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Article

Risk Factors in Various Climates of Wheat Production in Western Iran: Experts' Opinions

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Abstract: Agriculture is the origin of existence and survival in any society. However, this sector is always associated with risk and uncertainty, and farmers are faced with many challenges. Therefore, the main aim of this research was to explore the (production) risk factors of irrigated wheat production systems among farmers in Kermanshah province, Iran. The exploratory nature of this study on the one hand and the need for expert judgment on the other hand necessitated a Delphi research design. Thus, this study utilized a three-round Delphi technique. The population comprised of 10 subject-matter experts (SME) and 32 agricultural extension experts in two climates (warm and semi-arid and cold and moderate) in seven counties in Kermanshah province. A purposeful (complete) sample of 42 experts in the agricultural field participated in this study. Data were collected using a questionnaire designed on the basis of the Delphi technique. The findings indicated that, after three rounds of Delphi technique, the panel members reached a consensus on 75 factors which were categorized into biological, natural, managerial, and technological-structural groups for production risk. The results of this research provide useful insights for researchers, extension agents, and farmers.

Keywords: climate change; production risk; agricultural extension; irrigated wheat; Delphi technique

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1. Introduction

The nature of agricultural activities is mainly based on the risk, and agriculture is always known as an activity that is associated with various uncertainties and risks [1–6], because, on one hand, it depends on the nature of the weather conditions [7,8] and on the other, it has shown vulnerability against biological factors such as pests and plant diseases. Overall, climate change is expected to have an instant, negative, and stronger impact on agriculture, the food system [9], and the macroeconomy in poor countries compared with the global average (such as sub-Saharan Africa, the Middle East, and North Africa). Despite the sector's importance in terms of generating export revenue and income, this is due to current environmental conditions, less diversified and poor rural economies, and a lack of agricultural development [10,11]. However, unfortunately, producers have ignored the risk and uncertainty surrounding the production and marketing activities, resulting in high fluctuations in their income [3,12]. Therefore, identifying risk sources and ways to manage them should be investigated and given serious consideration

[13]. This means that risk management needs to be given more attention at the farm level. In agriculture, risk management has become an essential tool for farmers to anticipate, avoid, and respond to shocks [14]. However, it is preferable to identify the risk sources first. In agriculture, there are numerous and diverse sources of risk. Some risks are not predictable. Their occurrence and the damage they cause are largely unknown. Droughts and floods, for example, have a systemic component in that they affect most farmers across an entire region or country. Others, such as hail, are more sporadic and easier to collect [14].

Many risks in agriculture are observed to have various characteristics and can be classified in a variety of ways. In agriculture, Hardaker et al. [15] distinguish two types of risk: business risk and financial risk. Production, market, and institutional and personal risks are all included in business risk. Second, financial risks arise as a result of various farm financing methods. In this regard, one of the most important types of risks is the production risk. Hardaker and his colleagues go on to define several primary causes of risk in agriculture. In particular, they identify production risks stemming from the unpredictable weather and uncertainty about the performance of crops or livestock due to pests and diseases [16].

Several other researchers have studied agricultural risk factors. Kalkuhl et al. [17] investigated the link between sharecropping tenure and climate risk, as well as how it interacted with fertilizer use and livestock ownership, both of which have an impact on production risk. They discovered that farmers in low-rainfall areas are more likely to be sharecroppers. They also discovered evidence of risk management interaction effects, as sharecropping farmers are less likely to own livestock and use fertilizer. According to Miller and co-authors, the risk can be divided into four categories: production risk, price risk, casualty risk, and technological risk [18]. A different perspective on risk can be found in Smith and co-authors' study, which classifies risks based on physical and chemical factors, resources (all expressed as the amount of resource available per individual per time), disease/competition/predation, etc., and reproduction [19]. They refer to direct risk factors by providing a method for managing natural resources. According to Aimin [20], events related to climate and weather conditions, animal diseases, price changes in agricultural products, fertilizers, policy and regulatory risks, and financial uncertainties are all sources of uncertainty and risk in agriculture.

Decision-making and policy-making problems related to the management of risk factors in agriculture are exacerbated by the different perceptions of experts and farmers. Despite the scientific consensus on the existence of possible risks and solutions to deal with risk factors, it seems that farmers mostly underestimate these factors and risks and misinterpret them. This is partly due to two key facts: first, most farmers do not differentiate between risk factors. Second, most farmers consider the possibility that only climate crises can directly affect them. People tend to relate possible actions to probable consequences in a linear manner when making decisions about adaptation or confrontation with risk factors, ignoring feedback loops, delays, and nonlinearities. Farmers' awareness of risk factors in various climates, as well as their knowledge and beliefs about these factors and how they will affect them, is critical to the success of agricultural policies [21,22]. In these studies, various risk factors are quoted as being important such as climate change [5,6,23–25], rainfall pattern [23,26,27], drought [4,6,23,27–29], pests and disease [2,4,23,26], floods [27,30,31], etc. Therefore, production risk is an important component or type of farming risk [14]. Farmers from different countries live in different climatic and institutional environments, so differences in risk perception can be due to different probabilities of certain risk factors, different farmers' mentality and awareness, or a combination of both [32].

These risks also exist for wheat, the most significant agricultural product. Wheat is the most important commodity food in Iran in terms of region and importance since it is the major source of energy and protein in the local diet. Yet, its production always faces a wide range of risks, which threatens the achievement of increased production of this product [33]; during the past 40 years, Iran has experienced 27 drought occurrences [34]. Various risks associated with wheat production especially in recent years have caused many problems in rural areas. This problem has prompted researchers to look into the underlying causes in order to develop and implement effective management strategies. In recent years, wheat production methods have been closely monitored by government officials in Iran [35]. Wheat is the basis of the country's food security and the most important crop in the country, so recognizing the challenges of this product and providing scientific and technological solutions to solve it will help organize the production of this strategic product. For this purpose, the project of increasing wheat yield with the aim of improving the yield and increasing wheat productivity was launched in the 2018 crop season as educational-extension sites [36]. The basis of this project is conservation agriculture. Lack of tillage, conservation and management of residues and observance of crop rotation are its three main pillars. The general principles of wheat production with scientific methods in this project include ten basic factors: using high-yielding and certified cultivar seeds, bedding and proper planting arrangement, observing the appropriate plant density per square meter (amount of seeds consumed), planting on wide and long ridges, plant nutrition based on soil tests, development of a type of sprinkler irrigation, and principled control of pests, diseases, and weeds Despite the adoption and implementation of the aforementioned methods, and according to several studies (e.g., [37–41]), some risk factors such as non-chemical and biological controlling of invasive pests (e.g., wheat and locust age, Stem rust, and Fusarium) as well as the production and distribution of climate-resistant seeds, are not included in the national recommendations. Nonetheless, risk considerations for wheat production should be evaluated according to the farming system and diverse climates. Thus, exploring risk sources and developing risk management strategies to combat agricultural risks are extremely beneficial not only for production decisions but also for marketing decisions [3]. Understanding the origins and characteristics of specific types of risk should also lead to a risk management strategy. The goal of risk management in agricultural production should be to improve or maintain an agricultural holding's income as well as its financial and organizational stability [7]. To put it another way, good risk management entails anticipating potential problems and devising strategies to mitigate their negative consequences.

Most previous studies have used quantitative methods to focus on specific weather conditions (e.g., hot and dry or cold) to analyze risk factors. Therefore, limitations in the use of a qualitative methodology in previous research, which reflect the real view of risk factors in different climatic conditions, have led us to apply a qualitative approach (Delphi method) to fill the gap. In fact, a review of the literature (e.g., [35,36]) shows that the effect of climate change on the development of wheat cultivation as a strategic crop and staple food for most of the world's population has been studied many times. However, to the best of our knowledge, very few studies in Iran have used qualitative methods to examine the risk factors in different climates of wheat production, which is one of the innovative aspects of this study.

Overall, by predicting the extent and intensity of climate change, which can affect agricultural production sustainability, crop production changes can be specified in different regions, particularly in arid and semi-arid areas. Given that the farmers are mainly unaware of risk factors, identifying these factors can be very effective in tackling, adapting to, and mitigating the effects of climate change. Given that wheat is a staple food for more than half of the world's population, the findings of this study could have a significant impact on scientific communities. Risk factors can affect adaptation options, farmers' adaptation capacity, market fluctuations, levels of agricultural technology, genetic adaptation and plant breeding, and crop yield threshold. As a result, stakeholders and researchers must collaborate to develop criteria that will eventually become a common and agreed-upon criterion for risk analysis. Therefore, the scientific, academic, and research communities should strengthen risk analysis in the future.

Thus, this paper addresses this issue by exploring risk sources in wheat production regarding cultivation type and different climates in Kermanshah province, one of the main wheat-growing regions in Iran.

On the one hand, meteorological data show that Kermanshah province is one of Iran's riskiest provinces [37] where, according to the most recent assessment of field conditions, precipitation has decreased by 27% since 2014. On the other hand, no study has been conducted in this province, specifically on the risk sources of wheat production. Accordingly, the main research questions of this study are formulated as follows:

(1) What are the risk sources in wheat production regarding cultivation type (irrigated and rain-fed) in different climates?
(2) The relative importance of these risk sources may depend on what other issues?

2. Materials and Methods

2.1. Study Area

Kermanshah province is located in the west of Iran (Figure 1). This province, with an area of 25,000 km^2, accounts for approximately 1.5 percent of the country's total area. It has 14 counties, 28 cities, 31 districts, 86 rural districts, and 1870 residential villages [38]. According to the latest census of population in 2016, it contains 1,952,432 people [39]. The share of urban and rural areas in the total population of the province was 67.1% and 32.9%, respectively. In the rural population, most people work in agriculture. The area of agricultural land in the province is over 906,000 hectares (9060 km^2). Of this amount, 622,631 hectares (6226.31 km^2) are rain-fed land and 191,129 hectares (1911.29 km^2) are irrigated land. Among the main crops of the province, cereal products including wheat, corn, and rice account for 73% of the total. The province's agriculture provides about 4% of the country's total production. Kermanshah has different climates. Regarding the existence of different climates, this province can be divided into four regions (Table 1).

Table 1. The division of the province into four climatic regions.

No	County	Climates
1	Harsin-Sahneh-Kangavar-Songhor	Cold and moderate
2	Kermanshah-Eslam abad-Dalaho	Moderate
3	Ghasr-e shirin, Srapol-e zahab, Gilan-e gharb	Warm and semi-arid
4	Ravansar-Paveh-Javanrood-Salas	Cold

Source: Agricultural Organization of Kermanshah Province [42].

Figure 1. The geographical location of the study area.

2.2. Sampling Method

Although Delphi surveys with as few as 7 and as many as 1000 panelists have been conducted [40,41] recommends panels of 10 to 50. Given the amount of data and subsequent analyses that each panelist generates, these figures seem more appropriate. Furthermore, Gomez Paz et al. [43] suggested that a smaller sample size of 10 to 15 people might be sufficient. However, if multiple groups are involved (e.g., an international study), a larger sample will be needed, and several hundred people may be involved [44]. Above a certain threshold, heterogeneous groups can make a variety of contributions (such as increasing the complexity and difficulty of collecting data, reaching consensus, conducting analysis, and verifying results), but managing the Delphi process and analyzing the data becomes cumbersome [41].

Accordingly, the statistical population of the research was considered to be the expert groups. Therefore, the expert groups of this study consisted of the 10 subject-matter experts (SME) and 32 agricultural extension experts, who are located in 7 counties and the countryside. These individuals work in different climatic conditions (Table 2).

Table 2. Statistical population.

No.	Experts Grouping		The Study Area	Sample of Experts
1	Agricultural extension experts grouping	Warm and semi-arid	Ghasr-e shirin, Srapol-e zahab, Gilan-e gharb	15
		Cold and moderate	Harsin-Sahneh-Kangavar-Songhor	17
2	SME (subject-matter experts)		Agricultural Organization and Research Center	10
3	Total			42

2.3. Methods

The study used the qualitative method, because the research's primary goal was to identify the key factors of wheat production risk. Thus, the study was exploratory in nature, with the factors identified by expert perspectives. It is worth noting that before gathering expert opinions, a review of risk, particularly wheat risk, was conducted in order to enrich the literature review.

The exploratory nature of this study on the one hand and the need for expert judgment on the other hand necessitated a Delphi research design. Thus, this study utilized a three-round Delphi technique. The Agriculture Organization of Kermanshah provided a list of extension and research experts with a history of working on wheat production to help with preparations for the Delphi technique. Then, we contacted them to explain the research goals and clarify their cooperation. It should be noted that the experts introduced us to other experts who could help us with developing the surveys using the snowball technique [36,37]. As a result, the sample was purposefully chosen to include 10 wheat experts, 5 from the Research Center and 5 from the Agriculture Organization of Kermanshah province, as well as 21 extension and agriculture experts from 7 counties and relevant rural districts. The inclusion criteria were knowledge of wheat producers in Iran, which included both practical and theoretical expertise. These individuals were wheat production experts who had been confirmed at the provincial level. Since the main goal was to examine and determine the main sources of wheat risk in different climates, a preliminary questionnaire was created with two open-ended questions for each climate, including 'What are the main sources of risk of wheat production in the province in irrigated and rain-fed farming systems considering the regional climate?' and 'What programs have your organization implemented to help farmers deal with these risks?'. Once the questionnaire's validity was confirmed, it was distributed among experts for their feedback.

First, the participants were provided with a semi-structured questionnaire about the main sources of wheat production risk. The questionnaire was composed of three sections including (i) 5 experts in the Agriculture Organization of Kermanshah Province, (ii) 5 experts in the Research Center, and (iii) 32 extension and agriculture experts at the county and rural district levels. In addition, to consider their opinions, the participants were asked to write their opinions down. Following the collection of responses, the open-coding method was used to analyze the results of responses.

Traditionally, the Delphi process begins with an open-ended questionnaire [44,45]. Similarly, our initial round started with two open-ended questions, and another two rounds of Delphi surveys were conducted to achieve experts' consensus; each round was based on the results of the preceding ones. In other words, the results of the first round were categorized and synthesized to be used in the second and third rounds.

It should be mentioned that this study is a part of the research project that was performed in both qualitative and quantitative phases. The opinions of experts and researchers in various climates were used in the qualitative phase, and the results were provided to the farmers in the next phase, i.e., the quantitative phase. Fortunately, all the results derived from the experts' consensus were also supported by the farmers. As a result, we did not overlook their contributions. However, because the research emphasized the qualitative phase and the experts' perspectives, we restricted the manuscript to this phase.

According to the general goal, the semi-structured interviews were designed. In the first round, experts were asked to comment on the main sources of production risk of wheat. After collecting responses, an open-coding process was used to analyze the results. In this way, similar views were combined. Repetitive issues were given the same code and answers were summarized. Final results of this round along with the results from the review of literature helped to design the research instrument in the next round. In the second round, experts were provided with the results obtained in the first round and asked to review their ratings and add other factors they think must be considered. New ideas emerged at this round. In this round, the rules of Choi and Sirakaya were used to analyze the scores of factors yielded by the survey. According to this rule, if the mean score factor is f ≥ 3.5 and SD ≤ 1, then factor f is accepted, and if the mean score factor is f < 3.5 and SD > 1, then factor f is not accepted [46]. In the third round, to determine the percentage of final consensus, the second-round questionnaire was sent to 42 experts and they were requested to rate the factors in terms of "agreement" or "disagreement" attribute. This questionnaire was designed to confirm experts' opinions. During this round, experts presented the individual and group results from the second round. In this round, the agreement rate was considered to be 80% according to Roberts and Dyer [47]. All factors that did not receive 80% approval from the panel of respondents were removed from the source list. Finally, all of the sources and factors were classified.

3. Results and Discussions

3.1. First Round

I. Experts' view in the cold and moderate climate

This climate includes Sahneh, Harsin, Kangavar, and Sonqor counties where 17 experts participated in the study. The results of this section indicated the identification of 32 main sources of production risk of irrigated wheat. The highest frequency was related to sources such as heavy rains and Eurygaster integriceps pest (94.1%). After these sources, the most frequent sources were as follows: non-observance of crop rotation and continuous crop cultivation, weeds, late cultivation in the years when effective rain occurs late, fungal diseases, and drought (88.2%) (Table 3).

II. Experts' view in the warm and semi-arid climate

This climate includes three counties, namely Sarpul-e-Zahab, Qasr-e-Shirin, and Gilan-e Gharb, where 15 experts were benefited from participation in the study. The results of this section revealed that 17 factors of production risk of irrigated wheat were identified. The results are shown in Table 3. As shown in the table, the highest frequency was related to sources such as Eurygaster integriceps pest (86.6%). After this source, the most frequent sources were as follows: cultivation date (80%), drought (73.3%), dust, the particular pest outbreak, wheat stripe rust disease, and low rainfall (66.6%). These research findings are corroborated by the results of Kahan [23], Ullah et al. [4], and Riwthong et al. [2].

III. Experts' view in the Agricultural Organization and Research Center

The results of this section indicated the identification of 32 main sources of production risk of irrigated wheat. Subject-matter experts were referring to factors such as drought stress, late spring frost, inappropriate distribution of precipitation due to climate change, new cereal diseases, pesticides, weed resistance, common bunt disease (Tilletia laevis), weeds, storm, lack of access to machinery, no timely supply of inputs, sudden weather changes, lack of proper planting management, wheat cultivars (varieties), timely irrigation, low efficiency of irrigation systems, high seed density, late irrigation, planting in an inappropriate bed, and inappropriate time to fight with weeds (Table 4).

3.2. Second Round

In this phase, "wild radish weed" was added to the warm and semi-arid climate with the frequency of 2 (13.3%) and "sudden warming of the weather in June" by SME with the frequency of 3 (30%). The total source of risk of irrigated wheat in warm and semi-arid climates reached 18 and in the SME into 33 sources. In the next step, a structured questionnaire was designed. The questionnaire included the main sources of wheat risk in different climates and was then sent to the experts in each climate and they were asked to identify the importance of each item in the Likert scale. Therefore, in this phase, the ratings of comments were made (Tables 3 and 4).

Table 3. Production risks of wheat in the first to third round of Delphi (experts' opinions in two climates).

Cold and Moderate						Warm and Semi-Arid					
Production Risks	**First Round**		**Second Round**		**Third Round**	**Production Risks**	**First Round**		**Second Round**		**Third Round**
	Frequency	**Percentage (%)**	**Mean**	**S.D**	**Consensus (%)**		**Frequency**	**Percentage (%)**	**Mean**	**S.D**	**Consensus (%)**
Fungal diseases	15	88.2	4.71	0.11	100	Low rainfall	10	66.6	4.8	0.1	100
Seasonal river drying	12	70.6	4.24	0.13	100	Zabrus tenebrioides goeze (pest)	4	26.6	4.53	0.21	87
Late wheat cultivation in the years when effective rain occurs late	15	88.2	4.65	0.11	100	Amphimallon caucasicum gyll (pest)	4	26.6	4.47	0.19	87
Lack of adequate water in planting season	8	47.05	3.82	0.15	95	Eurygaster integriceps (pest)	13	86.6	4.93	0.06	100
Lack of adequate water during growth	8	47.05	3.76	0.16	95	Wheat stripe rust disease	10	66.6	4.73	0.11	100
Winter frost	13	76.5	4.29	0.14	100	Take-all disease	7	46.6	4.6	0.16	94
Hail	8	47.05	3.76	0.16	89	Wild oat (weed)	7	46.6	4.67	0.15	94
Heavy rains	16	94.1	4.94	0.05	100	Cultivation date	12	80	4.87	0.09	100
Eurygaster integriceps (pest)	16	94.1	3.71	0.05	100	Heavy rains in some years	5	33.3	4.6	0.19	87
Polyphylla ollivieri (pest)	6	35.3	3.53	0.12	89	Hail	3	20	4.07	0.18	87
Zabrus tenebrioides goeze (pest)	7	41.2	4.53	0.15	85	Frostbite	3	20	3.93	0.2	94

Rodents (e.g., mice)	13	76.5	4.53	0.12	100	Inappropriate equipment	4	26.6	4.4	0.19	94
Wheat stripe rust (disease)	12	70.6	4.12	0.14	100	The outbreak of a particular pest	10	66.6	4.73	0.11	100
Take-all disease	13	76.5	4.41	0.12	100	Flood	4	26.6	4.37	0.2	87
Weeds	15	88.2	4.82	0.09	100	Drought	11	73.3	4.8	0.1	100
The small size of farmland	5	29.4	3.24	0.1	-	Dust	10	66.6	4.67	0.12	100
Frostbite	6	35.3	3.55	0.11	85	Rodents	9	60	4.67	0.12	100
Non-observance of crop rotation and continuous cultivation	15	88.2	4.76	0.1	100	Raphanus sativus wild radish (weed)	-	-	3.87	0.21	67
Flooding farms due to lack of proper drainage	9	52.9	3.88	0.14	100	-	-	-	-	-	-
Non-optimal use of fertilizers and chemical pesticides	10	58.8	4.06	0.16	95	-	-	-	-	-	-
Low productivity of water resources by using irregular water systems	9	52.9	3.88	0.14	83	-	-	-	-	-	-
Climate changes	14	82.4	4.59	0.12	100	-	-	-	-	-	-
Drought	15	88.2	4.65	0.11	100	-	-	-	-	-	-
Reduced level of groundwater	13	76.5	4.53	12	100	-	-	-	-	-	-
Low fertility of land due to high use of farms	10	58.8	3.88	0.14	95	-	-	-	-	-	-

The negative balance of water	5	29.4	3.29	0.11	-	-	-	-	-	-	-
The introduction of varieties with low water requirements	4	23.5	3.18	0.09	-	-	-	-	-	-	-
Inappropriate rainfall in autumn and spring	10	58.8	3.94	0.13	100	-	-	-	-	-	-
The wind speed during the growth period	7	41.2	3.53	0.15	83	-	-	-	-	-	-
Average temperature	7	41.2	3.59	0.12	83	-	-	-	-	-	-
Late harvest of the previous product	5	29.4	3.29	0.11	-	-	-	-	-	-	-
High temperature at the end of the season	8	47.05	3.65	0.14	89	-	-	-	-	-	-

Source: Survey findings.

Table 4. Production risks of wheat in the first to third round of Delphi (experts' opinions in the Agricultural Organization and Research Center SME).

Production Risks	First Round		Second Round		Third Round
	Frequency	Percentage (%)	Mean	S.D	Consensus (%)
Drought	10	100	5	0	100
Drought stress	8	80	4.4	0.16	100
Wheat stripe rust (disease)	8	80	4.3	0.15	100
Late spring frost	5	50	4	0.20	90
Take-all disease	80	80	4.2	0.20	90
Inappropriate distribution of precipitation due to climate change	10	100	5	0	100
New cereal diseases	5	50	4	0.21	100
Water shortage	7	70	4.1	0.23	90
The outbreak of rodents	9	90	4.6	0.16	100
Pesticides	9	90	4.7	0.15	100
Weed resistance	5	50	3.9	0.18	90
Common bunt	4	40	3.1	0.18	-
Eurygaster integriceps (pest)	10	100	4.8	0.13	100
Weeds	10	100	4.8	0.13	90
Flood	5	50	3.9	0.18	90
Hail	4	40	3.6	0.16	90
Frostbite	7	70	4.2	0.20	90
Storm	4	40	3.6	0.16	90
Lack of access to machinery	5	50	3.8	0.20	90
Untimely supply of inputs	5	50	3.7	0.15	80
Sudden weather changes	9	90	4.5	0.16	100
The outbreak of some pests in some years	7	70	4.1	0.18	100
Lack of proper planting management	7	70	4.1	0.18	100
Wheat varieties	5	50	3.7	0.15	80
Non-observance of crop rotation	10	100	4.8	0.13	100
Untimely irrigation	5	50	3.6	0.16	100
Low efficiency of irrigation systems	5	50	3.6	0.16	80
Stealing irrigation equipment	3	30	3.2	0.13	-
High seed density	8	80	4.4	0.16	100
Inappropriate time to irrigation	6	60	4.1	0.23	100
Planting in inappropriate bed	5	50	3.7	0.15	100
Inappropriate time to fight weeds	5	50	3.7	0.15	100
Sudden warming of the weather in June	-	-	4	0	90

Source: Survey findings.

As indicated in the table, in warm and semi-arid climates, Eurygaster integriceps (pest) with the mean score of 4.93 (M = 4.93, SD = 0.06), cultivation date with the mean of 4.87 (M = 4.87, SD = 0.09), drought and low rainfall both with the mean score of 4.80, and standard deviation of 0.10 had the highest average among other factors. After these factors, wheat stripe rust disease, the outbreak of a particular pest, dust, rodents, etc., had an average higher than 4 and were recognized as the main sources of production risk. Radish weed which was recently added to resources achieved the lowest average (M = 3.87, SD = 0.21). This result shows that this weed exists only in a particular part of the region zone, but according to Roberts and Dyer [47], their mean score is above 3.5; thus, this case has not been removed and is known as a less important resource than other options. In the cold and moderate climate, all sources had an average above 3.5, with the exception of four sources (the small size of farmland, the negative balance of water, lack of introduction of varieties with low water requirements, and late harvest of the previous product). According to the SME view, all the factors achieved a mean score above 3.5, except for ustilago sp. disease (M = 3.10, SD = 0.11) and stealing irrigation equipment (M = 3.20, SD = 0.13), which is a necessary condition for entering the third phase.

3.3. Third Round

In this round, a strong consensus was reached on most of the factors with the exception of wild radish weed by consensus of 67% in warm and semi-arid climates which was removed from the consensus list (Tables 3 and 4).

3.4. Classification and Discussion

Exploring the risk sources and designing the risk management strategies to combat agricultural risks are very useful for not only making production decisions but also for marketing decisions [3]. In this regard, the classification of extracted resources can be helpful. Hence, the classification of the main production risk factors for irrigated wheat was the ultimate goal of this research. To achieve this goal, the factors identified by the experts were categorized into four groups (after eliminating items with consensus less than 80%). Thus, according to the SME, 30 main factors were entered into 4 categories (biological (7), natural (10), managerial (9), and technological-structural (4)). In warm and semi-arid climates, out of the 18 identified factors, 17 factors remained as the main factors in 4 categories (biological (8), natural (7), managerial (1), and technological-structural (1)). In cold and moderate climates, 28 identified factors were entered into the categories of biological (8), natural (13), managerial (5), and technological-structural (2) (Table 5). The results of this classification revealed that most of the factors introduced by the experts in warm and semi-arid climates belonged to the groups of biological and natural factors and only two were related to the managerial and technological categories.

Table 5. Classification of resources of production risk.

	Categories	Factors (Sources)
SME· S view	Biological (Pests, disease, and weeds)	Eurygaster integriceps (pest)
		The outbreak of a rodents
		Wheat stripe rust disease
		Take-all disease
		The outbreak of pests
		New cereal disease
		Weeds
	Natural	Drought stress
		Inappropriate distribution of precipitation due to climate change
		Sudden weather changes
		Frostbite
		Water shortage
		Warm weather in June
		Late spring frost
		Flood
		Storm
		Hail
	Managerial	Continuous cultivation and crop rotation
		Weed resistance
		Pesticides
		High seed density
		Lack of proper planting management
		Delay in irrigation
		Planting in inappropriate bed
		Inappropriate time to fight weeds
		No timely irrigation
	Technological-Structural	No timely supply of inputs
		Low efficiency of irrigation systems
		Wheat varieties
		Lack of access to machinery
Extension agent in warm and semi-arid	Biological (Pests, disease, and weeds)	Eurygaster integriceps (pest)
		The outbreak of a particular pest
		Wheat stripe rust disease
		Rodents
		Wild oat (weed)
		Take-all disease
		Zabrus tenebrioides goeze (pest)
		Amphimallon caucasicum gyll (pest)
	Natural	Dust
		Drought
		Low rainfall
		Heavy rains in some years
		Flood
		Hail
		Frostbite
	Managerial	Cultivation date
	Technological and Structural	Inappropriate function of planting and harvesting equipment
Extension agent in cold and moderate	Biological (Pests, disease, and weeds)	Eurygaster integriceps (pest)
		Weeds
		Fungal diseases
		Rodents (e.g., mice)
		Zabrus tenebrioides goeze (pest)
		Take-all disease
		Wheat stripe rust (disease)
		Polyphylla ollivieri (pest)
	Natural	Heavy rains
		Drought
		Climate changes
		Seasonal river drying
		Winter frost

	Inappropriate rainfall in autumn and spring
	Lack of adequate water in planting season
	Lack of adequate water during growth
	Hail
	Frostbite
	High temperature at the end of the season
	Average temperature
	The wind speed during the growth period
	Crop rotation (continuous cultivation)
	Late wheat cultivation
Managerial	Reduced level of groundwater
	Non-optimal use of fertilizers and chemical pesticides
	Low fertility of land due to high use of farms
Technological and Structural	Flooding farms due to lack of proper drainage
	Low productivity of water resources by using irregular water systems

Source: Survey findings.

The results for natural factors such as drought are similar to the previous research [4,6,23,27–29]. Drought is one of the main sources of risk that has been mentioned in most studies. It should be noted that drought, as one of the most important natural disasters, has many economic, social, and environmental costs. Furthermore, it is a natural and recurring phenomenon of climate. Although climatic factors are known as the main cause of drought, one should not neglect the role of other factors, such as the mismanagement of water resources, deforestation, land degradation, etc. While the weather and climate vary greatly among the region's major agricultural areas, drought is a constant that almost all farming communities must contend with [6].

The same is true for biological factors such as pests and diseases. The results for biological factors such as pests are similar to the previous research [2,4,23,26]. To address this issue, crop rotation can be effective. It is one of the most effective methods of agricultural cultivation. The continuous cultivation of a plant in one piece of land increases the number of pests, diseases, and weeds. Therefore, research centers can solve this problem with the introduction of alternative products, which are suitable for climatic conditions, and with this activity, they control pests, diseases, and weeds. Similarly, the findings of our study show that floods and heavy rains were major sources of risk. This result is also confirmed by Ullah et al. [4], who have stated that floods and heavy rains are common causes of dangerous and catastrophic climate crises. In the cold and moderate climate, experts believed that natural factors have the greatest impact on production risk, followed by biological and managerial factors [6].

However, it is interesting to note that SME consider the impact of all factors somewhat the same. The natural and managerial factors were at the head of these factors. They have considered the technological-structural factor important (Figure 2). Therefore, it is suggested that, by taking into account the risk factors in different climates, planners consider the climatic conditions of the region while planning for risk management. In managerial issues such as declining soil fertility, Yaghoubi et al. [48] achieved the same result in their study. They consider the decline in soil fertility as a risk factor for rain-fed wheat. It seems that excessive use of fertilizers and chemical pesticides, as well as excessive utilization of agricultural land, leads to a decrease in soil fertility. Salvati and Carlucci [49] achieved similar results. They demonstrated a two-step procedure to assess the risk of land degradation in agriculture, stating that a number of factors contribute to land degradation, including climate dryness and soil deterioration, as well as unsustainable agricultural practices and rising human pressures, all of which trigger processes that lead to desertification. Therefore, it is recommended that planners and policymakers in the agricultural sector consider the conservation management programs and incentive policies to successfully preserve natural resources.

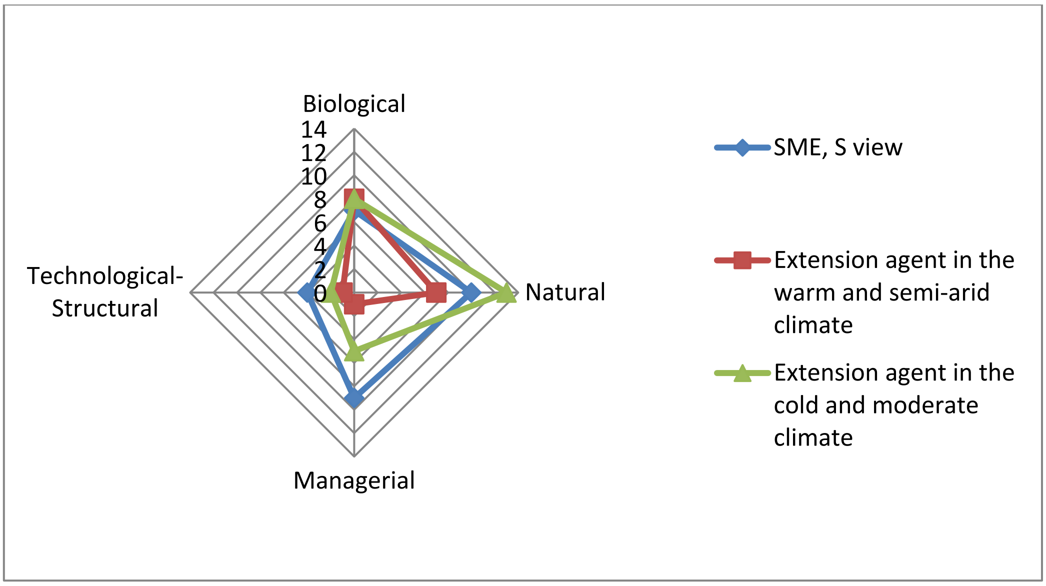

Figure 2. Classification of resources of production risk.

The findings revealed that irrigation system inefficiency was a key source of hazard. This finding is comparable to that of a prior study in which Alizadeh et al. [50] showed that irrigation utilization efficiency in agriculture is low, which indicates special attention to improving efficiency. It should be noted that the analysis of agricultural water consumption indicators reveals high water losses in this sector, which can be corrected with proper management. Extension services have provided the necessary knowledge in some cases, assisting farmers in adapting and implementing viable solutions, allowing them to reap greater benefits from irrigation technology [51]. According to the results, lack of access to machinery was a major source of risk. In line with this finding, Akcaoz and Ozkan [26] showed that insufficient machinery was referred to as 'production and technological risk'. It is now widely accepted that mechanization is a necessary component of increasing labor and land productivity. Along the value chain, mechanization can also be used to add value to primary products and create employment and income opportunities [52]. Applying new environmentally friendly technologies enables farmers to produce crops more efficiently by using less power. Therefore, it is expected that the government and mechanization companies will prevent this obstacle by providing the necessary equipment before the start of the planting season.

4. Conclusions

The findings indicated that, after three rounds of Delphi, the panel members reached a consensus on 75 factors which were categorized into biological, natural, managerial, and technological-structural for production risk. Given that natural and biological variables have the greatest impact on production risk, management strategies should be developed to reduce environmental impacts. Agriculture is one of the few activities where chemicals are intentionally released into the environment because they kill living organisms that exist in the soil. While agricultural use of chemicals is limited to a small number of compounds, it is one of the few activities where chemicals are intentionally released into the environment because they kill living organisms that exist in the soil. Pesticide contamination of water and soil, negative effects of pesticides on agriculture's natural resource base, and bioaccumulation and its effects on wildlife are the main environmental concerns about pesticides. It is well understood that pesticide overuse and other inappropriate uses can exacerbate the pest problem (e.g., destruction of natural pest enemies, development of pesticide resistance, etc.) and lead to more pesticide use. Therefore, to reduce the negative effects of chemical toxins on the environment, more actions should be taken to introduce biological inputs. This necessitates farmers' education and information. As a result, agricultural extension specialists should organize training sessions to teach farmers how to handle pesticides and biological fertilizers while also raising farmers' awareness. Furthermore, because biological inputs are expensive, it is proposed that the government encourage farmers to utilize them by giving government subsidies. Furthermore, the development of new wheat cultivars should be considered because developing the comparative advantage of new improved varieties over old, improved varieties on farms is critical in order to quickly deliver new, improved varieties to farmers. The purpose of introducing these new cultivars is to increase productivity under drought conditions and climate change. Similarly, the interactions between research, extension, and farmers should be considered. The finding of this study showed that the SME considers the impact of all factors somewhat the same, but the agricultural extension experts in two climates consider the natural and biological factors more effective than other factors. The natural and managerial factors were at the head of these factors. Farm management factors (e.g., continuous cultivation and crop rotation, high seed density, lack of proper planting management, inappropriate time to fight weeds, untimely irrigation, excessive use of groundwater resources, etc.) were identified as the main risk sources by the experts. In this context, the interaction between extension and farmers is helpful. Extending the cooperation among farmers helps them design an optimum risk management strategy in the research area. To address the risks caused by farmers' mismanagement on farms, the extension sector must be activated and provide practical training to remove the barriers of wheat production.

Some risk management practices of wheat production in Iran include implementing crop rotation, choosing varieties with resistance to disease and insect pests, planting on time (not too early, not too late) in a well-prepared seedbed, compulsory product insurance, guaranteed product purchase, training, and further communication with the research department in order to produce resistant and compatible cultivars.

Following the recent droughts, which resulted in numerous psychological and financial losses, it appears that most wheat farmers in the region are hesitant to take risks and prefer to be cautious. In such circumstances, it is critical to look into the psychological causes of risk aversion and possible solutions in order to help wheat farmers cope with drought and economic hardship in the region. As a result, helpful recommendations for wheat farmers to improve risk management in wheat production are provided. These recommendations include developing appropriate agricultural technologies, reducing risks, strengthening government support in terms of credits and loans, allocating supportive subsidies to poor wheat farmers, improving the administrative and legal process for wheat farmers seeking loans, and reinforcing and supporting cultural products insurance cases in wheat cultivation. Furthermore, purposefully leading the training of wheat controllers in the region to risk management, prevention, and control methods, as well as paying attention to wheat farmers in the region's awareness programs related to farmland insurance, can be beneficial. Climate change will, in general, affect wheat production in the future, and it will decrease in the studied region.

Agricultural production is a high-risk business. Every year, Iranian farmers face unexpected and untimely rains, floods, chilblain and frost, hail, drought, vegetable pests, and other natural disasters, and on average, they suffer significant economic losses as a result of these events, which are sometimes irreversible within the household economy of farmers. As a result, one of the most important issues in wheat production areas in Iran and other wheat-growing parts of the world is recognizing the factors that influence risk management of wheat farmers' production. We hope that the findings of this study can motivate discussions and trigger more research on the impact of climate change and crop productivity in Iran. Moreover, the results are also relevant for neighboring regions which have similar environmental conditions, and thus, face similar challenges related to future climate change. Such discussions are of scientific value and merit wider attention because of the global importance of grain production. As a result, greater empirical data in dealing with climate change challenges are critical for the international community to provide a sustainable supply of grain production for global markets.

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