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PRODUCTION RISK MANAGEMENT IN IRRIGATED AND RAINFED WHEAT FARMING

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ABSTRACT

This research presented a model for wheat production risk management in irrigated and rainfed farming systems among wheat farmers in Kermanshah province, western Iran using the survey technique, and the descriptive-correlational method for data collection and analysis. The statistical population was all wheat farmers (N = 102,000) of which 383 individuals were sampled by the stratified random sampling technique with a proportional allocation. From the questionnaire survey, all variables composite reliabilities were more than 0.7. The finding showed that the proposed model could make better predictions for the irrigated system (R^2 = 0.78) than for the rainfed system (R^2 = 0.50). The results give a new insight to researchers in research centers, extension agents, and farmers because the expansion of the cooperation of stakeholders in developing optimal strategies of risk management can be very effective so that those in charge can develop better plans by considering different sources of risk depending on the farming system.

Disciplinary: Agricultural Extension and Education.

1. INTRODUCTION

Agriculture plays a crucial role in food security and economic stability of societies to an extent that it is known as the survival factor of societies. However, efforts in this important economic sector of the world are always posed to risk because it depends on nature and climatic conditions on the one hand and is vulnerable to biological variables such as pests and diseases on the other hand. This has been underlined by many researchers [3, 8, 9, 11-14, 16, 18-22, 28]. Therefore, understanding the hazards and risks and ways to manage them is an issue that should be considered [25, 26, 30],. This is also true for various crops and the most important crop of the agricultural sector in Iran – wheat. Based on a report by Iran's Ministry of Agriculture, of about 11 million ha of

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planting area, 7.6 million ha (69.55%) is cultivated by grains among which wheat has the highest acreage [1]. Although wheat is the main staple crop in Iran with a significant role in people's food regime and plays a significant role as a strategic commodity in food security, sustainable rural livelihood, and sociopolitical independence of the country, its production is posed to a wide range of risks that threaten the improvement of the production of this crop [32].

However, investigating the risk factors of crops for the aim of their management is a well-established principle and an important step in research on agricultural development so that it can contribute to propose approaches to increasing farmers' adaptability and reducing their vulnerability against risks in the main wheat-producing regions. Having 411,000 ha of wheat farms, Kermanshah province is a leading wheat-producing region in Iran (Agriculture Statistics Book, 2018). It accounts for 8% of the total wheat acreage in Iran. However, it has been shown that once in a while, factors like drought, chilling, the outbreak of a certain pest and so on strike some regions and inflict heavy losses to crops including wheat and consequently to rural communities, so the production of these crops has always been posed to risks. In this respect, meteorological statistics of the recent decade in Kermanshah province show that the province is at the top of the list of provinces most frequently struck by disasters [15]. As such, this research explored a wheat production risk management model based on the farming system in the Kermanshah province of Iran.

2. THEORETICAL FRAMEWORK

From the agricultural perspective, risk has been considered by global circles since 1933. On the other hand, risk assessment and management in agriculture is very complicated. Risks that farmers faced are originated from many sources. Air, soil conditions, diseases, insects, pests, birds, rodents, livestock, and weeds are examples of these sources. Risk management refers to the selection of methods and solutions to alleviate the impacts of changes.

Within the context of risk management, studies have focused on farmers' behavioral strategies in risky conditions, including practical ways adopted by farmers to control or mitigate risks and improve agronomic conditions. They have been enumerated in the literature as to include crop diversity, the use of resistant cultivars, the cultivation of alternative crops with lower risk, attendance in educational-extension courses, insurance, and so on. The work [20] listed some of these strategies as appropriate farm location, proper sowing date, crop and cultivar diversification, search for alternative income resources, and the selection of sustainable agronomic techniques. Another strategy is to partially transfer the risk to organizations and to make guaranteed agreements and crop insurance. In this respect, some researchers have highlighted the role of personal, agronomic, economic and social factors in risk management. In e.g. [17], farm owners have more risk-taking capability than the others. Also, variables like income, educational level, and farm size are positively and significantly related to risk-taking and the adoption of new technologies. In [23], farmers respond to risk differently depending on their agronomic system, farm size, and income level. While [12] perceive that age is an important factor for people's risk aversion. Some have also revealed a significant relationship between farmer attitude with his/her income, farm size, and educational level. Noted in [10] that socioeconomic variables were influential on risk perception and management and mentioned that assets and insurance were the main risk management strategies. Marine and his colleagues addressed the role of training programs held by the extension service [24]. In a study on factors influencing the adoption of improved potato cultivars, [2] found that higher educational levels of the family head and access to media had positive impacts on the adoption of improved cultivars. Nonetheless, other factors, e.g. farmer perception and attitude, should not be neglected as perceptions precede behavior. Attitudes can be regarded as an individual's positive or negative assessment of behavior. The more positive the assessments are, the more willing the individuals will be to display a specific behavior. But, since knowledge and awareness by themselves cannot signify a good or bad behavior or performance and the reality is much more complicated than this linear trend, so other mediator factors should also be considered. Based on the theoretical framework, some of these variables include personal, social, economic, agronomic characteristics as well as communication channels.

3. METHODOLOGY

This research is a quantitative study, an applied study in terms of objective, and a descriptive-correlational study in terms of surveyed data collection methodology. The statistical population was all wheat growers in Kermanshah province, western Iran (N = 102,000). The sample size was 383 by the Krejcie and Morgan table and was taken by the multi-stage stratified random sampling technique with proportional allocation. Given the population ratio in each stratum, 313 individuals were taken from the rainfed stratum (81.7%) and 70 individuals from the irrigated stratum (18.3%). The alpha was in the range of 0.73-0.94.

4. RESULTS

Most farmers (91%) were the sole owner. The lowest farm size was 1 ha in the rainfed system and 0.5 ha in the irrigated system and the highest were 41 and 32 ha, respectively. Most farmers in both systems were at the intermediate level that 68.6% of rainfed farmers and 74.1% of irrigated farmers were placed in this group. The mean age was 48.2 years with SD 10.6 years, showing that most participated farmers were middle-aged. Over half of the sample was illiterate so that the educational level of over 60% was under diploma. Farming was the main job of most participants (92.7%). The participants had been a farmer for, on average, 26 years with SD 12.4 years (Table 1).

Table 1: Demographic characteristics of the farmers

Variables		Frequency	Percent (%)	Min	Max	Mean	SD.
Type of cultivation	Irrigated	70	18.3	-	-	-	-
	Rainfed	313	81.7	-	-	-	-
Type of tenure	Own farm	348	90.9	-	-	-	-
	Hiring	26	6.8	-	-	-	-
	Both of them	9	2.3	-	-	-	-
Age (year)	r≤30	10	2.7	28	75	48.2	10.6
	31-45	180	47.7				
	46-60	134	35.5				
	r>60	53	14.1				
Education	Illiterate	35	9.1	-	-	-	-
	Primary level	72	18.8	-	-	-	-
	High school	132	34.5	-	-	-	-
	Diploma	120	31.3	-	-	-	-
	Academic education	24	6.3	-	-	-	-
Agricultural experience (year)	r<20	174	45.4	4	55	26	12.4
	r≥20	209	54.6				
Main job	Agriculture	355	92.7	-	-	-	-
	Other	28	7.1	-	-	-	-

After the demographic characteristics, the use of educational-extension programs by farmers was explored (Table 2). It was found that the items like attendance in agricultural exhibits, interaction with academic centers, and using informing SMS and radio broadcasts did not have high averages among farmers.

Table 2: Average use of educational-extension programs and services

No.	Use of educational-extension programs	Mean	SD.	Rank
1	Interaction with experts in agricultural service centers	2.59	1	1
2	Interaction with the extension unit	2.25	1.1	4
3	Television programs	1.89	1.2	8
4	Radio broadcasts	1.55	1.2	13
5	Agriculture related websites	1.79	1.9	10
6	Using informing SMS	1.46	1.2	14
7	Interaction with input suppliers	1.94	0.8	7
8	Interaction with informant key and extension agent	2.43	0.9	3
9	Production cooperatives	1.18	0.9	16
10	Interaction with academic centers	1	1	18
11	Participation in workshops and courses	2.07	1.2	5
12	Demonstration farms	1.80	1.1	9
13	Educational journals and brochures	1.77	1.2	11
14	Technical-consulting services companies	1.76	1	12
15	Attendance in agricultural exhibits	1.45	1.1	15
16	Interaction with other organization	1.03	1.1	17
17	Pattern site tags and learning centers	1.96	1.1	6
18	Farmers of leader	2.47	0.9	2
	Total Mean	1.76		

On the other hand, since farmers employ various mechanisms to counteract risk, the types of strategies to adapt to wheat production risk were assessed on the Likert scale to identify the relative importance of individual strategy versus the other strategies. To this end, the adaptation strategy index (ASI), put forth by Uddin et al. (2014), was used in which a coefficient is assigned to each strategy based on its importance. To identify those adaptive strategies which held relative importance over others, an adaptation index procedure was implemented as measured by the following formula:

$$ASI = AS_n \times 0 + AS_l \times 1 + AS_m \times 2 + AS_h \times 3 + AS_{vh} \times 4 \quad (1),$$

where

ASI = Adaptation strategy index,

AS_n, AS_l, AS_m, AS_h, AS_{vh} = Frequency of farmers rating adaptation strategy as having no, low, moderate, high and very high importance.

Farmers in the study area managed risk by implementing practices that would reduce their exposure to risk. The results are shown in Table 3.

Out of 35 adaptation strategies, the use of disinfected seeds was ranked the first among farm adaptive measures, while cooperative cultivation was ranked as the least frequently utilized. The results show that few farmers use windbreakers, water transfer systems, soil conversation techniques, and diversification as risk management strategies. Although the results of [6, 17, 28, 35] have shown that one of the most important strategies to cope with risk is diversification. Also, according to Table 3, crop rotation is the most important strategy to cope with risk. This is consistent with [29], that the majority of food crop farmers use enterprise diversification to include mixed farming (85%), mixed cropping (80%), and crop rotation (72.5%).

Among risk management strategies, the ones considered the most included the use of disinfected and modified seeds, the application of crop rotation, more irrigation rates, the change in planting time, the application of fallow, and participation in training courses. These strategies have been considered in other studies, too. For example, Ellis believes that irrigation is not only a risk management strategy but it also has a major impact on output through it's complementarily with multiple cropping and improved seeds during cultivation [7]. Participation in training courses must learn a risk coping strategy. Noted that extension along with other factors will provide a satisfactory result. Extension agents should be trained about the vulnerabilities of farmers to be able to help farmers manage risks.

Table 3: Farmers copping strategies to deal with risk and ranked order of the adaption strategies

Strategies	Importance of Your Farm					ASI	Rank
	No	Low	Medium	High	Very high		
Use of modified seeds	-	3	48	143	189	1284	2
Use of disinfected seeds	-	1	63	95	223	1304	1
The change in planting time	17	46	138	70	111	976	5
Crop rotation	11	32	70	110	160	1142	3
Use drainage on arable land	28	96	42	142	69	884	9
leave (land) / fallow	50	10	88	118	108	972	6
Avoid second planting	54	28	54	127	76	821	14
More irrigation rates	13	32	107	115	113	1043	4
Reduce irrigation	73	90	102	46	57	660	20
Use of herbicides	32	94	79	129	49	835	12
Use of water pool	80	89	120	56	1	501	25
Water defrosting	60	79	115	114	9	687	19
Digging a new well	84	68	101	57	7	469	26
Change in the use of pesticides and fertilizers	87	85	78	100	26	645	21
Change of agriculture to animal husbandry	47	74	114	59	61	723	18
Planting in different parts	8	26	90	127	67	855	11
Cooperative cultivation	10	18	6	22	2	104	35
Use of wind breaker to prevent wheat lodging	10	16	11	21	6	125	34
Leveling the ground	3	18	5	18	23	174	33
Diversification	-	9	5	24	32	219	30
Acceptance of new technologies (machinery and inputs)	32	42	76	80	125	934	8
Planting different varieties	29	113	73	105	56	798	15
Change crop type and use of resistant varieties	11	99	52	82	94	825	13
Change the irrigation method	55	52	42	110	104	882	10
Improvement of water transfer system (using pipe or cement)	3	3	14	13	27	178	32
Increasing soil conversation technique	5	4	15	3	36	187	31
Renting or buying land elsewhere	87	91	79	41	47	560	22
Renting or selling land	140	56	87	30	-	320	28
Crop insurance	26	102	98	33	94	773	16
Take loan	100	75	90	35	48	552	23
Selling equipment and assets	130	17	138	7	-	314	29
Moved to Non-farm activities	82	111	109	60	2	517	24
Immigration (Migration)	135	59	148	18	11	453	27
Participation in training courses	41	75	57	82	125	935	7
Biological control	41	75	23	45	126	760	17

Another strategy that some farmers pursue is to transfer a portion of the risk to outside organizations. Contracting and insurance are two forms of external assistance that farmers often use to reduce their vulnerability to extreme weather and climate events [20]. Insurance that was ranked the 16th in our survey is one of the most important strategies in [27] who identified price and production risks as the most important sources of risk and rated insurance scheme as an appropriate strategy to manage risks. Insurance has been ranked high among different risk management strategies [5, 19, 27, 20].

To achieve the research goal, i.e. proposing a wheat production risk management model based on the farming system, modeling was performed. Table 4 shows indices of the goodness of fit (GoF), the assessment of measurement models summary (Table 5), the root of the average variance extracted (AVE), and correlation coefficients between the latent variables research (Table 6).

Table 4: Indices to assess the fit of the measurement model

Goodness of fit	SRMR	NFI	RMS_Theta
Suggested value	<0.10	>0.80	≤0.12
Estimated value	0.081	0.92	0.10

The results showed that the indices to assess the GoF of the latent variables measurement model were high enough (Table 4). The standardized factor loads (β) were high (> 0.50) and statistically significant ($P < 0.01$) for all indicators selected for the latent variables of the research. They provided adequate evidence to confirm that the indicators selected for each measurement model of the latent variables were one-dimensional. Also, the composite reliability (CR) was > 0.70 for the measurement model of all latent variables of the research (Table 5). Therefore, the measurement model of the research was reliable enough. Also, AVE was > 0.50 for all constructs of the proposed model (Table 5).

Table 5: Evaluation of measurement model

Standardized factor loads	CR	AVE	α
Risk management (0.60 ≤β≤ 0.79)	0.92	0.50	0.91
Financial management behavioral strategy (0.71 ≤β≤ 0.80)	0.87	0.58	0.82
Technological management behavioral strategy (0.62 ≤β≤ 0.83)	0.83	0.55	0.73
Agronomic management behavioral strategy (0.71 ≤β≤ 0.79)	0.78	0.55	0.70
Attitude to risk (0.72 ≤β≤ 0.89)	0.97	0.69	0.96
Awareness of risk sources (0.61 ≤β≤ 0.78)	0.90	0.51	0.87
Extension Programs (0.51 ≤β≤ 0.88)	0.95	0.53	0.94

This means that the measurement model of all latent variables had high convergent validity, and based on the results, the root of AVE for the measurement model (0.71 < AVE < 0.83) was higher than their correlation ($0.20 < r < 0.68$). This implies that the model proposed for the measurement of the research latent variables had a high diagnostic validity.

4.1 MULTI-GROUP ANALYSIS

Since the main research assumption was that the path coefficients of the proposed model would be based on the variable of farming system (irrigated vs. rainfed), the variable of the farming system was considered the mediator variable and multi-group analysis of the proposed model mediated by the farming system was performed in the Smart-PLS software package.

4.2 CONCEPTUAL MODEL ANALYSIS BASED ON FARMING SYSTEM

Table 6, there is a significant ($P < 0.01$) difference between the path coefficient for the effect of the variable of age on the awareness of wheat production risk sources based on the variable of the farming system so that it was revealed that the impact of age on risk awareness was -0.84 in the irrigated system but 0.24 in the rainfed system whereas the path coefficients showed that the impact of job experience on the awareness of wheat production risk sources was 0.48 in the irrigated system but -0.29 in the rainfed system.

Table 6: Evaluation of research conceptual model.

Structural paths	Path coefficient (Irrigated)		Path coefficient (Rainfed)		Difference of path coefficients	
	β	T	β	t	β	t
Age → awareness of risk sources	-0.84	3.94**	0.24	2.42*	1.08	5.01**
Experience→ awareness of risk sources	0.48	2.25*	-0.29	3.01**	0.76	3.52**
Income→ awareness of risk sources	0.05	0.51	-0.12	2.06*	0.17	1.55
Extension → awareness of risk sources	0.43	3.66**	0.76	22.80**	0.34	3.01**
Awareness of risk sources→Attitude to risk	0.34	3.58**	0.49	11.97**	0.15	1.59
Attitude to risk→ Financial strategy	0.46	6.54**	0.44	8.21**	0.01	0.16
Attitude to risk→ Technological strategy	0.45	8.04**	0.11	1.85	0.34	3.79**
Attitude to risk→ Agronomic strategy	0.28	2.79**	0.45	10.83**	0.17	1.56
Financial strategy→Risk management	0.13	1.84	0.47	9.62**	0.60	6.80**
Technological strategy→Risk management	0.68	7.54**	0.02	0.50	0.66	6.37**
Agronomic strategy→ Risk management	0.36	3.06**	0.33	7.55**	0.03	0.19

In the irrigated and rainfed systems, the variable of the use of educational-extension programs had a positive and significant ($P < 0.01$) impact on the awareness of wheat production risk sources. There was also a significant ($P < 0.01$) difference in the path coefficient of the impact of the use of educational-extension programs on the awareness of wheat production risk sources based on the farming system so that the impact of this variable on the awareness was 0.43 in the irrigated system and 0.76 in the rainfed system.

In both irrigated and rainfed systems, the variable of awareness of risk sources had a positive and significant ($P < 0.01$) effect on the attitude towards risk dimensions. Also, in both farming systems, the variable of attitude towards risk dimension was influential on behavior strategy for the financial management of farm positively and significantly ($P < 0.01$), but there was not a significant difference in the path coefficients of the farming systems for the effect of the attitude towards risk dimensions on the behavioral strategy towards financial management of the farm. On the other hand, in the irrigated system, the variable of attitude towards risk dimensions influenced behavioral strategy as to technology development management at farm positively and significantly ($P < 0.01$), whereas the effect of this variable on technology development management was insignificant in the rainfed system. Also, the results revealed significant ($P < 0.01$) differences in path coefficients for the effect of attitude towards risk dimensions on the behavioral strategy as to technology development management at the farm based on the farming system. The path coefficients showed that the effect of attitude towards risk dimensions on the behavioral strategy as to the technology development management was 0.45 in the irrigated system and 0.11 in the rainfed system.

The results showed that in both farming systems, the variable of attitude towards risk dimension had a positive and significant ($P < 0.01$) effect on the behavioral strategy towards agronomic management of the farm, but the farming systems did not significantly differ in path coefficients for the effect of the attitude towards risk dimensions on the behavioral strategy as to the agronomic management of the farm.

It is worth noting that in the irrigated farming system, the variable of behavioral strategy as to the financial management of the farm was not significantly influential on wheat production risk management whereas, in the rainfed system, the effect of the behavioral strategy as to the financial management was positive and significant ($P < 0.01$) on wheat production risk management. Besides, there was a significant difference at the $P < 0.01$ error level between the path coefficients for the impact of behavioral strategy as to the financial management of the farm on wheat production risk management based on the farming system so that it was found that the effect of this strategy was 0.13 in the irrigated system and 0.47 in the rainfed system.

In this respect, it was also found that in the irrigated system, the variable of behavioral strategy towards technology development management at the farm had a positive and significant ($P < 0.01$) effect on wheat production risk management. But, this impact was insignificant in the rainfed system. The farming systems differed significantly ($P < 0.01$) in the path coefficient for this effect so that the path coefficients indicated that the effect of the technology development management was 0.68 and 0.02 in the irrigated and rainfed systems, respectively.

Finally, Figure 1 illustrates that the coefficient of determination for the latent variable of wheat production risk management was about 78% for the irrigated system and about 50% for the rainfed system. This means that the latent variables of the model could capture about 78% of the variance in risk management in the irrigated system and about 50% of the variance in this variable in the rainfed system. Therefore, it can be stated that the proposed conceptual model performs better in predicting wheat production risk management by wheat farmers of Kermanshah province in the irrigated system than the rainfed system.

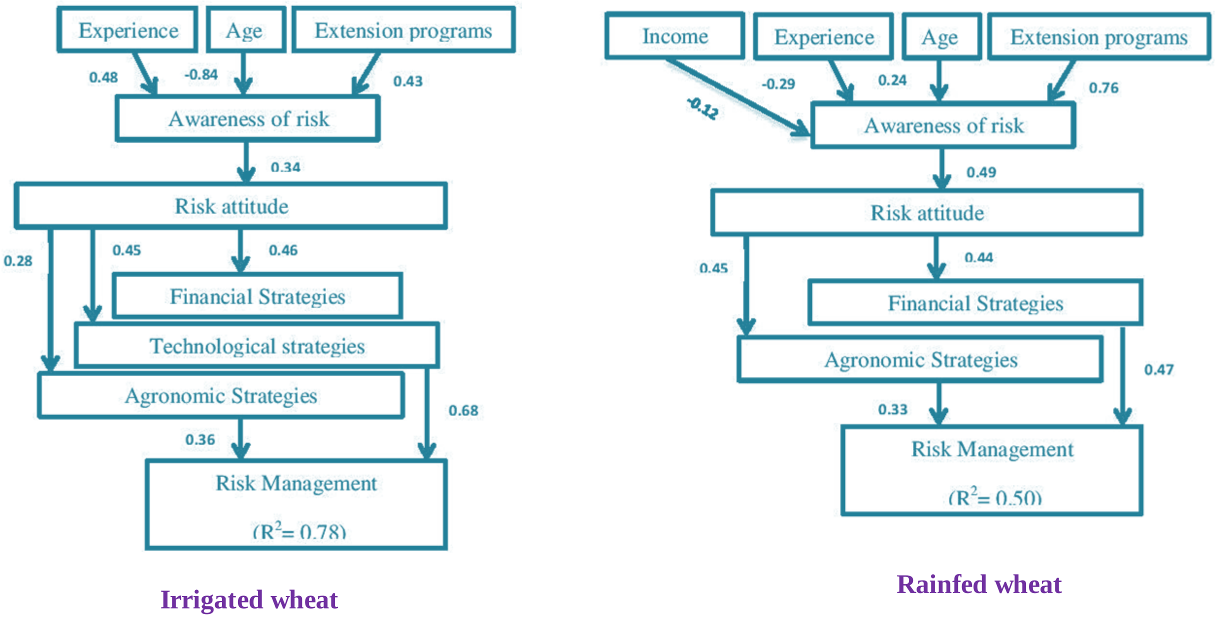

Figure 1: The proposed model in the irrigated and rainfed system.

5. CONCLUSION

The results showed that the average use of educational-extension programs and services by farmers was weak (< 1.76), which is in agreement with [31]. Noted that interaction with extension services and attendance in educational workshops and courses had higher averages than the overall average, which is consistent with [4]. But, items, like holding agricultural exhibits, interaction with academic centers, and using informative SMS and radio broadcasts, did have a high average among farmers, which is interesting because the programs sent by these media may not match farmers' needs and problems, so these broadcasts are not welcomed. Thus, extension programs should be based on the specific principles of farmers' teaching and learning. Since among the different channels to get information, farmers mostly rely on the interaction with experts, the use of pioneering farmers' abilities, and the interaction with informants and extension agents, this means that farmers select information sources that are more available and are more closely aware of their problems. For example, extension agents are present in rural areas most of the time, so they are more closely aware of their problems and/or they are more familiar with farmers' dialect and language, so they are more warmly welcomed by farmers as a source of information. Hence, to achieve one of the goals of extension, i.e. fostering local leaders and sharing information with farmers through these leaders, it is recommended to hold specific training courses for experts, pioneering farmers, and extension agents so that, as trained technical leaders, they can contribute to developing new concepts among rural people. Also, extension programs and services should match the literacy level and needs of farmers.

A strategy, which was ranked lower among the strategies and farmers did not show willingness, was crop insurance whilst it has been identified as key leverage to reduce susceptibility to risks [33]. Crop insurance implementations help compensations for the damages by different risk factors and sources, grant loans and facilities at an appropriate interest rate to allow tackling the challenges of input supply, supply inputs promptly, reinforce the links between the educational sector, extension sector, and insurance funds, develop policies to provide financial supports and liquidity for farmers, and ask for help from other sectors that have interests in agriculture, especially the private sector.

Models comparison, based on the path coefficients, the effect of using programs on the awareness of wheat production risk sources was 0.43 in the irrigated system while it was 0.76 in the rainfed system. Thus, extension plays a critical role in raising awareness of risk sources. Also, the proposed model can predict farmers' use of wheat production risk management in the irrigated system better than in the rainfed systems. This may arise from the conditions peculiar to rainfed farming, which is mainly influenced by climatic conditions. So, farmers cannot be so effective in improving the conditions in this farming system and leave crop production to such factors as rainfall. Then, they do not make themselves look for up-to-date information for the improvement of crop production and/or risk management and they take a fatalistic attitude. It is, therefore, recommended to motivate farmers to act more responsibly and make more efforts by providing strong motives, especially financial incentives that are more welcomed by farmers. Attention should also be paid to engaging farmers in programs by using modern cooperation techniques.

6. AVAILABILITY OF DATA AND MATERIAL

Data can be made available by contacting the corresponding author.

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