه به دست می آید نشان می دهد که گامای فازی به ترتیب ۰/۰۹، ۰/۲۲ و ۰/۵۲ می‌باشد که این امر بیانگر وضعیت نامطلوب پایداری محیطی مساکن روستایی در این منطقه بوده است.

۴. بحث و نتیجه‌گیری

در این تحقیق برای سنجش پایداری محیطی مسکن روستایی در روستاهای کلکجان، برده سفید، تازه آباد صوفی بله، ینگیجه، باغان و پیله در شهرستان مریوان واقع در استان کردستان، بنا به اقتضای روشی که برای تحلیل نتایج مورد استفاده قرار گرفت از مولفه‌های تخریب محیطی، بهداشت محیطی و تناسب محیطی استفاده شد. برای ترکیب نتایج حاصل از سنجش این مولفه‌ها توسط مدل استنتاج فازی نیز از gamma fuzzy استفاده شد. نتایج تحقیق بیانگر آن است که وضعیت پایداری محیطی مساکن روستایی منطقه مورد مطالعه بر اساس ضرایب ۰/۵، ۰/۷ و ۰/۹ گامای فازی به ترتیب ۰/۰۹، ۰/۲۲ و ۰/۵۲ می‌باشد که این امر بیانگر وضعیت نامطلوب پایداری محیطی مساکن روستایی در این منطقه بوده است؛ به ویژه از لحاظ تخریب محیطی که ساخت مساکن روستایی منطقه همسو و هماهنگ با محیط زیست پیرامون خود نبوده و منجر به از بین رفتن مراتع، اراضی کشاورزی و تغییر کاربری این اراضی شده است و در ادامه نیز جهت بهبود این وضعیت با توجه به نتایج سنجش مولفه-های پایداری محیطی مسکن روستایی یعنی تخریب، بهداشت و تناسب محیطی، راهکارها و پیشنهاداتی ارائه شده است.

واژگان کلیدی: مسکن روستایی، پایداری محیطی، استنتاج فازی(FIS)، گامای فازی، شهرستان مریوان.

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