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Drought risk management in agricultural sector with an emphasis on the socioeconomic dimension under Fuzzy Logic in the Sistan region

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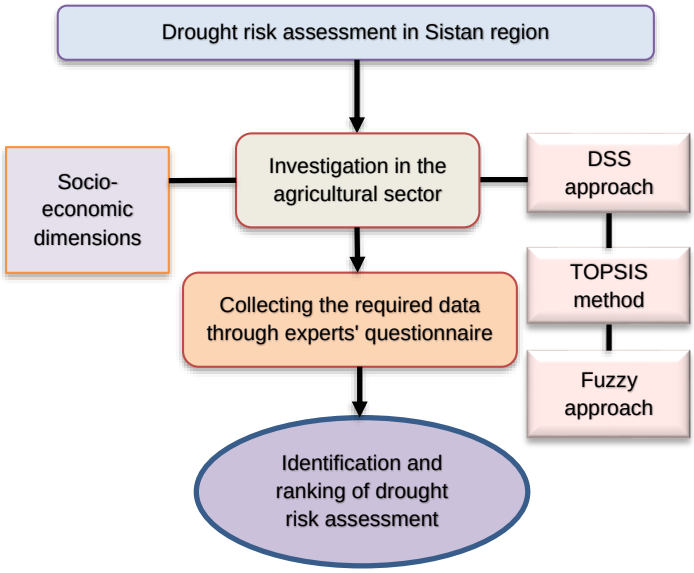
GRAPHICAL ABSTRACT



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ABSTRACT

Agriculture is an important sector for economic development in any society and country, so the development of this sector can be a big leap toward economic development. However, this sector is suffering from frequent droughts with extensive socioeconomic dimensions. Sistan is an important agricultural region in Iran where most people are employed in this sector. Nonetheless, the agricultural sector in this region is presently struggling with severe stress and crisis due to drought, which has had numerous risks in socioeconomic aspects. This research aims to deal with drought risk management in the agricultural sector considering its socioeconomic dimensions. In this respect, the most important dimensions and criteria of agricultural risk management were identified and prioritized based on the opinions of participants (including farmers and experts) using the fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) with the Decision Support System (DSS) approach. Based on the results, the farmers put the production risk in priority with a weight of 0.8. But, based on the experts, the price risk has the highest weight of 0.8. In contrast, the legal risk (with a weight of 0.2) had the lowest rank from the perspective of the farmers, which is similar to the experts' opinion. In addition to the legal risk, the human and social risks are also at lower ranks with a weight of 0.4. According to the farmers, the top priority option is crop insurance with a weight of 0.592163 whereas according to the experts, it is the low-water irrigation system with a weight of 0.637997.

1. Introduction

Agriculture plays a key and strategic role in socioeconomic systems in the contemporary world. It is a priority to have a plan for this sector as it is imperative to pay sufficient attention to supplying food for the growing population and making arrangements to maximize crop production (Khairi *et al*., 2022). Production in the agricultural sector differs from other manufacturing and commercial fields. The most important differences are the high reliance of the activities of this sector on nature and the exposure to environmental, social, financial, and legal changes, which makes the activity in this sector a risky venture (Ghaffari Moghadam *et al*., 2022). The agricultural sector has an essential role to play in strengthening the economic bases of developing countries whereas most countries and regions are suffering

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from drought (Aliahmadi *et al*., 2021). The agricultural sector has peculiar capabilities when compared to other economic sectors of Iran owing to its role in the continuous and sustainable economic growth, the supply of food security, capital return, exchange generation, and the creation of social justice (Keshavarz *et al*., 2010). This sector is a vital part of the economy (Sardar Shahraki *et al*., 2018) and is regarded as the most important economic sector and the axis of socioeconomic development plans in all countries). In recent years, due to the increase in population pressure, it has been necessary to increase crop production more than ever (Sardar Shahraki *et al*., 2016; Koocheki *et al*., 2013). A goal of Iran's development planners is to pay special attention to the agricultural sector and increase crop production so that this sector can meet the food requirements of the population and even export its surplus in addition to helping the growth of other economic sectors. The accomplishment of this goal needs the optimal use of production resources. However, recent droughts in many parts of the world have created stressful conditions for farmers and other stakeholders and have increased the risk in this sector (Ghaffari Moghadam *et al*., 2022). Risk management is a dynamic and active method that aims to minimize the risk of an adverse phenomenon (Astles *et al*., 2006; Kiani Ghalehsard *et al*., 2021). The production process in the agricultural sector has always been exposed to various risks because production in this sector depends on nature and climatic conditions on the one hand and is always vulnerable to plant diseases and pests on the other hand. This has made risk management crucial in agriculture (Ghaffari Moghadam *et al*., 2021). Due to the occurrence of natural and non-natural risks in agricultural activities, crop producers are faced with unreliable conditions, making their revenue unstable. So, risk management is highly important, which reflects the need to consider farmers' risks and risk management. Agriculture risks influence farmers' lives and revenues, injure the environment, and aggravate the poverty of farmers and rural workers (Rakhshani *et al*., 2021; Geravandi and Alibeygi, 2011).

Drought is a natural and reversible climatic feature and occurs almost in all climatic regimes. It happens not only in regions with low rainfall but in regions with heavy rains. Drought is a source of many issues and problems in different social, economic, and environmental fields. Rural and agrarian communities are the first communities that endure heavy losses (Moslemi *et al*., 2021).

Iran has an arid and semi-arid climate due to its location in the drought belt and adjacency with the high-pressure tropical zone, so it suffers from severe droughts in most years. Given the inefficient method of drought management in this country, it is crucial to find a solution that can tackle the shortages and improve the ability to deal with drought. In this regard, drought planning should obviously be aligned with risk management (Ghaffari Moghadam *et al*., 2022). Owing to the close link between villages and agriculture, the negative impacts of consecutive droughts have affected rural and agricultural economies, and their persistence will change functions and motivate migration from rural areas (Rakhshani *et al*., 2021).

The climate in the Sistan region is hot and arid in all climatic classification systems (Ghaffari Moghadam *et al*., 2022). A major factor limiting the expansion of agricultural activities and the use of new technology in this sector is the lack of capital. This shortage is more profound in the deprived regions of Sistan and Baluchistan. A problem that is usually aroused by drought is the risk of investment in the economic sectors, especially the agricultural sector (Rakhshani *et al*., 2021). Farming is the main employment of most people in the Sistan region. Given this point and the fact that many barriers have been raised as controversial challenges in regional agriculture in recent years, it is necessary to review past experiences, recognize the present status, draw future perspectives, and evaluate the feasibility of transition from the present study in order to soundly cope with the barriers and accomplish the goals of agriculture development in the regions considering the recent drought and the risks. The instability of crop production in the Sistan region has made farming a risky activity. In this regard, it will be useful to employ precise and effective instruments to support and supply the economic security of the people employed in the agricultural sector and enhance their productive power and their living level. As well, the issues of capital and investment are more important in the agricultural sector of the Sistan region due to the structural bottlenecks and lack of farming facilities. Agriculture risks influence farmers' lives and revenues, damage the environment, and aggravate the poverty of farmers and rural workers in this region. So, the research goals are as follows:

Measuring the socioeconomic factors involved in drought risk management in the agricultural sector in the Sistan region with a decision support system (DSS) approach Ranking the socioeconomic factors of drought risk management in the agricultural sector in the Sistan region with the DSS approach. The literature is reviewed below. Geravandi and Alibeygi (2012) conducted a study to identify the determinants of agricultural risk management in a case study on farmers in Kermanshah County, Iran. The results revealed that corn farmers used the approaches of production risk management, human risk management, and legal risk management for managing the sources of risk that they faced. Zhang (2004) analyzed drought risk management in corn farms using GIS and climatological, geographical, and environmental perspectives for the analysis and assessment of drought risk in the Songliao plain, China. The results showed that the strategies for reducing the damages of drought and developing agriculture sustainably can be very effective in risk mitigation. Nelson and Loehman (2005) investigated the relationship between farmers' agronomic features and risk-taking feature and their adoption of crop insurance. Based on the results, the adoption of crop insurance had a significant relationship with cropping season, crop type, and farming system. The authors reported that farmers were more willing to adopt insurance for the likely losses in low-water seasons. Moslemi *et al*. (2021) investigated the relationship between risk and acceptance of new inputs in agriculture in a case study on summer crop farmers in Kerman province, Iran. They collected data with 140 questionnaires filled out by summer crop (cucumber, tomato, and potato) farmers in three counties of Jiroft, Anbarabad, and Kahnuj in the summer of 2017. To estimate and compare new and traditional inputs and the difference in input costs, they used the momentum method to calculate variance, skewness, and kurtosis, as well as the translog cost function.

2. Methodology

To manage drought risk with a focus on its socioeconomic dimensions, the research uses the Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (fuzzy TOPSIS) under the decision support system (DSS) approach. Criteria and options used in the research Table 1 presents the options and criteria studied in this research.

Table 1. The criteria and options used in the research.

Criterion	Option	Variable name
Production risk management	The use of chemical fertilizers	C1
	Observing proper sowing dates	C2
	The use of herbicides	C3
	The use of chemical pesticides	C4
	Timely plowing	C5
	Timely weeding	C6
	The use of pure seeds	C7
	Observing technical cultivation principles	C8
	Soil testing	C9
	Supplying element requirements of the soil	C10
	Using meteorological forecasts	C11
	Manure application	C12
	The use of high-yielding cultivars	C13
	Avoiding middle-of-the-day irrigation	C14
	The use of biological methods	C15
	The use of indigenous knowledge for weather forecast	C16
	The use of low-water irrigation systems	C17
	The use of resistant cultivars	C18
	The use of early-maturing cultivars	C19
	Activity diversification	C20
	Intercropping	C21
Human risk management	Work division between family members	C22
	Determining a successor when the farm manager is not present	C23
Legal risk management	Integrating indigenous knowledge	C24
	The use of others' legal experiences	C25
	Understanding the regulations	C26
Price risk management	Awareness of future sale market	C27
	Gaining information via mass media	C28
	Selling crops to cooperatives	C29
	Preselling the crops	C30
Social risk management	Participation in ensuring village security	C31
	Land defragmentation before sowing	C32
	Settling conflicts with neighbors	C33
	Settling family conflicts	C34
Financial risk management	Crop insurance	C35
	Money saving	C36
	Establishing loan funds spontaneously	C37

In MCDM models, data are qualitatively and quantitatively collected from experts using a questionnaire. The present study used fuzzy TOPSIS for modeling. To scrutinize the results, the experts were divided into two groups of pioneering farmers and agricultural experts, each containing 25 participants. Then, they were asked to fill out the research questionnaire. The target technique was modeled with the Fuzzy $MADM_{solver.2018}$ software suite.

Fig. 1. Weight assignment to criteria based on the farmers' opinions with the DSS approach.

3. Results and discussion

As was already mentioned, the participants in the research were divided into farmers and experts. Tables 2 and 3 present their specifications.

3.2. Results derived from the group of farmers

This section presents the results from the perspective of the participants in the group of farmers. According to Fig. 1, the farmers assigned the highest weight (0.8) to the production risk criteria among the criteria. The second-highest weight was 0.7 assigned to price risk management. The financial risk was ranked third with a weight of 0.6. The results reveal that production risk management is more important than price and financial risk management from the perspective of the farmers. As well, the farmers ranked the social risk and the human risk next with weights of 0.5 and 0.4, respectively. The lowest rank was assigned by the farmers to legal risk management with a weight of 0.2.

Table 2. The demographic and professional characteristics of the farmers (n = 25).

Profile of experts	Mean	Standard deviation	Minimum	Maximum
Age (year)	48.2	23.22	18	78
Educational level (year)	7.08	3.2	0	18
Number of years engaged in farming (year)	35.3	21.2	2	50
Cultivation area (ha)	0.5	0.03	0.4	5
Annual farming revenue (thousand IRR)	31,000	10010	12,000	87,000
Annual non-farming revenue (thousand IRR)	11,000	5510	8,000	56,000

Table 3. The demographic and professional characteristics of the experts (n = 25).

Profile of experts	Mean	Standard deviation	Minimum	Maximum
Age (year)	35.3	12.1	25	55
Educational level (year)	21.1	4.4	12	22
Number of years engaged in agriculture	10.1	8.2	1	25
Annual income (thousand IRR)	42,000	12000	25,000	105,000

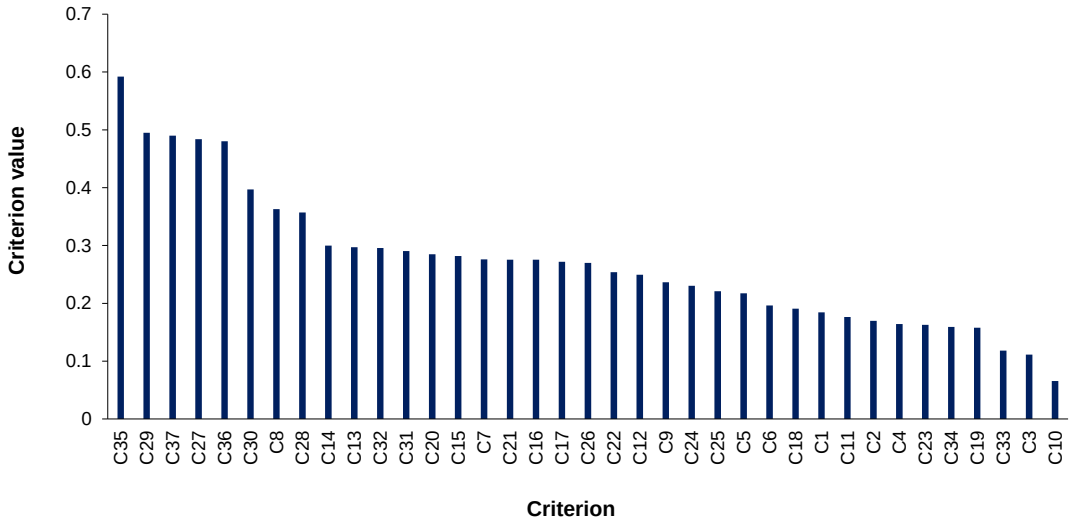

Fig. 2. The ranking of the options based on the farmers' opinions by the DSS approach.

The results based on the participants in the group of farmers can be summarized as follows. The option of crop insurance with a weight of 0.592163 has the highest similarity to the fuzzy ideal option and is ranked at the top. The literature supports the role of insurance in risk mitigation in the agricultural sector. The second option is crop sale to cooperatives with a weight of 0.495052, reflecting the significance of forming cooperatives and cooperating within them. The options of establishing loan funds spontaneously and awareness of future sale market with weights of 0.490034 and 0.483763 are ranked third and fourth, respectively. The closeness of C29, C37, C27, and C36 to the ideal option is interesting. After these options, the next options are placed at much lower ranks than these four options. The results reveal that supplying soil nutrients with a weight of 0.065501 is the least important option from the perspective of the experts.

3.3. Results derived from the group of experts

The second group was composed of experts in the agricultural sector. Data were separately collected from them and modeled. The results are summarized in Tables 6 and 7. The results obtained from the group of experts differ from those obtained from the group of farmers. The management approach of the experts for coping with the risk of drought in the agricultural sector was obtained as follows. The price risk management with a weight of 0.8 has the highest weight among the risks to be managed, showing the significance of price risk from the perspective of experts and its impact on the agricultural sector. The second rank is for financial risk management with a weight of 0.7. Production risk management with a score of 0.6 is ranked third whereas production risk management was ranked first by the farmers. According to the experts, human, legal, and social risk management were ranked next with a weight of 0.4.

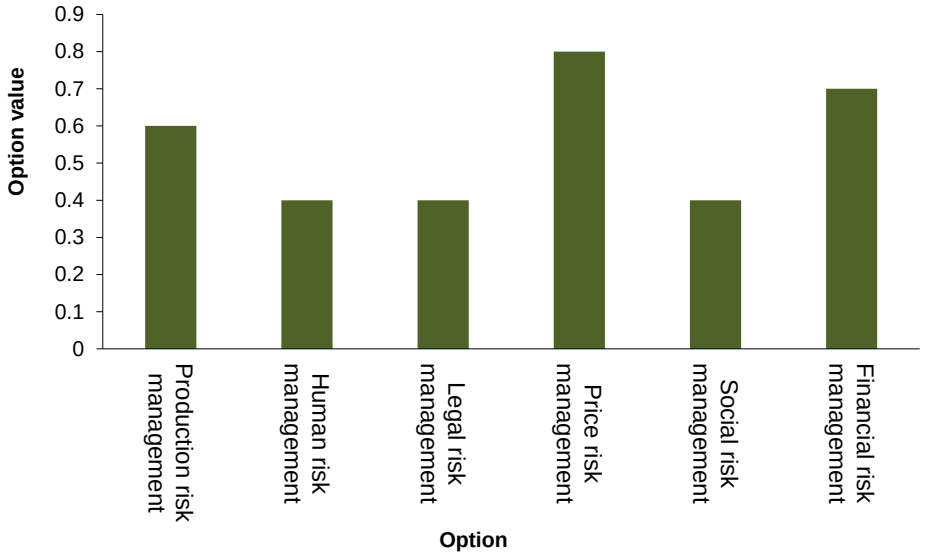

Fig. 3. Weights assigned to criteria based on the experts' opinions with the DSS approach.

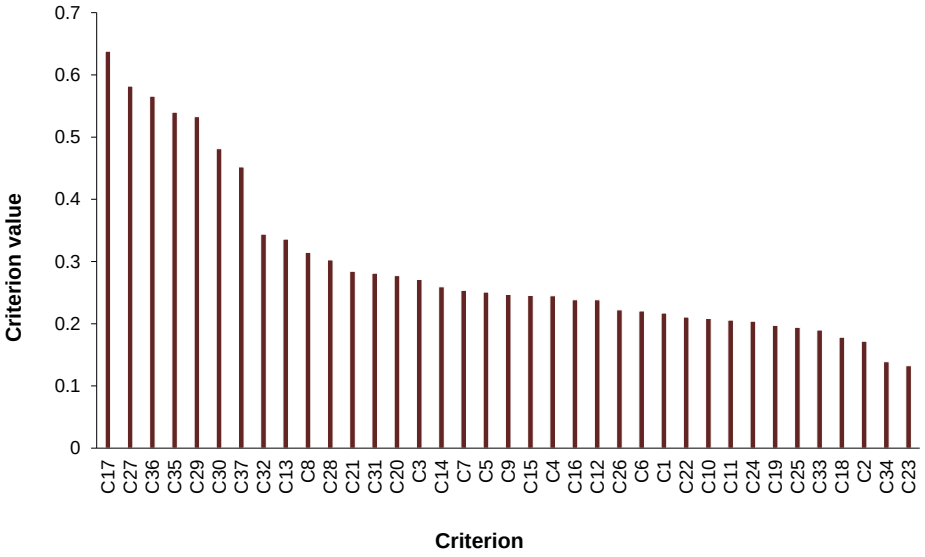

Fig. 4. The ranking of the options based on the experts' opinion with the DSS approach.

Based on the results of the experts' opinions, the use of low-water irrigation systems with a weight of 0.637997 is the priority in risk management. This reflects the importance of using modern irrigation systems in drought conditions in the Sistan region. The second priority was found to be the awareness of future sale markets with a weight of 0.582088. This option is important from the perspectives of both farmers and experts and shows the importance of market information in risk management and mitigation. Money saving with a weight of 0.565851 is in the third rank of importance followed by crop insurance in the fourth rank. The results reveal that determining a successor for the time when the farm manager is not present, settling family conflicts, observing proper sowing dates, and using resistant cultivars are the last priorities of risk management in the Sistan region.

4. Conclusions

The results show that the option of crop insurance is at a high level of priority. Therefore, conditions should be provided to make it obligatory for strategic crops in the Sistan region in order to largely mitigate the risk in the agricultural sector. Developing insurance contracts with relevant agencies, e.g., Agriculture Jahad Organization and Agribank, can be very effective. Based on the results, production cooperatives in the agricultural sector are in priority from the perspective of the experts. The experience and information in the Sistan region show that the establishment of water users associations has failed in the Sistan region where governmental agencies have considered their clients' attitudes, interests, and needs. Therefore, to establish any cooperation system for irrigation management, in addition to considering the attitudes of local people and aligning them with the goals and requirements of water users associations in the Sistan region, the agencies in charge should try to reach a general agreement with stakeholders about the goals and need for establishing water users cooperatives. It is also recommended to develop an optimal system of agriculture water use, which needs the cooperation and coordination of all relevant agencies, especially Agriculture Jahad Organization, Regional Water Company, and their affiliates. The two systems of production cooperatives and rural cooperatives have been designed mainly for large-sized and small-sized agricultural units whereas since smallholding is the dominant system in the agricultural sector of the Sistan region, these two systems do not seem to match the conventional farming system in the region. So, it is recommended to study relevant global experiences in order to develop models that are more tailored to the smallholding system. Based on the results, awareness of the future sale market is highly important. The literature on risk management also supports this finding. In this regard, educational and extension courses can be held on crop sales and markets in the Sistan region to provide farmers with the required information and reduce the role of brokers in crop trade in the region. The high importance of using low-water irrigation systems points to the significance of using modern irrigation systems in the drought conditions in the Sistan region. A project has been initiated by the Ministry of Energy in recent years to deploy the pressurized irrigation system in 46,000 ha of agricultural lands in the Sistan region. This project should be accelerated and managers and planners should pay more serious attention to this issue.

Author Contributions

Zahra Sarani: Analysis, modeling, writing of the article.
Ali Sardar Shahraki: Collecting information and editing of the article.
Mahdi Safdari: Collecting information and editing of the article.

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Conflict of Interest

There is no conflict of interest in this article.

Data Availability Statement

Data will be available when needed.

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