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Annals of Biological Research, 2012, 3 (9):4593-4600
(http://scholarsresearchlibrary.com/archive.html)

Annals of Biological Research
Scholars Research Library
ISSN 0976-1233
CODEN (USA): ABRNBW

Identification and measurement of indicators of drought vulnerability among wheat farmers in Mashhad County, Iran

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ABSTRACT

The identification of drought vulnerability indicators is an essential step for planning about drought mitigation management. So, this study is to identify and measure drought vulnerability indicators (economic, social and technical) among wheat farmers in Mashhad County, Iran. Delphi technique was used based on experts' concuss to determine vulnerability indicators. For measuring vulnerability formula of Me-Bar & Valdes was applied. Findings revealed that with respect to economic parameter, farmers had the highest vulnerability in indicators such as insuring crops (Pi= 2.890), land ownership type (Pi= 2.845), access to governmental and bank credits (loans) (Pi= 2.818). With respect to social parameter, farmers had the highest vulnerability in indicators such as education level (Pi= 2.970), dependency to government (Pi= 2.742) and collaborative farming activities (Pi= 2.587). Furthermore, farmers were most vulnerable in technical indicators such as irrigation method (Pi= 3.183), cultivation method (traditional/ mechanized) (Pi= 3.001) and weeds, pests and diseases control (Pi= 2.916). Totally, comparing three economic, social and technical parameters, farmers were more vulnerable in technical parameter. Results of this study may have some implication for reconsidering priority of government supporting credits allocation and planning for agricultural extension-education programs in same regions.

Keywords: Drought, Wheat farmers, Vulnerability, Agricultural extension programs.

INTRODUCTION

Drought is a slow-onset disaster that has economic, social, and environmental consequences and it is one of the most important hazards. Over the last decade, Iran has experienced its most prolonged, extensive and severe drought in over 30 years. This drought of 2003–2011 (as it is still ongoing) has affected many farm families and rural communities across most of the central, eastern and southern parts of Iran. Although Iran has a history of drought, critical features of the current drought are not only their widespread natures and severity, but the fact that the impacts of the current drought have been exacerbated by its proximity to the previous drought (1998–2001) [12]. Drought can therefore be regarded as a normal part of the Iranian farmers' environment. Drought is the most complex of all natural hazards, and more farmers are affected by it than any other hazard. There is few studies have identified the complexity of these impacts at varying indicators, and databases to document impacts and track trends by region or sector are virtually nonexistent [27].

Nelson et al. (2007) defined vulnerability as the susceptibility of a system to disturbances determined by exposure to perturbations, sensitivity to perturbations, and the capacity to adapt [15]. Vulnerability is closely correlated with human infrastructure and socioeconomic conditions. Vulnerability is defined as the set of conditions and processes resulting from physical, social and economic factors, which increase the susceptibility of a community to the impact of hazards (ISDR 2004) that social factors are related to social issues such as levels of literacy, education, the existence of peace and security, access to human rights, social equity, traditional values, beliefs, and organizational systems and economic factors are related to issues of poverty, gender, level of debt and access to credits. Vulnerability assessment provides a framework for identifying the social, economic, technical and environmental causes of drought impacts [28]. A considerable body of vulnerability literature has been related to identifying those population groups that are likely to be affected by negative effects of drought and other natural hazards [1, 2 and 6]. This is mostly because one of the main aspects of drought mitigation and planning is the assessment of who and what is vulnerable and why? [26].

Wilhelmi and Wilhite (2002) in their study based on analysis of drought literature, suggestions from Nebraska's climate and agriculture specialists, and data availability hypothesized that the key biophysical and social factors that define agricultural drought vulnerability were climate, soils, land use, and access to irrigation [27].

Shahid and Behrawan (2008) selected four individual socio-economic and three physical/structural indicators as important to their study. These indicators selected to represent the vulnerability. The socio-economic indicators were population density, female to male ratio, percentage of people living below poverty level, and percentage of people depending on agriculture. Three physical/structural indicators (technical) were percentage of irrigated land, soil moisture holding capacity and food production per unit area [18].

Simelton et al. (2009) identified socio-economic indicators associated with sensitivity and resilience to drought for some of China's main grain crops (rice, wheat and corn). Their study results showed that socio-economic indicators related to land, labor and economic inputs were significantly associated with reduced vulnerability in sensitive farming systems. The vulnerability to drought was quantified by crop-drought vulnerability indicators and were represented by land, labor, technical and economic inputs. Also, the economic investments in rural areas generally are correlated with reduced vulnerability where harvests were sensitive to droughts. For resilient harvests however, these same indicators had no, or the opposite, correlation [21].

Iglesias et al. (2009) have presented an index for evaluating socio-economic vulnerability to drought which was consisted of four components including natural, economic capacity, human and civic resources and agricultural innovation. Natural component is consisted of variables including: agricultural water use, total water use, average precipitation 61–90, area salinized by irrigation, irrigated area, population density. Economic capacity was including: GDP millions US$, GDP per capita US$, agricultural value added/GDP%, energy use, population below poverty line. Human and civic resources were consisted of variables including: adult literacy rate, life expectancy at birth, population without access to improved water. Variables like fertilizer consumption and agricultural machinery formed agricultural innovation competent [8].

Deressa (2010) in his study addressed farmers' vulnerability to climate change (drought) at household and regional levels and analyzed determinants of adaption measures and indicators influencing the perceptions of climate change in the Nile Basin of Ethiopia. Result indicated that indicators of lack of insurance or poor social safety nets, loans, selling of crop outputs, low income level, credits, irrigation method, and household extension packages (socio-economic vulnerability parameters) influenced farmers' vulnerability [4].

Keshavarz et al. (2011) in their study in Fars Province (Iran), concluded that there was considerable difference between different farmer groups perception about vulnerability or non vulnerability to drought; so that less vulnerable farmers; perceived that a set of components such as level of access to agricultural water, agricultural innovation adoption, interaction with experts and acquiring knowledge from extension institutes, irrigation method, cultivation method, insuring crops and the kind of land ownership had a major role in reducing vulnerability to drought; while more vulnerable farmers, believed that a set of indicators (such as lack of access to enough agricultural water, inability to receiving bank credits, family members unemployment and lack of their participation in agricultural activities) were among the most important indicators increasing their vulnerability [11].

Sharafi and Zarafshani (2011) in their research assessed the economic and social vulnerability among wheat farmers towards drought (years of 2006-2008) in Kermanshah Province (Iran). Their results revealed that farmers in

Ravanasar County who experienced highest drought intensity were most vulnerable in socio-economic aspects while farmers in Kermanshah County with lowest drought intensity were least vulnerable in socio-economic aspects. In addition, Sahne County experienced drought with intensity somewhere between Ravansar and Kermanshah Counties felt in the middle regarding socio-economic vulnerability parameters. Also, there is a relationship between drought intensity and vulnerability level among areas of study. Also, Sharafi and Zarafshani (2010**)** in another study assessed the technical and psychological vulnerability parameters during drought in Kermanshah Province. Result revealed highest vulnerability for farmers in Javanrood County in terms of technical parameter and farmers in Sarpol-E-Zahab County in terms of psychological parameter. Whereas, farmers in Islamabad-Gharb County had less vulnerable coefficient in respect to technical and psychological vulnerability parameters [20, 19].

Totally, this study provides a new and realistic look for identification and measurement of vulnerability indicators in drought conditions. It seems farmers' capacities to cope with drought depend on ownership or access to a wide variety of resources such as land ownership, farmers' incomes, farming lands size, education level, access to governmental and bank credits (loans), crops insurance, technical assistance and information, social networking, and public support programs [16, 5 and 22] that in this study, categorized in three parameters of social, economic and technical. So, the main objective of this study is to identify and measure drought vulnerability indicators (economic, social and technical) among wheat farmers in Mashhad County, Iran.

MATERIALS AND METHODS

Study region

This study conducted in Mashhad County (rural areas) located in Khorasan-e-Razavi Province, Iran. Wheat is the dominant crop in the region, so statistical sample of the study was consisted of wheat farmers who live in Mashhad County. The selected region was severely affected by drought during the year 2009-2011. The capital of Mashhad County (which is warm and semi-arid) is the Mashhad City. Mashhad County is the most populous county in Khorasan-e-Razavi Province and 992–1184 meter above sea level. This county is divided in four districts (Bakhsh), with their capitals (Statistical Centre of Iran 2012): Ahmadabad (capital: Malekabad), Central (capital: Mashhad), Razaviyeh (capital: Razaviyeh) and Torghabeh (capital: Torghabeh). The results were shown in **Figure 1**.

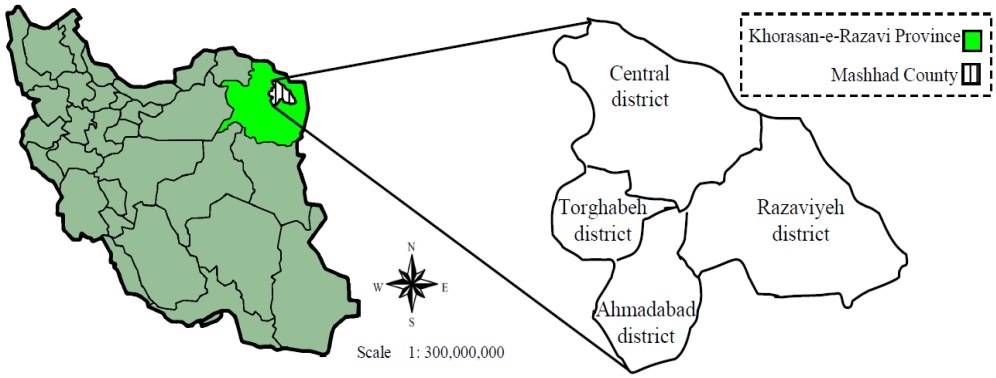

Figure 1: AREA OF STUDY (MASHHAD COUNTY, KHORASAN-E-EAZAVI PROVINCE, IRAN)
Reference: Statistical Centre of Iran (2012)

Selection of sample

A proportional stratified random sampling was applied to determine the respondents. First, consistent with the number of study statistical population, applying Cochran's test, the number of sample was determined 293 wheat farmers. The results were presented in **Table 1**.

$$nk = n \times pk; \qquad pk = Nk / N$$

(nk= The number of cases in each district; n= The total number of cases in four districts; pk= The ratio of each district wheat farmers to the statistical population; Nk= The number of statistical population in each district, N= Statistical population)

Table 1: Sample size in each district (Mashhad County)

Districts (Bakhsh)	Statistical population	Sample size
Central district	2574	125
Razaviyeh district	1320	65
Ahmadabad district	1086	53
Torghabeh district	960	50
Total	5940	293

The study instruments

Two questionnaires and method of interview were designed and used for gathering data that during the interviews, retrospective questions were asked so that farmers could go back to the past and gradually see the present with the aim of visioning the future.

The first questionnaire included open questions to determine the most important socio-economic and technical vulnerability indicators in Mashhad County by Delphi technique. The second questionnaire was consisted of two parts. The first part was for gathering data about farmers' personal and professional characteristics. The second part was consisted of vulnerability indicators obtained through first stage (Delphi technique) to calculate level of vulnerability indicators among farmers.

Stages of data collection and analysis

This study is conducted in two main stages:

1- *First stage (Delphi technique)*: Vulnerability indicators are directly relevant to the local study context and the particular hazard [24]. So, first stage was including using Delphi technique for indentifying and weighting major indicators of vulnerability in the study region, as has been used in many previous studies [3, 4 and 10]. Delphi technique was used based on experts' concuss to determine the most important vulnerability indicators in socio-economic and technical parameters. Snowball method was used to determine experts related to the study objectives. In other words, we asked the experts who were known in the research process to introduce other experts to us. Finally 45 experts were chosen among which, 31 experts resent the questionnaires and their data was used. They were experts who had field research about drought or extension experts who were directly engaged in programs or activities related to drought in the study region. A primary questionnaire including open question (i.e. to determine the most important socio-economic and technical vulnerability indicators in Mashhad County) was distributed among experts. In next step, first questionnaire data was used to determine and categorize common major social, economic and technical indicators with the most frequency. Acquired data was used to design another questionnaire including the primary indicators which were edited to send again to the experts to be confirmed by them. In third step, the questionnaire was consisted of final confirmed economic, social and technical indicators and also a section for determining the weight (relative importance) (Wi= 1… n) of each indicator in farmers' vulnerability by experts. They could weigh the indicators from 0 (the lowest importance) to 10 (the highest importance) [19, 20]. It was emphasized in the questionnaire that, weighing must express the relative importance of indicators, so the indicators could not be weighted the same. These indicators used to design the next stage questionnaire.

2- *Second stage (determining farmer's vulnerability level)*: In this stage another questionnaire was used. Farmers' social, economic and technical vulnerability level determined by method of Me-Bar and Valdez (2005). Among vulnerability assessment methods, a formula suggested by Me-Bar and Valdez (2005) was considered appropriate for assessment of socio-economic and technical vulnerability parameters in this study. Me-Bar and Valdez (2005), stated that vulnerability is a qualitative concept which for comparing societies on it need to be quantitatively measured. Mentioned formula, is based on subjective assessment of factors affecting drought vulnerability [13]. Considering the lack of reliable resources of data and information which is a prerequisite for applying other common methods in the studied region and its successful application in other regions of Iran in previous studies (for example the studies of Sharafi and Zarafshani (2011) in Kermanshah Province and Keshavarz *et al.* (2011) in Fars Province [11, 20]) the applicability and efficiency of this method for the country condition was proved. So, this formula was applied for vulnerability assessment.

$$V = 1 / C_0 \sum (P_i W_i)$$

(V= each farmer vulnerability amount; C_0= Sum of total vulnerability weight; Pi= Each parameter amount; Wi= Each parameter weight)

Also, in this formula: $C_0 = \sum W_i$; $\sum W_i = (W_{max} \times n) / 2$; $C_0 = (W_{max} \times n) / 2$; $C_0 < W_{max} \times n$

(W_{max}: The maximum weight that can belong to each parameter (10); n: The number of each factor parameters)

RESULTS AND DISCUSSION

Personal and Professional Characteristics

The most age frequency of the respondents (43 percent) was between 51 to 60 years old. With a view to the gender of the respondents, 84.5 percent were men and 15.5 percent were women. The most frequency of the wheat farmers education level were secondary education level which constituted 33 percent of the sample and also 21 percent of wheat farmers were illiterate and only 9 percent of statistical population had a degree higher than diploma. The most experience of wheat cultivation among the respondents was between 21 to 30 years. Also, with a view to the extent of farmlands, the highest frequency was related to the farmers who had 4 to 7 hectares.

Vulnerability Parameters

Findings related to economic, social and technical vulnerability parameters have been shown in the tables (2, 3 and 4). Firstly, for measuring indicators of any parameter, total vulnerability weight ($\sum W_i$) was calculated [13].

$$\sum W_i = (W_{max} \times n) / 2 = (10 \times 9) / 2 = 45$$

Economic vulnerability indicators

Findings showed that experts believed among economic parameter indicators, insuring crops (W_i= 6.12), regional extension experts economic advices (W_i= 5.46), and access to governmental and bank credits (loans) (W_i= 5.41), respectively, were the most important indicators for explaining economic parameter of vulnerability. Also, indicators such as insuring crops (P_i= 2.890), land ownership type (P_i= 2.845), access to governmental and bank credits (loans) (P_i= 2.818), respectively, had the highest economic vulnerability ranks among wheat farmers during drought. The results were presented in **Table 2.**

Table 2: The amount and weight of economic vulnerability indicators among wheat farmers

Economic vulnerability indicators	Indicators weight (W_i)	Indicators amount among wheat farmers (P_i)
Insuring crops	6.12	2.890
Land ownership type	4.82	2.845
Access to governmental and bank credits (loans)	5.41	2.818
Amount of liquidity	4.65	2.407
Sale price of crops	5.24	2.029
Farmers' incomes	4.95	2.021
Farming lands size	4.60	1.866
Pre-sale crops to middlemen	3.75	1.832
Extension agents' economic advices	5.46	1.718
Total	45	-

Table 3: Amount and weight of social vulnerability indicators among wheat farmers

Social vulnerability indicators	Indicators weight (W_i)	Indicators amount among wheat farmers (P_i)
Education level	5.35	2.907
Dependency to government	4.77	2.742
Family members collaboration	6.06	2.587
Social esteem	4.93	2.428
Participation in rural development programs	4.64	2.346
Collaborative farming activities	4.81	2.103
The level of related to farming religious believes	3.82	2.068
Membership in rural associations / organizations	5.10	1.985
Attending in extension education programs	5.52	1.942
Total	45	

Social vulnerability indicators

According to experts' view, collaborative farming activities (W_i= 6.06), attending in extension education programs (W_i= 5.52) and education level (W_i= 5.35) were three indicators with the highest importance in explaining social

vulnerability. The results were presented in **Table 3**. Also, indicators such as education level (Pi= 2.970), dependency to government (Pi= 2.742) and collaborative farming activities (Pi= 2.587) were three indicators which had the most vulnerability intensity for wheat farmers during drought.

Technical vulnerability indicators

According to findings in **Table 4**, experts believed that indicators of cultivation type (rain fed / watery) (W_i= 6.06), irrigation method (W_i= 5.65) and weeds, pests and diseases control (W_i= 5.29), were three indicators with the highest importance among technical vulnerability indicators. Also, indicators of irrigation method (P_i= 3.183), cultivation method (traditional/ mechanized) (P_i= 3.001) and weeds, pests and diseases control (P_i= 2.916) respectively were three indicators which had the most vulnerability intensity among wheat farmers.

Table 4: The amount and weight of technical vulnerability indicators among wheat farmers

Technical vulnerability indicators	Indicators weight (W_i)	Indicators amount among wheat farmers (P_i)
Irrigation method	5.65	3.183
Cultivation method (traditional/ mechanized)	5.12	3.001
Weeds, pests and diseases control	5.29	2.916
Planting, saving and harvesting times	4.71	2.908
Cultivation type (rainfed/ watery)	6.06	2.870
Use of chemical fertilizers	4.55	2.777
Tillage implements	3.84	2.709
Use of drought resistant varieties	4.94	2.661
Cultivation pattern (spring / autumn)	4.84	2.290
Total	45	

Total vulnerability parameters

Formula of Me-Bar and Valdez (2005) was applied to calculate total vulnerability amount in economic, social and technical parameters (table 5). As an example, total economic vulnerability parameter is calculated:

$$V = 1 / C_0 \sum (P_i W_i) = (2.890 \times 6.12) + (2.845 \times 4.82) + (2.818 \times 5.41) + \ldots + (1.718 \times 5.46) = 103.307 / 45 = 2.296$$

According to **Table 5**, comparing three economic, social and technical parameters, wheat farmers were more vulnerable in technical vulnerability parameter during drought.

Total 5: Total vulnerability parameters amount in among wheat farmers

Vulnerability parameters	**Total vulnerability**
Economic vulnerability	2.296
Social vulnerability	2.356
Technical vulnerability	2.825

CONCLUSION

This paper is to identify and measure drought vulnerability indicators in economic, social and technical dimensions among wheat farmers in Mashhad County, Iran. It's obvious that the length of the drought in study region implies that it is a harsh reality of Iran agriculture and mitigation to the severe continuous impacts of it, is critical. Thus, identification and measurement of farmers' vulnerability indicators is one of the necessary requirements for reducing impacts of drought in Iran. According to findings, with respect to economic parameter, respectively, farmers had the highest vulnerability in indicators such as insuring crops [7], land ownership type, access to governmental and bank credits (loans) [17, 20], while they had lowest vulnerability in extension agents' economic advices. With respect to social parameter, farmers believed that they had the highest vulnerability in indicators such as education level, dependency to government [20] and collaborative farming activities [8]. Furthermore, farmers were most vulnerable in technical indicators such as irrigation method, cultivation method (traditional/ mechanized) and weeds, pests and diseases control. Findings are summed in **Table 6**.

Table 6: A summary of indicators priority vulnerability among farmers in drought

Vulnerability parameters	Economic vulnerability	Social vulnerability	Technical vulnerability
prioritization of indicators	Insuring crops	Education level	Irrigation method
	Land ownership type	Dependency to government	Cultivation method (traditional/ mechanized)
	Access to governmental and bank credits (loans)	Family members collaboration	Weeds, pests and diseases control
Total vulnerability amount	2.296	2.356	2.825

For optimum managing and reducing negative consequences of social and economic vulnerability resulting from drought following mechanisms are recommendable. It can be said as emphasized by Vásquez-León et al. (2003) and Nelson and Escalante (2004), to manage and reduce negative impacts of drought economic vulnerability, mechanisms such as granting gratuitous or low interest loans based on farmers livelihood level, establishing small rural banks [25, 14], more governmental attention to crops insurance Hazell (2004) fund, developing and enriching local credit funds, should be regarded as high priority actions [7]. Furthermore, granting of gratuitous and low-interest loans must be reconsidered so that farmers with collaborative farming activities have more priority in receiving them. Therefore, extension education programs (short training courses on subject such as irrigation and cultivation methods) for strengthening of collaborative farming activities among farmers and development of rural associations and cooperatives can lead to reducing drought vulnerability. Farmers had the highest vulnerability in technical parameter among three major parameters namely technical, social and economic parameters so it can be said that a high priority should be placed on technical indicators of vulnerability. In this regard paying attention to educational programs is important because technical vulnerabilities mostly can be reduced by increasing farmers' knowledge and skills. Thus extension education and so agricultural organization can have a critical role in reducing technical vulnerability. In this regard designing educational programs about mechanized irrigation methods appropriate for optimum water consumption, appropriate cultivation method for drought condition, weeds, pests and diseases control is very important. Furthermore government supportive plans should be consistent with educational courses to lead to more effective technical vulnerability reduction. An up-to-date vulnerability assessment helps extension agents to plan more effective content for their educational programs. The results of this study have also contribution to drought vulnerability literature development and future studies.

REFERENCES

[1] P. Blaikie. J. *Environment and Planning*. **2000**, 32, 1033–1050.
[2] S.L. Cutter, B.J. Boruff, W.L. Shirley. *J. Social Science Quarterly*. **2003**, 84 (2), 242–261.
[3] S. Dercon. *J. Development Economics*. **2004**, 74 (2), 309-329.
[4] T.T. Deressa. Assessment of the vulnerability of Ethiopian agriculture to climate change and farmers' adaptation strategies, PhD thesis in environmental economics, Department of Agricultural Economics, Extension and Rural Development. University of Pretoria, Pretoria, **2010**. available from: http://upetd.up.ac.za/thesis/available/etd-10232010-165854/unrestricted/thesis.pdf
[5] F. Ellis., Rural Livelihoods and Diversity in Developing Countries. Oxford University Press, Oxford. **2000,** pp:44-79.
[6] S.H. Eriksen, P.M. Kelly., **2007**, Developing Credible Vulnerability Indicators for Climate Adaptation Policy Assessment. *Mitigation and Adaptation Strategies for Global Change*, 12, 495–524.
[7] P. Hazell. *J. Environment & Policy*. **2004**, 39, 385-395.
[8] A. Iglesias, L. Garrote, A. Cancelliere, F. Cubillo, D. A. Wilhite. Coping with drought risk in agriculture and water supply systems: Drought management and policy development in the Mediterranean. Springer Netherlands. *Advances in Natural and Technological Hazards Research* **2009**, 26(2), 153-159
[9] International Strategy for Disaster Reduction (ISDR). *Info.net*, **2004**, Available from: http://www.unisdr.org/we/inform/publications/657
[10] U. Kaly, C. Pratt., Environmental vulnerability index:, development and provisional indices and profiles for Fiji, Samoa, Tuvalu and Vanuatu. Phase II. SOPAC, Suva, Fiji. SOPAC Technical Report **2000**, 306, 88-89.
[11] M. Keshavarz, E. Karami, G. Zamani. *J. Iranian agricultural extension and education*. **2011**, 6 (2), 15-33.
[12] M. Keshavarz, E. Karamia, F. Vanclay, *Land Use Policy*. **2013**, 30, 120– 129.
[13] Y. Me-Bar, F. Valdez. *J. Archaeological Science*. **2005**, 32, 813-825.
[14] CH. Nelson, CL. Escalante., Toward Exploring the Location-Scale Condition: A Constant Relative Risk Aversion Location-Scale Objective Function. *European Review of Agricultural Economics*. **2004**, 31(3), 273-287.

[15] D. Nelson, W. N. Adger, K. Brown. *Annual Review of Environment and Resources*. **2007**, 32, 395-419.
[16] I. Scoones. IDS working paper, University of Sussex. Brighton. England. **1998**, 72, 1-18.
[17] L. Sengestam. *Community Development.* **2009**, 40, 154-176.
[18] S. Shahid, H. Behrawan. *J. Natural Disaster*. **2008**, 46 (3), 391-413.
[19] L. Sharafi, K. Zarafshani. *Arid regions geographic studies.* **2010,** 1(1), 106-120
[20] L. Sharafi, K. Zarafshani, *J. rural research.* **2011**, 1(4), 129-154.
[21] K. Sharp, S. Devereux., *J. Human Development.* **2004**, 5, 227-247.
[21] E. Simelton, E. D.G. Fraser, M. Termansen, P. M. Forster, A. J. Dougill., J. *Environmental science & policy.*, **2009**, 12, 438– 452.
[22] J.F. St. Cyr., *J. Homeland Security and Emergency Management*, **2006**, 2(2), 1-5. Available from: http://www.geo.mtu.edu/volcanoes/06upgrade/SocialKateG/ Attachments%20Used/AtRisk Review.pdf
[23] Statistical Centre of Iran, Population and Housing Census, Administrative units of Razavi Khorasan and their populations. (Excel- files, in Persian). **2012**, pp:1-5.
[24] United Nation Development Program (UNDP), *info.net*, **2004**, pp: 1-7. Available from: http://www.undp.org/bcpr/disred/rdr.htm.
[25] M. Vásquez-León, CT. West, TJ. Finan., **2003**, *Global Environmental Change*. 13, 159-173.
[26] O.V. Wilhelmi, D. A. Wilhite. *Natural Hazards* **2002**, 25, 37-58.
[27] D.A. Wilhite, M.D. Svoboda, MJ. Hayes., *J. Water Resources Management*, **2007,** 21, 763-74.
[28] J. Wu, B. He, A. Lu, L. Zhou, M. Liu, L. Zhao., **2011**, Quantitative assessment and spatial characteristics analysis of agricultural drought vulnerability in China. *Natural Hazards*, 56 (3), 785-80