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Drought Risk Vulnerability Parameters among Wheat Farmers in Mashhad County, Iran

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Abstract

Identification and analysis of farmers' vulnerability associated with their risk aversion degree is one of the necessary requirements for planning and reducing impacts of drought in Iran. So, this study was investigated three risk vulnerability parameters (economic, social and technical) among wheat farmers categorized in accordance with their risk aversion degree in the Mashhad County (Iran) between drought years of 2009-2011. Vulnerability parameters were determined by Delphi technique. For measuring vulnerability and risk aversion degree, formula of Me-Bar and Valdes and method of Safety First Rule were applied respectively. Findings revealed that in social vulnerability indicators; education level, collaboratively farming activities and dependency on government and in technical vulnerability; irrigation method, cultivation method and type of cultivation; risk averse farmers have had the highest vulnerability level under drought conditions. While respecting economic vulnerability, risk neutral farmers (in insuring for crops, sale prices of crops and the type of land ownership), have had the highest vulnerability level.

Keywords:
Drought, Wheat farmers, Vulnerability, Risk aversion degree

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INTRODUCTION

Drought is a slow-onset disaster that has economic, social, and environmental consequences. In Iran, drought is a re-current phenomenon and current drought management strategies in Iran are based on crisis management. For example, when drought occurs in different parts of the country, a state of emergency is declared and thus all resources are mobilized in that particular region.

However, this type of drought management strategy is proved to be ineffective. It is considerable that the year 2011 was the 13th continuous year that drought had been occurred in Mashhad County, northeast of Iran, and this has impacted most of the socioeconomic and technical dimensions of agricultural and rural sectors (The Agriculture Organization of Khorasan-e-Razavi Province, 2011). Therefore, this study is an abiding interest in how farmers cope with and overcome agricultural crises such as drought or natural disasters and provides a new and realistic vision for identifying of risk vulnerability indicators in drought. Drought risk is best defined as a combination of a location's exposure to drought and its vulnerability to drought (Ajijola *et al.,* 2011) and vulnerability is identified as the exposure to uninsured risk leading to an unacceptable level of well-being among farmers (Hoddinott and Quisumbing 2003, Hoogeveen *et al.,* 2005). Many studies (Gwimbi 2009, Deressa, 2010, Wilhelmi *et al*., 2002, Kapoor and Ojha, 2006, Barbier *et al*., 2008, Mongi *et al.,* 2010, Keshavarz *et al*., 2011) highlight geographical situations and rainfall level as key factors on farmers' vulnerability. However, people within a locality and same area are not evenly vulnerable to drought (Slegers 2008). So, there is a growing appreciation that other factors such as farmers' characteristics including levels of their risk aversion (internal risk factors) have directly influenced drought vulnerability parameters but this still has been considered by rare studies (Hoogeveen *et al*., 2005, Franke *et al*., 2005, Brondizio and Moran, 2008, Ajijola *et al*., 2011). Farmers' capacities to cope with drought, depending 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 (Scoones 1998; Ellis 2000; St. Cyr 2006) are categorized in this study in three parameters of social, economic and technical. Eakin *et al*. (2006), Deressa (2010), Ajijola *et al.* (2011), Keshavarz *et al.* (2011) and Sharafi and Zarafshani (2010 and 2011) examined the impact of risk attitudes (level of risk aversion) on poverty and vulnerability level among rural farmers. The variety of information on household human resources and income sources, production and losses to climate hazards and pests, crop and livestock management practices, commercialization practices, input and machinery use, farmers' risk mitigation practices, landholding size, and farm profit, loans, selling of crop outputs, low income level, credits, irrigation method, household extension packages and farmers' access to resources and use of them considered importance of adaptation (technology, technical assistance, credit and insurance) on farmers' capacities to respond to stress and uncertainty conditions (drought). So, the main purpose of this study was to identify the most vulnerable farmers regarding their risk aversion degree in the Mashhad County (Iran). Particular interests are as follows:

- To identify wheat farmers based on economic, social and technical vulnerability indicators.
- To calculate wheat farmers' vulnerability.
- To calculate wheat farmers' risk aversion degree and categorize them according to it.
- To determine wheat farmers' vulnerability in each category of risk aversion degree.

MATERIALS AND METHODS

This study was conducted in the Mashhad County (rural areas) located in Khorasan-e-Razavi Province, Iran. The capital of Mashhad County is the Mashhad City. This County that is located in North East of Iran and is the most populous county in *Khorasan-e-Razavi* Province. This county is 992–1184 meters above sea level. The area of this county is 1490 km^2. This county consists of 591 villages. The cultivated land of the county is 56615 km^2. This county with an arid- semi-arid and arid climate receives an average rainfall of 256 mm (The agricultural statistics and information office of *Khorasan-e-Razavi* Province, 2009). Wheat is

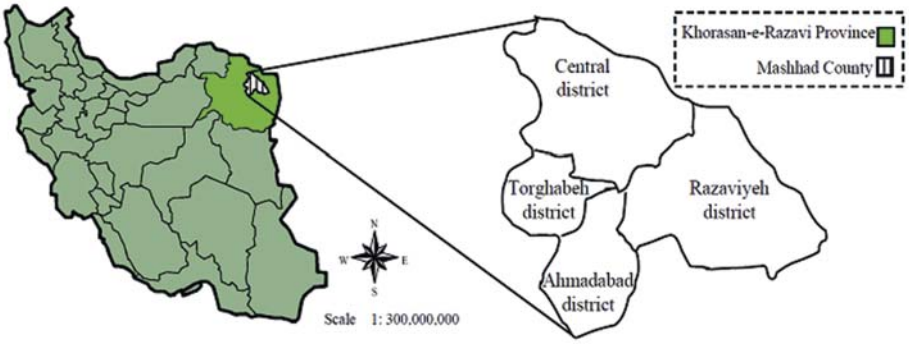

Figure 1: Area of study (Mashhad County, Khorasan-e-Razavi Province, Iran)
Reference: Statistical Centre of Iran (2012).

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

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

the dominant crop in the region, so the statistical sample of this study consisted of wheat farmers who live in *Mashhad* County. The selected region was severely affected by drought during the year 2009-2011. Mashhad County is divided into four districts (Bakhsh), with their capitals (Figure 1): Ahmadabad (capital: Malekabad), Central (capital: Mashhad), Razaviyeh (capital: Razaviyeh) and Torghabeh (capital: Torghabeh).

A proportional stratified random sampling was applied to access the respondents and using Cochran's test the size of sample was determined 293 wheat farmers (Table 1).

Two questionnaires and methods of interview were designed and used to gathering data. The first questionnaire included open questions to determine the most important socioeconomic and technical vulnerability indicators in the Mashhad County by Delphi technique. The second questionnaire was consisted of three parts. The first part was to collect data about farmers' personal and professional characteristics. The second part consisted of risk aversion indicators (according to formula of Safety First Rule). The third part consisted of vulnerability indicators was obtained through the first stage (Delphi technique) to calculate vulnerability level of farmers. This study is conducted in two main stages.

First stage (Delphi technique): This stage includes usage of the Delphi technique to identify and weigh major indicators of vulnerability in the study region as used in many previous studies (Kaly and Pratt 2000; Dercon 2004; Deressa 2010). 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 resend the questionnaires and their data was used. They were people who had field research about drought or extension experts who were directly engaged in programs or activities related to drought in the area of study. A primary questionnaire including open-ended questions (i.e. determine the most important socioeconomic and technical vulnerability indicators at Mashhad County) were distributed among experts. In the next step, first questionnaire data were used to determine and categorize common major social, economic and technical indicators with the most frequency. Acquired data were used to design another questionnaire including the primary indicators which were edited to send again to the experts to be confirmed by them. In the third step, the questionnaire was consisted of final confirmed economic, social and technical indicators and also a section for determining the weight (relative importance) (W_i=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). 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

Table 2: Status of the respondents, by the risk- aversion degree.

Risk- aversion coefficient	Status of wheat farmers	Frequency	percent
0.1 ≤ R j ≤ 1	Risk taker	52	18
-0.1 ≤ R j ≤ 0.1	Risk neutral	63	21
-1 ≤ R j ≤ -0.1	Risk averse	178	61
Total	-	**293**	**100**

stage questionnaire.

Second stage (determining farmers' risk aversion degree and vulnerability level): In this stage another questionnaire was used. Formula of Safety First Rule was used to calculate the farmers' risk aversion degree and also categorizes them in three groups (namely risk adverse, risk neutral and risk taker). Furthermore, farmers' social, economic and technical vulnerability amount was determined by method of Me-Bar and Valdez (2005).

To calculate risk aversion degree Safety First Rule formula was used. Randhir (1991), Parikh and Bernard (1988), Sekar and Ramasamy (2001), Ajetomobi and Binuomote (2006) and Ajijola *et al.* (2011) used this method in their studies in order to determine the risk-aversion degree of farmers. Because of lack of access to accurate data needed for other common methods and lack of valid and categorized databases in the studied region, the mentioned formula was applied in this study. In this formula:

$R\,j = [E^*j - E\,j] / [S\,j],\quad j = 1, 2\ldots, n$

*(R j: Risk-aversion degree of farmer (j), E*j: Critical income level of farmer (j), E j: Expected income of farmer (j), S j: The standard deviation of the farmer (j)'s annual income (in the past three years of agricultural and non-agricultural activities))*

$$E^* = 7955936\,(FAM - CHI / 2) + DPT - (UAR + UAR')$$

$$E = VP\,(1 + DMG) - TC$$

The weighted crop damage variable was defined as:

$DMG = (\Sigma k_i DMG_i) / (\Sigma k_i)$

The parts of the above formulas are as the following:

-7955936: The per capita cost of supplying the least calorie supply in one year in Rial (the standard rate in Iran).

-FAM: The household's farm size (Hectare).

-CHI: Number of children (active members of the family in working of agriculture).

-DPT: Farmer's debt amount to formal and informal institutions (IRR).

-UAR: The farmers' annual income from activities other than wheat cultivation (IRR).

-UAR': The beneficiaries' annual income from non-agricultural activities (IRR).

- Total value of wheat production (IRR).

-DMG: The proportion of farmer's damage due to losses and abnormal incidents as a weighted average.

-TC: Total wheat production cost in the same year (IRR).

Among vulnerability assessment methods, a formula suggested by Me-Bar and Valdez (2005) was considered to be 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 for which comparing societies should be measured quantitatively. Mentioned formula based on subjective assessment of factors is affecting drought vulnerability. 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) 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

Personal and professional characteristics

Among farmers, 84.5 % were men and 15.5 % were women. The most frequency of the wheat farmers education level was secondary education level which constituted 33 % of the sample and also 21 % of wheat farmers were illiterate and only 9 % of statistical population had a degree higher than diploma. The most experiences of wheat cultivation among the respondents were between 21 to 30 years. Also, by looking to the extent of farmlands, the highest frequency was related to the farmers who had 4 to 7 hectares. The average area of each farmer farmlands was 1.14 hectares and the most experiences of farming among the respondents were 31 to 40 years.

Risk-Aversion degree of respondents

In the table (2), risk-aversion coefficient (Rj) was calculated according to Safety First Rule formula. Based on the findings, 61 % of the respondents were risk averse, 23 % were risk neutral and 18 % were risk taker.

Parameters of vulnerability

Findings related to economic, social and technical parameters of vulnerability are shown in the tables (3, 4 and 5). First, for measuring indicators of any parameter, total vulnerability weight ($\sum W_i$) was calculated.

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

Indicators weight of parameters:

Findings showed that experts believed that economic parameter indicators (insuring crops (W_i=6.12), regional extension experts with economic advices (W_i=5.46), and access to governmental and bank credits (loans) (W_i=5.41)), social parameter indicators (farming collaborative activities (W_i=6.06), attending in extension

Table 3: The amount and weight of economic parameter indicators in three farmers' groups

Economic parameter indicators	Indicators weight (W_i)	Indicators amount in farmers groups (P_i)		
		Risk taker farmers (P_{i1})	Risk neutral farmers (P_{i2})	Risk averse farmers (P_{i3})
Insuring crops	6.12	1.98	3.49	2.87
Extension agents' economic advices	5.46	2.08	1.78	1.59
Farmers' incomes	4.95	2.12	1.54	2.17
Amount of liquidity	4.65	2.65	2.03	2.47
Pre-sale crops to middlemen	3.75	2.67	1.71	1.63
Sale price of crops	5.24	1.77	2.89	1.80
Land ownership type	4.82	1.54	2.75	3.26
Farming lands Size	4.60	1.63	1.57	2.04
Access to governmental and bank credits (loans)	5.41	3.25	2.68	2.74
Total	**45**	-	-	-

Table 4: Amount and weight of social parameter indicators in farmers groups

Social parameter indicators	Weight of indicators (W_i)	Indicators amount in farmers groups (P_i)		
		Risk taker farmers (P_{i1})	Risk neutral farmers (P_{i2})	Risk averse farmers (P_{i3})
Social esteem	4.93	2.63	2.63	2.56
Membership in rural associations / organizations	5.10	1.98	2.40	1.84
Dependency to government	4.77	3.27	2.65	2.62
Attending in extension education programs	5.52	1.65	3.15	1.60
Education level	5.35	2.29	1.94	3.43
Farming collaborative activities	6.06	2.21	1.67	2.76
Family members collaboration	4.81	2.50	2.15	1.97
The level of related to farming religious believe	3.82	1.85	2.13	2.11
Participation in rural development programs	4.64	1.90	2.25	2.51
Total	**45**	-	-	-

Table 5: The amount and weight of technical parameter indicators in groups of wheat farmers .

Technical parameter indicators	Indicators weight (W_i)	Indicators amount in farmers groups (P_i)		
		Risk taker farmers (P_{i1})	Risk neutral farmers (P_{i2})	Risk averse farmers (P_{i3})
Cultivation type (rain-fed/ watery)	6.06	3.03	2.37	3.00
Cultivation pattern (spring / autumn)	4.84	1.90	2.13	2.46
Cultivation method (traditional/ mechanized)	5.12	2.96	2.98	3.02
Use of drought resistant varieties	4.94	2.51	2.59	2.73
Irrigation method	5.65	2.46	3.11	3.42
Planting, saving and harvesting times	4.71	3.05	2.90	2.87
Use of chemical fertilizers	4.55	2.19	2.97	2.88
Weeds, pests and diseases control	5.29	2.64	3.19	2.90
Tillage implements	3.84	2.36	3.22	2.63
Total	**45**	-	-	-

education programs (W_i=5.52) and education level (W_i=5.35)) and technical parameter indicators (cultivation type (rain-fed / watery) (W_i= 6.06), irrigation method (W_{ii}=5.65) and weeds, pests and diseases control (W_i=5.29)), respectively were the most important indicators in order to explain parameters of vulnerability in target regions.

Indicators amount in parameters of vulnerability:

Considering the findings among risk taker farmers, the economic parameter indicators (access to governmental and bank credits (loans) (3.25), pre-sale crops to middlemen (2.67) and amount of liquidity (2.65)), the social parameter indicators (dependency to government (P_{i1}=3.27), social esteem (P_{i1}=2.63) and collaboration of family members (P_{i1}=2.50)) and the technical parameter indicators (planting, saving and harvesting times (P_{i1}=3.05), cultivation type (rain-fed /watery) (P_{i1}=3.03) and cultivation method (traditional / mechanized) (P_{i1}=2.96)), respectively were three indicators which had highest scores.

Among risk neutral farmers, the economic parameter indicators (insuring crops (P_{i2}=3.49), sale price of crops (P_{i2}=2.89) and land ownership type (P_{i2}=2.75)), the social parameter indicators (participation in rural development programs (P_{i2}=3.15), dependency to government (P_{i2}=2.65) and social esteem (P_{i2}=2.63)) and the technical parameter indicators (irrigation method (P_{i3}=3.42), cultivation method (traditional/ mechanized) (P_{i3}=3.02) and cultivation type (rain-fed / watery) (P_{i3}=3.00)), respectively had the highest intensity during drought. Also among risk averse farmers, the economic parameter indicators (Land ownership type (P_{i3}=3.26), insuring crops (P_{i3}=2.87) and access to governmental and bank credits (loans) (P_{i3}=2.74)), the social parameter indicators (education level (P_{i3}=3.43), farming collaborative activities (P_i3=2.76) and dependency to government (P_{i3}=2.62)) and the technical parameter indicators (Irrigation method (P_{i3}=3.42), cultivation method (traditional / mechanized) (P_{i3}=3.02) and cultivation type (rain-fed / watery) (P_{i3}=3.00)), respectively had the highest rank and means that during drought, these farmers have had the highest vulnerability in these indicators.

Total 6: total vulnerability amounts in farmers groups.

Vulnerability amount	farmers groups		
	Risk taker farmers	Risk neutral farmers	Risk averse farmers
Economic vulnerability	2.13	2.34	2.30
Social vulnerability	2.25	2.32	2.38
Technical vulnerability	2.59	2.83	2.90
Total vulnerability	6.97	7.49	7.58

Table 7: A summary of indicators priority in farmers groups.

Farmers groups	farmers groups		
	Economic vulnerability	Social vulnerability	Technical vulnerability
Risk taker farmers	Access to governmental and bank credits (loans) Pre-sale crops to middlemen Amount of liquidity	Dependency to government Social esteem Family members collaboration	Planting, saving and harvesting times Cultivation type (rain-fed / watery) Cultivation method (traditional/ mechanized)
Risk neutral farmers	Insuring crops Sale price of crops Land ownership type	Attending in extension education programs Dependency to government Social esteem	Tillage implements Weeds, pests and disease control Irrigation method
Risk averse farmers	Land ownership type Insuring crops Access to governmental and bank credits (loans)	Education level Farming collaborative activities Dependency to government	Irrigation method Cultivation method (traditional /mechanized) Cultivation type (rain-fed / watery)

Total vulnerability

Formula of Me-Bar and Valdez (2005) was applied to calculate total vulnerability amount. For example, economic vulnerability in risk averse farmers is calculated:

$V = 1 / C_0 \sum (P_i W_i) = (6.12 \times 1.98) + (5.45 \times 2.08) + (4.95 \times 2.12) + \ldots + (5.42 \times 3.25) = 95.63/45 = 2.13$

According to table 6, the highest economic vulnerability was among risk neutral farmers and the lowest was among risk taker farmers. With respect to social vulnerability, the highest vulnerability was among risk averse farmers and the lowest vulnerability was among risk taker farmers. Also in technical vulnerability, risk averse farmers were the most vulnerable groups and risk taker farmers were the least vulnerable groups.

DISCUSSION

This paper describes an investigation of drought vulnerability in Mashhad County (Iran). The length of drought in studied region implies that it is a harsh reality of Iran agriculture and mitigation to the severe continuous impacts of that is critical. As the results pointed out, most of the farmers are vulnerable. Therefore, farmers are being extremely stressed to find alternative appropriate mechanisms to reduce their vulnerability. Although most of the farmers are risk averse, they hardly adopt the new advises with potential risks. This means that policy makers should significantly act different from what they currently do. Findings imply that the kind and amount of vulnerability among farmers with various risk aversion degree is different, so when we categorized them in three groups named risk taker, risk neutral and risk averse, they would completely had different and general vulnerability parameters and thus unspecific supports from these groups would be inefficient.

The interesting conclusion which could be made is that there is a relationship between farmers' risk aversion degree and their vulnerability level. In other words, various effects of drought on different farmers' groups have not been considered by policy makers and managers in the studied region and thus managerial, educational and support programs have not been appropriate for these groups. In sum, findings revealed that risk taker farmers had the least vulnerability in all three vulnerability parameters named economic, social and technical parameters, while risk neutral farmers were the only most vulnerable group in economic parameter. Risk averse farmers were the most vulnerable group, because they were the most vulnerable group in two parameters named social and technical parameters. So, it can be said that they are the most vulnerable farmers. Some other parts of findings are shown in table 7.

Considering the common indicators in all three farmers groups, it can be said that as emphasized by Vásquez-León *et al*. (2003) and Nelson and Escalante (2004), in order 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, more governmental attention to crops insurance fund (Hazell, 2004), and developing and enriching local credit funds should be regarded as high priority actions.

With respect to social vulnerability, findings revealed that among risk taker farmers, dependency to government (consistent with Sharafi and Zarafshani (2011)), social esteem and family members' collaboration have had the most effect on social vulnerability. Among risk neutral farmers, attending in extension education programs, dependency to government and social esteem and education level among risk averse farmers which is consistent with Vásquez-León *et al*. (2003), Sengestam (2009) and Deressa (2010), farming collaborative activities (consistent with Iglesias *et al*. (2009)) and dependency to government have had the most effect on economic vulnerability.

With respect to technical vulnerability indicators for risk taker farmers, planting, saving and harvesting times, cultivation type (rain-fed/watery) and cultivation method (traditional/ mechanized) have had the most effect on their technical vulnerability. Among risk neutral farmers, weeds, pests and diseases control and irrigation method and among risk averse farmers, irrigation method, cultivation method (traditional/ mechanized) and cultivation type (rain-fed/watery) have had the most effects on their technical vulnerability. Hence, identification and promotion of varieties and species which are suitable for each group of farmers and also compatible with continental conditions as substitutions for crops with high water requirements, providing infrastructures for sustainable development of water resources such as draining, pressured irrigation systems and helping farmers to control pests and common diseases during drought is recommendable. The results of this study can imply that drought relief programs should be based on the rate of socio-economic and technical vulnerability among farmers' groups in term of their risk aversion. Furthermore, an up-to-date vulnerability assessment helps extension agents to plan more effective content for their educational programs.

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