Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 3 [9] August 2014: 123-131

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804

ORIGINAL ARTICLE

Analysis of Effective Indicators in Rural Sustainability (Case Study: Falavarjan County in Isfahan Province)

Zahra Hedayati-Moghadam[1], Sayed Eskandar Seidayi, Hedayatollah Nouri
Dept. of Geographical Sciences and Planning, Univ. of Isfahan, Hezar-Jarib Ave., Isfahan, Iran
[1]Corresponding Author, Email: za.hedayati@geo.ui.ac.ir

ABSTRACT
In a broad sense rural sustainable development is establishing and maintaining of development processes in rural areas in different social, economic, and environmental dimensions. In practice achieving sustainable development requires noticing and recognizing the involved effective elements and presenting them in a coherent framework as the set of sustainability indicators. Employing such indicators in a sustainable development planning is essential for success of the plan. The present study aims at identifying indicators influencing the sustainability of rural areas in Falavarjan County, as well as evaluating the sustainability status of the areas. The method used in this study is a combination of descriptive-analytical and survey methods. The required data was collected through both library and field research. The area under study includes 47 villages with 387 families. In order to identify effective indicators, 13 indices, 23 criteria and 145 indicators were applied within social, economic and environmental dimensions, using a multi-indicator method. The results of sustainability barometer model show that the areas under study are in an average sustainability situation. To determine the priorities in the sustainable development planning of the area, product of the obtained values of criterion weight coefficients and reverse of obtained sustainability values were calculated for all the criteria. The findings show that management of water resources, soil conservation, economic prosperity, economic stability, and economic justice, in order, need to be given highest priorities in a sustainable development planning of the area.
Keywords *: Sustainability Measurement, Sustainability Indicators, Barometer Model, Falavarjan County*

Received 12.05.2014 **Revised 14.06.2014** **Accepted 14.07.2014**

INTRODUCTION

Sustainability in its broad sense refers to the ability of society, ecosystem, or any ongoing system to maintain their continuous operations unlimitedly in the future without being weakened, perforce, due to depletion of resources or overuse. Sustainability in human societies is considered as the compatibility of environmental, economic, and social aspects. Jepson (2001) describes the framework as: "In essence, the emerging sustainability doctrine holds that the natural environment can be protected, the economy developed, and equity achieved all at the same time and that the extent to which we are successful in this simultaneous achievement is the extent to which we will achieve sustainability" [1]. This framework is specified as the framework of rival goals and focuses on social, economic, and environmental balance and aims at meeting a vast range of human needs such as food, hygiene, education, equality, and on the whole all material and spiritual needs.

Recognizing and measuring the influential parameters in sustainable development and careful planning is a requisite for achieving sustainability. Measurement and sustainability as two inseparable principles can deal with environmental, social, and economic problems effectively. In a dynamic system like human society, sustainability means a balance over time. Therefore, it cannot be easily measured or evaluated, since the concept depends on many unstable parameters and is not a fixed point over the time [2]. According to the definition by IUCN "measurement" is a multistep process including data collection and observation, data analysis, and estimation, that pursues following goals: a) a better understanding of the system through a clear explanation of the assumptions and help to test them, b) forming the goals through the better understanding of the system, c) improving the decision making in the process of adopting policies by providing information and clarifying the effects of each of the strategies, and finally, d) reaching to the desired goals by improving the decision making [3]. Measurement can have its best effect only when it is in continuous cycle of action and reaction and applied continuously in the process of

forming and directing the policies. Figure 1 illustrates this matter. Sustainability indicators are necessary tools for measuring and evaluating the amount of progress toward sustainable development [2]. These indicators show the link between economic, social, and environmental systems and function as a guide for developing policies [4]. They present social and physical situation in measurable units of information thus facilitate decision making for managers [5]. The most significant feature of the indicators is their ability to summarize, centralize, and integrate the complications in a system, and turn them into a set of meaningful, statistical information [6]. Sustainability indicators are classified based on the type of links between social, economic, and environmental systems. Such classification includes many overlaps that reflect the complexity and interdisciplinary nature of the sustainable development. Some indicators like unemployment rate index show the connection between economic, environmental, and social aspects and possess integrating characteristic.

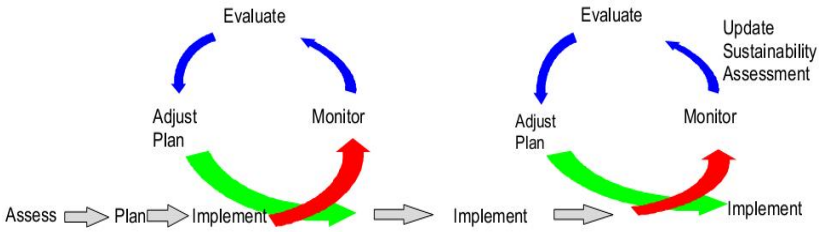


Fig 1- Using measurement in the process of forming and directing the Policies. [3]

In order to compile and combine indicators for measuring the progress and obtain final results for reaching a sustainable condition, many different tools and methods have been designed in the last few decades. There are different viewpoints in the methods and there is no consensus on one particular approach that be widely accepted and applicable to all areas and districts. Bossel has introduced 5 approaches for evaluating sustainability, i.e., 1- Ecological Footprint 2-Sustainability Barometer 3- Ad hoc or Trial and Error selection of indicators 4- the framework of Pressure-State-Response (PSR), and 5- A system approach [7]. In addition to different methods, several mathematical models have been widely used. During the recent decades, owing to the advancements in math and computer sciences, some multi-criteria models have been introduced. Multi-criteria decision making models divide into two categories of multi-objective decision making and multi-attribute decision making models.

In the last decades, rural areas in Iran have faced great challenges such as poverty, inequality, severe population decline, and vulnerability to natural disasters. This has greatly challenged sustainability in these areas. On the other hand considering the very high important role of the rural areas in various social, economic, and environmental aspects of the country, planning for rural sustainable development is of top priorities of the country. In fact the rural sustainability has an effective role on the national sustainability development of the country. Present study investigates the indicators effective on the rural sustainability of rural areas of Falavarjan County in the center area of Iran, as well as the sustainability status of these areas based on Barometer model.

LITERATURE REVIEW

Sustainable development has been viewed as a dominant approach in development planning since the late 1970s. It has begun since Brundtland Commission when discussion on sustainable development was initiated; and thereafter, became one of the key issues in development studies [8]. In this regard, rural sustainable development with its significant role in economy, environment, and society became also one of the main subjects in sustainable development studies. To achieve the goals of rural sustainability, studying indicators in rural areas is of vital importance. A lot of research has been carried out to evaluate rural sustainability and the following are a few examples. European committee offered a framework for economic-social and agricultural sustainability in a report published in 2001. Atkisson et al in their research have introduced sustainability indicators and emphasized on the interaction between economic, social, and environmental aspects [9]. Golusim has also studied the indicators that are applied in measurement of sustainability [10]. This study suggests four types of social, economic, environmental, and institutional indicators for measuring the sustainability. Singh has reviewed the features of different sustainability measurement methods and introduced sustainability indicators [11]. Van- Hsien et al have also studied sustainability development indicators in their research, in which in an incorporated

approach and by using different indices, the capacity of resources, and the challenges facing sustainable development have been investigated [12].

METHOGOLOGY

The present study is an applied one and the procedure employed is a combination of descriptive and analytical research using library and field methods. 13 indices, 23 criteria and 145 indicators were applied within social, economic and environmental dimensions to measure sustainability. Table 1 illustrates the employed indices and criteria which are grouped based on their roles in different aspects of sustainability. Parameters F and W in the table represent the values of sustainability and weight coefficient, respectively. The required data was collected using questionnaires, an officially reported housing and population census, and interviews with rural affairs experts. To investigate and analyze the objective of the study, Multi Criteria Decision Making model, consisting of making tables of raw data, converting qualitative indices into quantitative indices, aligning and normalizing the values, and weighting the indices, is used. In the normalizing stage fuzzy logic method is used, and in the index weighting stage both the entropy method and interview with experts were used. Barometer sustainability model introduced in [13] was used in measuring of level of sustainability. In this model, conclusion about sustainability of society and ecosystem and their reciprocal effects is made through organizing and combining of the indicators. The values of the indices and criteria with values between zero to one, are calculated and the obtained results are used as the indicators for the level of sustainability. Figure 2 shows the classification of sustainability based on this model. The area under study is Falavarjan County with an area of 310.3 km^2 that lies at longitude 51° 30'E and latitude 32° 32'N, 1600 meters above sea level. This County is 450 km far from Tehran. In this region 93285 people, out of the population of 247014, with 27024 families live in rural areas. (Department of Planning, Isfahan 2013) The research population includes 56 villages, each with at least 20 families. Using Cochran Formula, 378 families in 47 villages were selected to complete the questionnaire, and through stratified sampling, with proportional assignment from each class. Figure 3 illustrates the location of Falavarjan County and its villages in Isfahan. Table 2 shows the political subdivisions of this county.

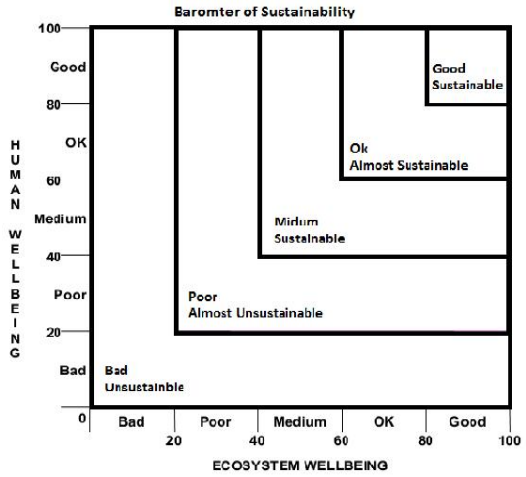


Fig. 2- Different Levels of Sustainability Based on Barometer Model

ANALYSIS OF RESEARCH FINDINGS

As mentioned above in order to identify effective indicators, 13 indices and 23 criteria and 145 indicators were applied within three social, economic and environmental aspects. To identify effective elements, first, based on the data from 384 families $\left[fa_i\right]_{i=1}^{384}$ and the 145 indicators $\left[ind_j\right]_{j=1}^{145}$ a raw data matrix $\left[d_{ij}\right]_{i=1,j=1}^{i=384,j=145}$ was formed, and then, the qualitative data was converted into quantitative data. This data, then, was normalized and aligned through the fuzzy method based on following equation:

$$z_{ij} = \frac{d_{ij} - Min\left\{d_{ij}\right\}_{i=1}^{384}}{Max\left\{d_{ij}\right\}_{i=1}^{384} - Min\left\{d_{ij}\right\}_{i=1}^{384}} \qquad j = 1,\ldots,145 \qquad (1)$$

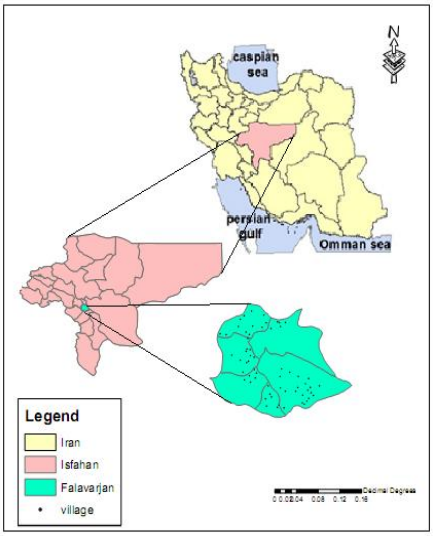


Fig.3. Location of Falavarjan county and Its Villages

Using z_{ij} data, and through the averaging and grouping procedures, the values of the 23 criteria $\left[C_j\right]_{j=1}^{23}$ for each of the 47 villages $\left[V_i\right]_{i=1}^{47}$ are calculated. These data form a 47*23 matrix $\left[a_{ij}\right]_{i=1,j=1}^{i=47,j=23}$ as the decision matrix. Using this matrix, the weight coefficients of the 23 criteria are assessed by using combination of Entropy method and experts' opinions. To that end , first the entropy of each of the criteria is calculated by using following equation:

$$E_j = -\theta \sum_{i=1}^{47} \left(p_{ij} - Ln(p_{ij})\right) \quad , \quad j = 1,...,23 \qquad (2)$$

in which $\theta = \frac{1}{Ln(47)}$ and $p_{ij} = \frac{a_{ij}}{\sum_{i=1}^{47} a_{ij}}$. Then, the uncertainty of each criterion is calculated as:

$$e_j = 1 - E_j \,, \quad j = 1,...,23 \qquad (3)$$

and following that the weight coefficient of each criterion is calculated based on ei values as:

$$w'_j = \frac{e_j}{\sum_{j=1}^{k} e_j} \qquad j = 1,...,23 \qquad (4)$$

Applying experts' opinions about the importance of each criterion results in final values of weight coefficients of the criteria as:

$$w_j = \frac{\lambda_j w'_j}{\sum_{j=1}^{k} \lambda_j w'_j} \qquad j = 1,...,23 \qquad (5)$$

in which λ_i is the average weight coefficient given by the experts for the j^{th} criterion. The obtained weight coefficients, and also the values of each criterion in the region which are calculated through averaging process on decision matrix $\left[a_{ij}\right]_{i=1,j=1}^{i=47,j=23}$ data, are named corresponding to the notations shown in the first column of table 1. The weight coefficients and values of indices and dimensions in columns 2 and 3 of the table are calculated based on the values of column 1. Figure 4 shows all the values and their relationship. In the figure each F_{ijk} represents the level of sustainability in one criterion, that each of them is obtained through questionnaires and collected data. F_{ij} shows sustainability in different indices which is obtained based on sustainability level of the criteria and their W_{ijk} weights. F_i is sustainability level in various dimensions which is calculated based on sustainability level of indices and their W_{ij} weights. And finally, F indicates general sustainability status which is obtained based on sustainability levels in different dimensions and their related W_i weights. As the figure show the weight coefficients of the economic, environmental, and social dimensions are 0.345, 0.331, and 0.323 respectively.

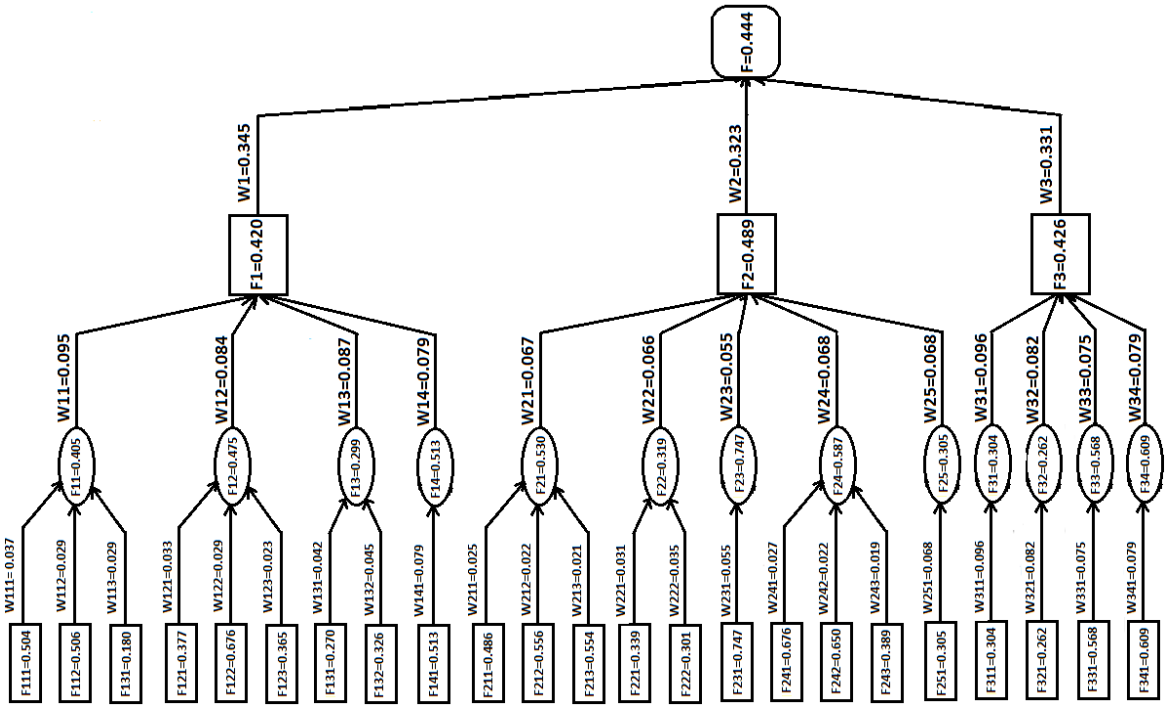


Fig. 4- Values and Relations between Sustainability Levels and weight coefficients

Figures 5 to 8 illustrate weight coefficients in economic, social, and environmental dimensions, sustainability level in different dimensions, sustainability level in different rural districts, and sustainability of rural districts in different dimensions, respectively. As the results show the obtained values for weight coefficients, and also sustainability levels are close. However, results indicate more effectiveness of economic and then environmental elements in sustainability of these areas. Despite the fact that weight coefficients are bigger, in order in economic, environmental, and social dimensions, the sustainability level in same order is conversely smaller.

Table 3- illustrates the weight coefficients and the level of sustainability of indices, arranged in the descending order of weight coefficients. Studying the information in this table shows that the indices of water management, economic stability, economic welfare, and economic justice with 0.096, 0.095, 0.087, 0.084 weight coefficients, respectively, have the highest coefficients. The indices of psychological security and attachment to place with 0.066 and 0.055, respectively, have the lowest weight coefficients. Results also show a higher level of sustainability in attachment to place with 0.747 and environment hygiene with 0.609. The lowest levels of sustainability are observed in soil preservation with 0.262, economic welfare with 0.299, and water management with 0.304. The above findings are justifiable with regard to the recent droughts and their economic and environmental consequences in the region. In order to prioritize the indices in planning for sustainable development of the area, the product of the value of weight coefficient and reverse value of sustainability level for different indices were calculated as:

$$p = w \times \left(\frac{1}{f}\right) \qquad (6)$$

The results are shown in Table 4. The results indicate that water management (0.315789), soil preservation (0.312977), economic welfare (0.29097), economic stability (0.234568), and economic justice (0.234568), take top priority for planning in the area, respectively.

For contrastive analysis of human welfare and environmental conditions in the area the obtained values for sustainability and the Barometer Model were used. In Barometer Model the environmental aspect is considered as the basis for Ecosystem Well-being, and a combination of social and economic aspects are taken as an indicator for Human Well-being. In this Model, in a two-dimensional coordinate plane, each of the two axes represents one of the above aspects and the axis with a smaller value determines the sustainability status. In other words, sustainability level is determined by the smaller value of those two Ecosystem and Human Well-being aspects (IUCN, 2001, 18). The values in each axis with five segmentations are between 0 and 1, corresponding to the values shown in Figure 2. Figure 9 shows the overall sustainability status throughout the villages of the area. Considering sustainability value of 0.426 in Ecosystem Well-being and sustainability value of 0.453 in Human Well-being, it can be concluded that these areas in general have normal sustainability status. Figure 10 illustrates the sustainability status of

the villages separately. In this figure some of the villages have poor sustainability status due to unfavorable environmental conditions.

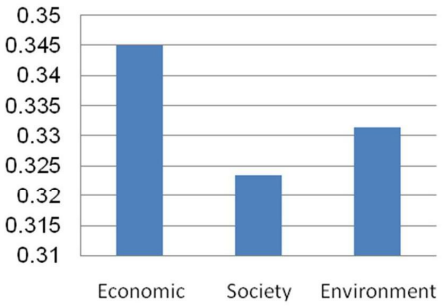


Fig.5- Weight Coefficients of different Dimensions

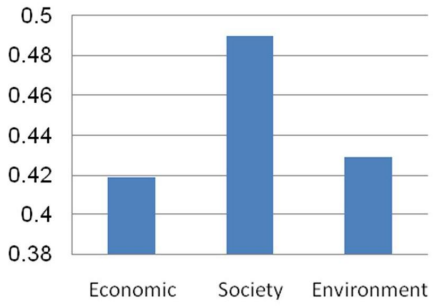
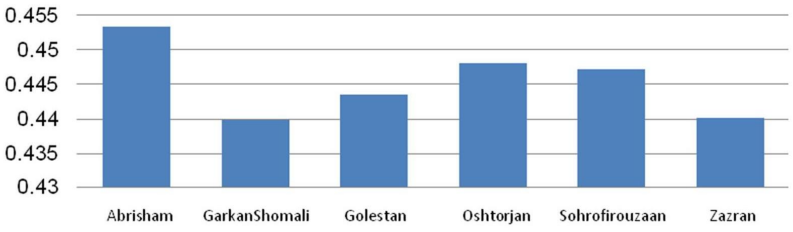


Fig.6- Sustainability Level in different Dimensions

Fig.7- Sustainability Level of different rural districts



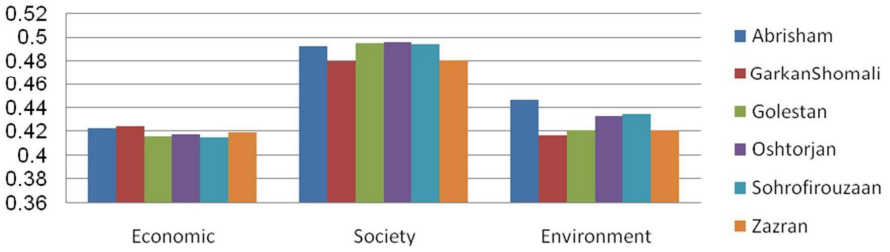


Fig.8- Sustainability Status of rural districts in Different Dimensions

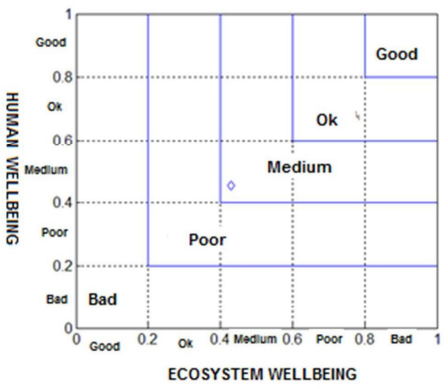


Fig.9- General Sustainability Status of the Villages

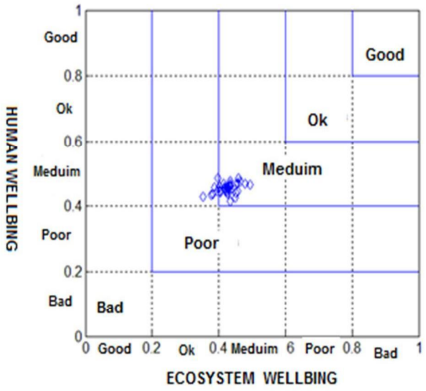


Fig.10- Sustainability Status of Different Villages

CONCLUSION

Rural sustainability requires establishing and maintaining development processes in all social, economic, and environmental aspects in rural areas. Basically, achieving sustainable development requires paying attention to influential factors that are presented in a coherent framework as a set of sustainability indicators. Recognizing and employing such indicators in sustainable development planning is essential to its success. Sustainability of Falavarjan rural areas was examined using 13 indices, 23 criteria and 145indicators within social, economic, and environmental dimensions. In this analysis, water management, economic stability, economic welfare, economic justice, and soil preservation had the highest weight coefficients based on Entropy method and interview with experts. In order to prioritize the indices in planning for sustainable development of the area, the product of the value of weight coefficients and reverse value of sustainability level for different indices were calculated. According to the findings, water management, soil preservation, economic welfare, economic stability, and economic justice, take top priority for planning in the area, respectively. For contrastive analysis of human welfare and environmental conditions in the area the obtained values for sustainability and Barometer Model were used.

Considering sustainability of 0.426 in Ecosystem Well-being and sustainability of 0.453 in Human Well-being, the areas of the study in average has normal sustainability status, however, some of the villages have poor sustainability status due to unfavorable environmental conditions. The recent droughts and their social-economic consequences can be a major determinant of sustainability status. The economic structure of this region is mainly based on farming and agriculture activities that have been greatly influenced by recent drought years. This has hugely troubled the economic status in the villages of the area and their survival. It is of primary importance to conduct more related studies in order to identify and resolve such problems.

Table 1- Dimensions, Indices, and Criteria used in Evaluation of Rural Sustainability of Falavarjan County.

	Dimension	index	Criterion
Sustainability (F,W)	Economic (F1,W1)	Economic Stability (F11,W11)	Diversification (F111, W111)
			Vulnerability Reduction (F112, W112))
			Income Change Ratio (F113, W113)
		Economic Justice (F12,W11)	Poverty (F121, W111)
			Distribution of Resources (F122, W122)
			Food Security (F123, W123)
		Economic Welfare (F13,W11)	Competence (F131, W1131)
			Efficiency (F132, W132)
		Housing (F14,W11)	Housing Status (F141, W141)
	Social (F2,W2)	Social Capital (F21,W11)	Social Trust (F211, W211)
			Interaction-Solidarity -Social Cohesion (F212, W212)
			Civic Participation (F213, W213)
		Psychological Security (F22,W11)	Life Satisfaction (F221, W2221)
			Life Expectancy (F222, W222)
		Attachment to the place (F23,W23)	Feeling Attached to the place (F231, W231)
		Services (F24, W24)	Access to Services (F241, W241)
			Quality of Service (F242, W242)
			Change of Services Ratio (F243, W243)
		Government Institutions (F25 ,W25)	Government Institutions Performance (F251, W251)
	Environmental (F3,W3)	Water Resources Management (F31, W31)	Water Resources Management (F311,W311)
		Soil conservation (F32, W32)	Soil conservation (F321,W321)
		Natural Hazards (F33, W33)	Natural Hazards (F331,W331)
		Environment Hygiene (F34, W34)	Environment Hygiene (F341,W341)

Table 2- The political Subdivisions of Falavarjan County (2013)

County	Rural district	villages
Falavarjan	Abrisham	4
	Zazeran	7
	Golestan	9
	Oshtorjan	7
	Garkan shomali	19
	Sohr-O-Firozan	10
Total	6	56

Department of Planning, Isfahan 2013

Table 3- Weight Coefficients and Level of Sustainability of Indices (Weights in descending order)

index	Wight Coefficient(*w*)	Sustainability(*f*)	index	Wight Coefficient(*w*)	Sustainability(*f*)
Water Resources Management	0.096	0.304	Natural Hazards	0.075	0.568
Economic Stability	0.095	0.405	services	0.068	0.587
Economic Welfare	0.087	0.299	Government institution	0.068	0.305
Economic Justice	0.084	0.475	Social Capital	0.067	0.53
Soil conservation	0.082	0.262	Psychological Security	0.066	0.319
Housing	0.079	0.513	Attachment to the place	0.055	0.747
Environment Hygiene	0.079	0.609			

Table 4- Priority of index in Planning for Rural Sustainable Development

Rank	Index(*f,w*)	Priority(*p*)	Rank	index(*f,w*)	Priority(*p*)
1	Water Resources Management	0.315789	8	Housing	0.153996
2	Soil conservation	0.312977	8	Natural Hazards	0.132042
3	Economic Welfare	0.29097	10	Environment Hygiene	0.129721
4	Economic Stability	0.234568	11	Social Capital	0.126415
5	Government institution Performance	0.222951	12	services	0.115843
6	Psychological Security	0.206897	13	Attachment to the place	0.073628
7	Economic Justice	0.176842			

REFERENCE

1. Jepson, E., (2001) Sustainability and Planning: Diverse Concepts and Close Associations. In Journal of Planning Literature. Vol. 15, No. 4, p.503
2. Moldan, B., & Billhars, S., (1999) Sustainability Indicators: A Report on the project on indicators of sustainable development, Department of the Environment, p.17,84
3. IUCN, (2001) Resource Kit for Sustainability Assessment: Part C: Slides for Facilitators, written by Irene Guijt and Alex Moiseev with Robert Prescott-Allen, http://www.iucn.org/themes/eval/index.html, p.2
4. UN., (2000) Indicators of sustainable Development :Guidelines and Methodologies; Report as the culmination of the CSD Work Programmer on Indicators of Sustainable Development (1995- 2000).
5. Bell, S., & Mores, S., (2003) Measuring Sustainable Development, learning for Doing. First published in UK and USA, p.30
6. Godfrey, L., Todd, C.,(2001) Defining Thresholds for Freshwater Sustainability Indicators Within the Context of South African Water Resource Management. 2nd WARFA/ Waternet Symposium: Integrated Water Resource Management: Theory, Practice, Cases. Cape Town, South Africa. http://www.waternetonline.ihe.nl /aboutWN/pdf/godfrey.pdf
7. Bossel, H., (1999) Indicator for sustainable development: theory, method, application. A report to Balaton Group, pp.13-14
8. European commission. (2001), "A framework for indicator for the economic and social dimensions of sustainable agriculture and rural development", Available on: ec.europa.eu/agriculture/public /reports/sustain/ index_en.pdf.

9. Atkisson, A., (2001) Developing Indicators of Sustainable Community: Lessons from Sustainable Seattle. In Environmental Impact Assessment Review. Vol. 16, pp.337- 350.
10. Golusim, M., (2009), "Definition characteristics and state of the indicators of sustainable development in countries of Southeastern Europe", Agriculture, Ecosystems and Environment, Vol.130, No. 1-2, pp. 67-74.
11. Singh, R.K. (2009), "An overview of sustainability assessment methodologies" Ecological Indicators, No. 9, pp.189-212
12. Ven-Hsien T., Wen-Chin C., (2009) Selecting management systems for sustainable development in SMEs: A novel hybrid model based on DEMATEL, ANP, and ZOGP. Expert Syst. Appl. 36 (2), pp.1444-1458
13. Prescott – Allen, R., (1999), The System Assessment Method. Lustrated by the Wellbeing of Nations; IUCN/PADATA.
14. Provincial Government of Isfahan (2013). *Statistical Yearbook* of 2013 of Falavarjan County, Bureau of statistics, Information, and GIS.

CITATION OF THIS ARTICLE

Zahra Hedayati-M, Sayed E S, Hedayatollah N .Analysis of Effective Indicators in Rural Sustainability (Case Study: Falavarjan County in Isfahan Province).Bull. Env. Pharmacol. Life Sci., Vol 3 [9] August 2014: 123-131