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# Solutions to Reduce the Vulnerability of Farmers and Beneficiaries of Agricultural Sector to Climate Change

*AbdolWahed Kaabi [a], Kourosh Rousta [b,*], Saeed Mohammadzadeh [c] and Reza Baradaran [d]*

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Abstract

Climate change in the Middle East and Iran, as well as the decline in agricultural products and croplands in Iran over the past 10 years, has attracted the attention of many researchers. Numerous researches have considered economic, environmental, psychological-social, and technical-agricultural damages as a result of climate change in the agricultural sector. Solutions to reduce the vulnerability of farmers and beneficiaries to climate change in Khuzestan province will be discussed. The present study was performed in three stages of qualitative study and one stage of quantitative study. The statistical population of the qualitative section consisted of 83 highly experienced farmers and those suffering from climate change, 18 exemplary farmers introduced by the Jihad Agricultural Organization of Khuzestan province, 33 Ph.D. and 237 master students in agriculture from various universities in the province as well as 100 agricultural experts from the Agricultural Jihad Organization. The research variables were also categorized into six solutions and three barriers (challenges) in the third stage of the qualitative investigation, and introduced for a quantitative stage. The fourth stage of the study was a quantitative stage in which the statistical population consisted of 384 farmers and farming beneficiaries in Khuzestan province. The tool for data collection in the quantitative stage of the questionnaire was based on a Likert scale. As well, the sample in the quantitative and qualitative stages was selected via the convenience method. Economic losses have been affected by various such solutions as economic-financial support by the government, as well as training-promotional, technical-agricultural, and social issues. Also, environmental damages have been affected by economic-financial as well as supportive solutions by the government, training- promotional and institutional-infrastructure issues, and finally, psychological-social ills and technical-agricultural damages have been affected by managerial and technical-agricultural solutions, respectively. The solutions stated in the practical dimension face barriers or challenges.

***Keywords:***
***Vulnerable farmers; agriculture; climate change***

[a] *PhD Student, Department of Agricultural Extension and Education, College of Agriculture, Birjand Branch, Islamic Azad University, Birjand, Iran*
[b] *Associate Professor of Department of Agricultural Extension and Education, College of Agriculture, Birjand Branch, Islamic Azad University, Birjand, Iran*
[c] *Assistant Professor, Department of Agricultural Extension and Education, Agricultural Sciences and Natural Resources University of Khuzestan, Molla Sani, Ahwaz, Iran*
*d Associate Professor of Department of Agriculture and Plant Breeding, College of Agriculture, Birjand Branch, Islamic Azad University, Birjand, Iran*

** Corresponding author's email: k.roosta@iaubir.ac.ir*

## INTRODUCTION

The climate or weather condition of a region is the average state of the quantities determining the climate situation of that region (Moghaddam & Rezaei, 2012). Climate change occurs when this quantity deviates from its standard and average state and persists over time (Khaleghi et al., 2015; Hageback et al., 2005; Kham Chin Mogaddam et al., 2009).

Currently, a trend change of the main climatic elements is both confirmed scientifically and is observed objectively in Iran and other parts of the world (Nasiri Mahallati et al., 2006; Christopher et al., 2018; Nicholson, 2014). Climate change impacts on rainfall and temperature levels, as well as the shortage of water resources in the Middle East, especially in Iran, has led to damages to agriculture, natural resources, food production, environment, and public health sectors (Azizi Khalkhili et al., 2016; Horton, 2007; Eslami, 2017; Abdelaziz & Gohar, 2016). In the meantime, the most destructive agricultural damages seen in the areas under crop cultivation fell from 13.42 million hectares to around 11.77 million hectares in the past 10 years (Ministry of Agriculture, 2017).

The effective role of weather conditions and climate changes in the short (during the growth period) and long term on agricultural products, levels of production and their sustainability has led researchers to pay special attention to the damage inflicted on agriculture, farmers, and agricultural beneficiaries (Nasiri Mahallati et al., 2006).

Since the issue of climate change plays a decisive role in human life, large-scale research can be found in various corners of the world, especially in recent years focusing on identifying the consequences of damages from the economic, social, and biological perspectives.

Upon recognizing the research gap inside and outside Iran concerning the solutions to reduce the vulnerability of farmers and beneficiaries in the agricultural sector to climate change, the present study investigates the solutions from the perspective of a statistical population.

### Damages caused by climate change

The issue of vulnerability has been applied in various theoretical and empirical contexts from medical sciences to poverty and development (Berry et al., 2006). Vulnerability or "Vulus" in Latin denotes "injury and harm" and in English dictionaries, it is defined as "to sustain injury from a physical or emotional view" (Kelly & Adger, 2000). According to the United Nations' definition (1991) vulnerability is taken to mean a certain element or set of elements sustaining losses as exposed to risk, resulting in the incidence of a natural phenomenon of a certain magnitude expressed on a scale from zero (no vulnerability) to one (complete vulnerability) (Farajzadehet, et al., 2011). This cumulative scale is the extent to which different elements are vulnerable in comparison with the stable and dynamic state of different aspects in the environment (Pourmosavi et al, 2014). The United Nations (2004) considers four factors to be effective in the level of vulnerability: Physical factors: such as (society's infrastructure such as roads, electricity, water, etc.); Economic factors: such as (income, capital, etc.; Social factors: such as education, security, Justice, etc.) and Environmental factors: such as (weather conditions in a region) (Fussel, 2007).

Vulnerability is said to be a process related to the sensitivity and capacity of the system to resist and to respond (Daheshvar et al., 2014). In this connection, climate change is seen as one of the main environmental problems that have affected human development. Climatic vulnerability is an extent of inability that refers to the geophysical, biological, and socio-economic system inertia relative to the negative impacts of climate change.

Climate change is viewed as an unavoidable threat in many parts of Iran because of its geographical location and climatic conditions (Chakoshi, 2009). According to the geographical location of Iran and the synoptic systems affecting this region, it is clear that drought is characteristic of this region (Khazanedari et al., 2009). The very location of Iran, especially

Khuzestan province in the arid geographical belt, has made Khuzestan one of the regions experiencing the least rainfall levels in the world. The rainfall here is almost one third of the global average and with an annual rainfall of 270 mm, it has an arid and semi-arid climate (Mohammadiyeganeh et al., 2012).

Climate change has actual economic, social, environmental, psychological, and technical impacts on the agricultural sector and substantially reduces the yield of agricultural products. It has also affected the lives of a large number of people (Manouchehri, 2001). Climate change has been known as a creeping phenomenon; in other words, it is not clear when it started (Khoshakhlagh et al., 2010). According to the United Nations, 31 countries will face water shortages in a near future, with Iran being considered one of the countries facing water shortages in the future (Pourtaheri et al., 2013). Failure to pay attention to the phenomenon of climate change in Iran as a drought-prone country has caused many economic and social damages to the country's economic infrastructure every year (Kaboli et al., 2012).

The extent to which this creeping phenomenon has affected rural areas has been more than other places and, in this regard, the agricultural community has faced the most consequences because of drought, and therefore, farmers are regarded as the most vulnerable group (Sharafi & Zarafshani, 2010).

The direct impacts of climate change are often related to climatic, weather, and ecological characteristics, while the indirect impacts, which are broader and more intangible, are often related to economic and social damages. This is while, the extent of these damages can be difficult to measure (Walker & Thers, 1996). Some have considered the most important climate change impacts to be environmental, economic, and socio-psychological impacts (Hoseini, et al., 1987); in yet another categorization, climate change impacts are divided into three environmental, economic, and social groups (Keshavarz & Karami, 2003 & Gupta & Gupta, 2003).

Vulnerability from climate change can be assigned to social factors such as population, demographics, migration and settlement pattern, technology, social policies and behaviors, economic development, health, ability to deal with the impacts of drought, or to such factors as ethnic, racial, religious, climatic issues, income diversity, infrastructure facilities, social classes, gender, age, level of capital, resources, and power, global and regional events such as wars and the prevalence of infectious diseases, as well as macro-political, economic, and social structures. These factors are constantly changing and the degree of vulnerability varies as these issues change (Hoseini et al., 2011).

Increased knowledge of the economic, social, and environmental costs from climate change helps develop active perspectives in the area of drought risk management and optimal allocation of financial resources considering the degree of agricultural vulnerability. On the other hand, the climate change risk management process, i.e., a set of measures taken before climate change aiming to minimize surprises during the operation, as well as preparedness in the community and environment will certainly guarantee the success of any program aimed at preventing and reducing damages from climate change (Pourtaheri et al., 2013).

## Solutions to reduce vulnerability

Looking at the research literature indicates that solutions to reduce damages to farmers and beneficiaries in the agricultural sector from climate change were studied from different dimensions. For example, various researches considered an adaptation to new climatic conditions and change of cultivation as an appropriate solution to reduce the damage inflicted on agriculture and farmers. In the meantime, Thi Phuoc Lai Nguyen, 2016; Qunying Luo, 2017; Zvi Hochman, 2017; Mugi-Ngenga et al. 2016 and Tas Thamo et al. (2017) introduced adaptation to climate change as an important solution. They also stated that the less farmers adapt to the new

conditions, the greater the amount of damage will be. Tesfamicheal et al., (2018) considered government's political interventions as a basic solution to reduce undesirable climatic change impacts and damages to the farmers and agricultural sector. They also remarked that giving credit to farmers by the government was the most important way to reduce damages.

Other researchers, such as Rosaine & Yegbemeg (2014) and Stone (2014) discussed the implementation of a protection solution and policy program as the most important way to reduce damages to farmers. Lam Thi and Lindsay (2018) considered support-economic package planning to create an effective communication between officials and farmers to reduce social vulnerability in the region as a solution to reduce damages to farmers.

A number of researchers also believed extension-education plans could work as an important solution to reduce damages to farmers. For example, Stefanos Xenarios (2017) considered gender to be an effective factor in reducing the economic damage to farmers' households, stating that government supportive policies in setting up high-yield workshops for women farmers' households can be an effective way to reduce damages to household economic advantages. Christopher et al. (2017) also introduced the creation of non-agricultural jobs along with the agricultural profession as an important solution. They stated that employment training in various fields can reduce economic and social damages while at the same time reducing technical and agricultural damages as it prevents migration.

Nataliya (2017) considered increasing farmers' public awareness of climate change and crop production as the only way to reduce damages to the agricultural sector and farmers. He considered training modern agricultural methods, water resources management, and holding symposium workshops and skills courses to manage water resources in the wake of climate change as an important solution to reducing the damage farmers sustain.

Various researchers have recognized management as a fundamental solution to reduce damages to farmers. For example, Martin Bozzola (2014) introduced optimal water management as a solution to reduce damages farmers receive. Tobias Böhmelt (2014) also considered water supply and demand management as an important way to reduce damages by considering the existing restrictions. Heather Randell (2016) considered increasing water efficiency in production, transfer and distribution in the agricultural sector as an important solution to control for the damages farmers sustain. Arragaw Alemayehu (2016) considered the establishment of model, research, and demonstration farms as well as the development and promotion of an insurance supportive system in relation to pastures and crops as a management solution to reduce damages. Stefanos Xenarios (2017) evaluated all-out attention and support for employment in the affected areas as an important solution.

Various studies have recognized institutional and infrastructural solutions as effective factors to reduce the damages to the farmers and agricultural operators, including such solutions as controlling the harvesting of rivers and permissible wells (Tesfamicheal et al, 2018), developing marketing for the direct supply of rural products by removing profiteering intermediaries (Sharon & Magda, 2018), developing an appropriate cultivation model and careful monitoring of the way it is implemented (Nataliya, 2017), and making coordination between executive, research, extension and education agencies to apply the research results and to prevent the establishment of unrelated workshops and companies in agricultural areas (Abdelaziz & Gohar, 2016).

Other researchers consider economic and social skills as significant issues in reducing the damages to farmers. Included in these studies are Martin FlatÃ (2017) considering social participation and technical and agricultural activities of female-headed households

as part of solutions to reduce the damages. They also stated that women are more vulnerable than other people and strengthening their position will reduce damages they receive. Samuel Adu-Prah (2015) maintained that as farmers' economic and social skills increase, their economic and livelihood change from a mono-axis direction to a multi-axis direction; this helps them rethink the way they do business considering agriculture the only way to secure their livelihood.

The conceptual model of the present study included the challenges and solutions to reduce the vulnerability of farmers and beneficiaries in the wake of climate change in Khuzestan province as shown in Figure 1. The present study will also investigate the research variables in the statistical population of this study.

## METHODOLOGY

The present study was applied in terms of goal, while in terms of data type, it used both quantitative and qualitative methods. The subjects in the study were farmers and beneficiaries in the agricultural sector, students, and experts at the Jihad Agricultural Organization, Khuzestan Province, Iran. The main objective of the research was done by four steps (Table 1):

- The first stage was performed qualitatively, and 12 effective factors, as well as 138 items, were identified by the statistical population.
- The second stage provides specialized scoring for effective factors introduced in the first stage. As a result, three effective factors were removed and nine factors remained.
- The third stage involved a review of the effective factors by the statistical population of the research. At this stage, the effective factors included solutions and challenges to reduce the damages farmers and beneficiaries in the agricultural sector received. Finally, six solutions and three challenges related to reducing the damages to farmers and beneficiaries in the agricultural sector were transferred to the fourth stage of the study for a quantitative review.
- The fourth stage involved a quantitative review conducted by 384 farmers and beneficiaries in the agricultural sector in Khuzestan province. Final variables included nine variables and 138 items in form of a questionnaire and were provided to the statistical population of the study. SPSS and PLS statistical software were also used to analyze the field data.

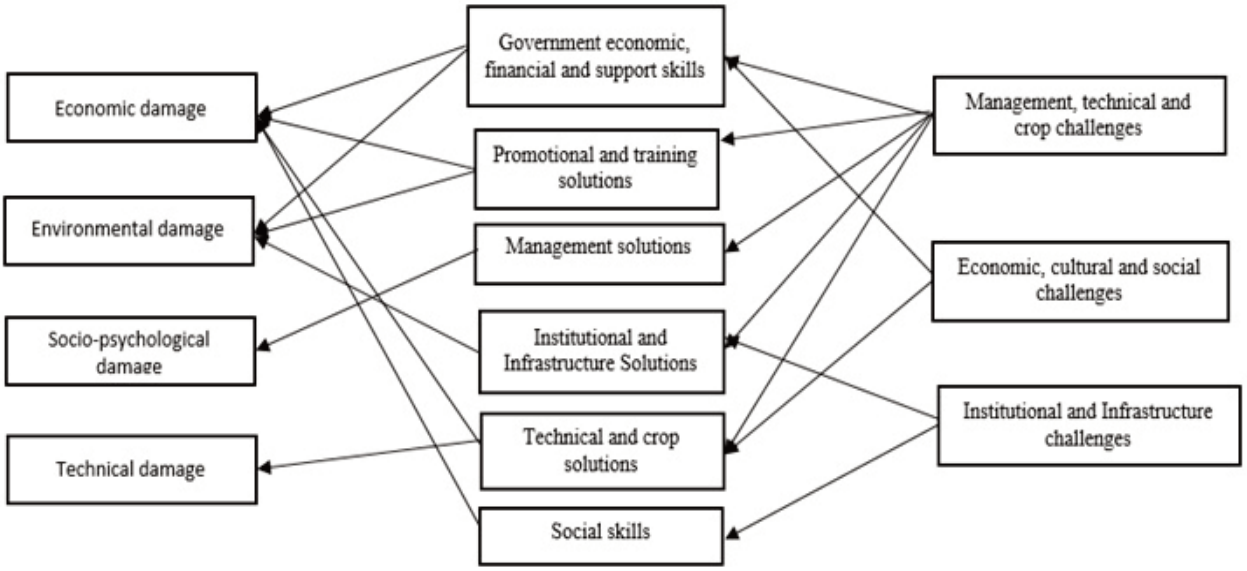


*Figure 1*. Conceptual model of research

Table 1
*Stages of Investigating the Research Objective*

| Stages of investigation | Method of investigation | Description of the study | Sample size | Sampling method/ determining the sample size | Sample | Area under study |
|---|---|---|---|---|---|---|
| **First stage: qualitative** | Interview | Recognizing effective dimensions and variables | 83 | Selective/ Morgan Table | Farmers with over 20 years of agricultural experience and farmers affected by climate change | Khuzestan Province |
| **Second stage: qualitative** | Interview | Specialized investigating and scoring of the effective dimensions introduced in the first stage by experts, reducing the effective factors | 288 | Convenience sample/Morgan Table | 18 exemplary farmers introduced by Jihad Agricultural Organization, 33 Ph.D. students in Agriculture and 237 M.A. agricultural students | Khuzestan Province |
| **Third stage: qualitative** | Interview | Selecting the most important factors and solutions affecting the objective of the study (review of effective factors) | 100 | Convenience sample/Morgan Table | Agricultural experts at the Khuzestan Jihad Agricultural Organization | Khuzestan Province |
| **Fourth stage: quantitative** | Survey | Validating factors affecting the research objective | 384 | Convenience sample/Morgan Table | Farmers and beneficiaries of Khuzestan province | Khuzestan Province |

* The students participating in the second phase of the study also consisted of Ph.D. students in agriculture at Chamran University and Islamic Azad University of Ahvaz Branch, as well as M.Sc. students in agriculture at Chamran University, Ramin, Islamic Azad University of Ahvaz and Shushtar Branch.

To conduct a quantitative assessment in the fourth stage of the research, the data collection tool was a questionnaire made of four sections. The questionnaire sections included personal and professional characteristics (including 5 questions), variables related to solutions of different dimensions (including 95 items in form of a Likert scale), variables related to the challenges of reducing damages to farmers and beneficiaries (including 43 questions in form of Likert scale).

The validity of the questionnaire was confirmed by a group of faculty members, Department of Agricultural Extension and Education at the Islamic Azad University, Birjand Branch. Its reliability was determined by conducting a pilot study on 50 samples in a community similar to the study population (Khuzestan Province). Cronbach's alpha for different sections of the questionnaire was calculated as shown in Table 2. The lowest level of reliability is related to institutional and infrastructural challenges being equal to 0.934 while the highest numerical level of reliability is related to managerial, technical, and agricultural challenges being equal to 0.986.

It was also found that the AGFI and GFI absolute fit index was greater than 0.9 and the *p*-value was smaller than 0.05. Also, NFI and CFI comparative fit was reported to be greater than 0.9 and economical fit such as PNFI was higher than 0.5; this is while PGFI was reported to be larger than 0.1 and RMSEA less than 0.08. The fit indices of all constructs indicated a proper fit of the research model and a desired validity. The skewness and kurtosis of the items in the Shapiro–Wilk test are in the normal range of -2 and +2 and indicate the normality of the research data.

The sample size in the quantitative research was 384 people answering the questionnaire. The average respondents' age was about 40 years, with the highest frequency relating to the 30 to 40-year group and the highest frequency of agricultural activity to the 5 to 10-year interval. The average number of family members was about 6 and the average number of family members working in agriculture or of family breadwinning co-workers was about 4 and its highest frequency was 5 Table3. In terms of education, most of the respondents held a bachelor's level (38.3%). The highest income frequency from non-agricultural activities was between 25-50 dollars per month (42%). Their predominant crop system was farming (93%).

Table 2

*Calculation of Cronbach's Alpha Coefficient for the Proposed Variables of the Statistical Population*

| Questionnaire variables | No. of items | Cronbach's alpha coefficient |
|---|---|---|
| Extension-education | 15 | 0.935 |
| Management solutions | 18 | 0.942 |
| Institutional and infrastructure solutions | 25 | 0.980 |
| Technical and crop solutions | 18 | 0.973 |
| Social skills | 4 | 0.952 |
| Government's economic, financial, and support skills | 16 | 0.984 |
| Economic, cultural, and social challenges | 10 | 0.935 |
| Management, technical and crop challenges | 18 | 0.986 |
| Institutional and infrastructure challenges | 15 | 0.934 |
| Social challenges | 4 | 0.952 |

Table 3

*Description of Some Respondents' Characteristics*

| Indicator | Item | Freq. | Freq. percentage | Mean | SD | Min. | Max. |
|---|---|---|---|---|---|---|---|
| Age (year) | Under 30 | 67 | 17.4 | 40.15 | 13.97 | 24 | 73 |
| | 31-40 | 167 | 43.5 | | | | |
| | 41-50 | 104 | 27.1 | | | | |
| | Over 50 | 46 | 12 | | | | |
| Level of education | Primary | 50 | 13 | Bachelor's | 9.82 | Primary levels | PhD |
| | Junior school | 78 | 20.3 | | | | |
| | Diploma | 64 | 16.7 | | | | |
| | Bachelor's | 147 | 38.3 | | | | |
| | M.A. and higher | 45 | 11.7 | | | | |
| History of activity (year) | Less than 5 | 67 | 17.4 | 14.23 | 11.32 | 4 | 55 |
| | 5-10 | 166 | 43.2 | | | | |
| | 11-15 | 105 | 27.3 | | | | |
| | Over 15 | 46 | 12 | | | | |
| Number of family members (people) | Less than 5 | 233 | 60.7 | 5.92 | 3.75 | 3 | 14 |
| | 5-8 | 83 | 21.6 | | | | |
| | 9-12 | 47 | 12.2 | | | | |
| | Over 12 | 21 | 5.5 | | | | |
| Co-worker family members (people) | 2 and lower | 53 | 13.8 | 4.23 | 1.33 | 1 | 7 |
| | 3 | 85 | 22.4 | | | | |
| | 4 | 78 | 20.3 | | | | |
| | 5 | 124 | 32.3 | | | | |
| | 6 and higher | 43 | 11.2 | | | | |

## RESULTS

A qualitative study (interview) was performed in the first three stages of the study, with nine variables (six solutions and three challenges to reduce the damage to farmers and beneficiaries) and 138 items being introduced for quantitative analysis in the fourth study. Damages to farmers and agricultural beneficiaries were repeatedly stated by various internal studies which included economic, environmental, socio-psychological, and technical damages (Ekrami et al., 2015; Farajzadeh et al., 2019; Mahboobi et al., 2018; Ramezani et al., 2017).

The damages mentioned were removed from the current study as they were not the main subject of the article, and only the solutions and challenges were examined. Of course, in this study, attempts were made to provide for solutions to remove economic, environmental, socio-psychological, and technical damages.

### Solutions to reduce damages to farmers and beneficiaries in the agricultural sector

In the first three stages of the qualitative study in the present study, solutions to reduce the vulnerability of farmers and beneficiaries in the agricultural sector were identified and categorized. These solutions included extension-education strategies, management strategies, institutional and infrastructure strategies, technical and agricultural strategies, the government's economic-financial support skills, and social skills. The findings demonstrate that all items of the mentioned variables enjoy the necessary and standard normality with the mean rate in all of them being higher than zero, indicating the importance of each of the variables and items.

Data relating to promotional-training solutions in Table 4 indicated that the most important items falling under the category of promotional-training solutions included "using virtual training and Internet sites"

Table 4

*Prioritization of Extension-Education Solutions to Reduce the Vulnerability of Farmers and Agricultural Beneficiaries*

| Items | Mean | Mode | Standard deviation | Final rank |
|---|---|---|---|---|
| Training new agricultural practices and water resources management | 3.05 | 4 | 0.97 | 6 |
| Establishing a training network especial for villagers and enhancing the promoters' knowledge | 2.80 | 2 | 1.02 | 12 |
| Increasing counseling services to villagers and distributing educational packages | 3.22 | 4 | 1.16 | 3 |
| Establishing model, research and promotional farms | 2.74 | 2 | 0.77 | 14 |
| Using regular training methods with the presence of promoters and experts | 2.90 | 2 | 0.92 | 10 |
| Holding sympathy and skill courses to manage water resources in the wake of climate change | 3.07 | 4 | 0.93 | 5 |
| Training and strengthening public beliefs about climate change and the water crisis and creating a culture of adaptation | 2.97 | 2 | 1.1 | 7 |
| Familiarizing students with the issue of water shortage | 3.23 | 4 | 1.03 | 2 |
| Teaching effective and efficient saving methods in irrigation and drinking water and preventing its waste | 2.78 | 2 | 1.06 | 13 |
| Encouraging successful farmers and modeling them | 2.96 | 2 | 1.14 | 8 |
| Promoting the cultural perspective of water in the Holy Quran by scholars and clergies of the region | 3.08 | 4 | 1.1 | 4 |
| Making use of farmers' training visits special for villagers on localized and modern solutions implemented for water management solutions | 2.86 | 2 | 1.25 | 11 |
| Using virtual training and Internet sites | 3.27 | 4 | 0.79 | 1 |
| Using scientific festivals and conferences to manage water resources in climate change | 2.78 | 2 | 0.87 | 13 |
| Increasing the role of women to save agricultural water | 2.94 | 2 | 0.89 | 9 |

* Mean range of 1=very low, 2=low, 3=medium, 4=high, 5=very high

ranked first, "familiarizing students with the issue of water shortage" second, "increasing counseling services to villagers and distributing educational packages" third", "promoting the cultural perspective of the water in the Holy Quran by scholars and clergies of the region" fourth and also "holding sympathy and skill courses to manage water resources in the wake of climate change", fifth in terms of importance. Also, "establishing model, research and promotional farms" averaging 2.74 ranked last by importance.

Data in Table 5 relating to management solutions to reduce the vulnerability of farmers and beneficiaries in the agricultural sector suggests that "observing the area under cultivation with water discharge" ranked first, "investment on research and education and promotion" second, "development and promotion of a supportive insurance system in connection with pastures and agricultural products" third, "use of modern technology and experiences of other countries to minimize water shortages and evaporation management" fourth, and "integration and consolidation of lands and laser-leveling" fifth in terms of importance. Also, "use of management and popular participation in comprehensive water management" ranked last with an average of 2.14.

Table 5

*Prioritization Of Management Solutions to Reduce the Vulnerability of Farmers and Agriculture Beneficiaries*

| Items | Mean | Mode | Standard deviation | Final rank |
|---|---|---|---|---|
| Using updated technology and other countries' experiences to minimize water losses and evaporation management | 2.18 | 2 | 0.73 | 14 |
| Use of management and popular participation in comprehensive water management | 2.14 | 2 | 0.12 | 15 |
| strengthening existing organizations, cooperatives, and institutions Like Islamic Councils | 2.37 | 2 | 0.36 | 7 |
| Development of new irrigation systems with preservation of the previous area under cultivation | 2.33 | 2 | 0.37 | 9 |
| Increasing water efficiency in production, transmission, and distribution in the agriculture sector | 2.31 | 2 | 1.02 | 10 |
| Observing the area under cultivation with water discharge | 2.59 | 2 | 1.43 | 1 |
| Construction of double purpose pools for water storage | 2.34 | 2 | 0.21 | 8 |
| Planning to protect, restore, and develop rivers, canals, and well deepening | 2.39 | 2 | 1.13 | 6 |
| Integration and laser leveling of lands | 2.50 | 2 | 0.26 | 4 |
| Investment in research and education and promotion | 2.55 | 2 | 0.17 | 2 |
| Development and promotion of a supportive insurance system in connection with pastures and agricultural products | 2.51 | 2 | 0.34 | 3 |
| Establishment of predicting and alerting information system ranked | 2.33 | 2 | 0.65 | 9 |
| Changing traditional agricultural practices to modern practices | 2.21 | 2 | 1.19 | 12 |
| Comprehensive attention and support of employment in the affected areas | 2.43 | 2 | 0.27 | 5 |
| Improving the cooperation of public, non-public and private organizations active in the field of agriculture | 2.24 | 2 | 0.29 | 11 |
| Consultation with your local experienced people | 2.20 | 2 | 0.67 | 13 |
| Using the opinions and suggestions of the scientific elite | 2.43 | 2 | 0.82 | 5 |
| Use of modern technology and experiences of other countries to minimize water shortages and evaporation management | 2.51 | 2 | 0.13 | 4 |

* Mean range of 1=very low, 2=low, 3=medium, 4=high, 5=very high

The prioritization of institutional and infrastructural solutions in Table 6 indicates that "planning for cloud seeding" ranked first, "examination and re-engineering of existing water resources facilities" second, "avoiding increased cultivated area" third, "placing pipes for wells and covering them to control evaporation" fourth, in terms of importance. Also, "description of duties in the organizations operating water resources" with an average of 0. 56 ranked last in terms of importance.

An investigation of agro-technical solutions to reduce the vulnerability of farmers and agricultural beneficiaries in Table 7, indicates that "removing soil sealing to maintain soil moisture and reduce evaporation" ranked first, "correcting planting methods (direct cultivation by special machines, single-area cultivation, multiple-area cultivation) to significantly reduce water" second, "proper nutrition and use of potash fertilizers to

Table 6

*Prioritization of Institutional and Infrastructure Solutions to Reduce the Vulnerability of Farmers and agriculture Beneficiaries*

| Items | Mean | Mode | Standard deviation | Final rank |
|---|---|---|---|---|
| Control of premature and excessive grazing and forbidding of some rangelands | 2.18 | 2 | 1.03 | 10 |
| Identifying wells with lower efficiency and reducing the operating license of them | 2.14 | 2 | 0.16 | 11 |
| Preventing drilling new wells and identifying unauthorized wells and their sealing | 2.37 | 2 | 0.78 | 4 |
| Control of harvesting from permitted rivers and wells by installing smart meters | 2.18 | 2 | 0.43 | 10 |
| Description of duties in the organizations operating water resources | 0.56 | 2 | 0.12 | 13 |
| Development of marketing for direct supply of the products with eliminating profit-seeking intermediaries | 0.37 | 2 | 1.63 | 14 |
| Promoting and developing an appropriate cropping model and strict monitoring on its implementation | 2.18 | 2 | 0.55 | 10 |
| Planning based on indigenous knowledge, local capacities, and farmers' experiences in the field of water | 2.14 | 2 | 0.33 | 11 |
| Coordination between executive, research, promotion, and training systems to make the results of research applied | 2.37 | 2 | 0.89 | 4 |
| Transfer of water from other areas of the province | 2.13 | 2 | 0.13 | 12 |
| Creating job diversification and sources of secondary income with regard to the potential of the region (handicrafts, medicinal plants, etc.) | 2.37 | 2 | 0.98 | 14 |
| Paying attention to diversification of agricultural activities in rural areas | 2.18 | 2 | 0.56 | 10 |
| Identification, modification, and development of traditional modern methods of rainwater collection and water recycling for various uses | 2.24 | 2 | 0.29 | 7 |
| Planning for cloud seeding | 2.47 | 2 | 0.57 | 1 |
| Strengthening of aquifers | 2.28 | 2 | 0.87 | 5 |
| Construction of windmill and creating haloxylon farms to control wind erosion | 2.23 | 2 | 0.99 | 8 |
| Placing pipes for wells and covering them to control evaporation | 2.40 | 2 | 0.34 | 3 |
| Implementation of watershed management and flood plans and creation of earth dams and barriers at upstream of agricultural lands to strengthen groundwater aquifers | 2.20 | 2 | 0.73 | 9 |
| Transition to extra-territorial cultivation and importing some products from outside the province | 2.20 | 2 | 0.33 | 9 |
| Examination and re-engineering of existing water resources facilities | 2.43 | 2 | 0.72 | 2 |
| Corporate development of agriculture and industries for better management of water resources | 2.23 | 2 | 0.56 | 8 |
| Establishment of science and training courses | 2.27 | 2 | 0.47 | 6 |
| Avoiding increased cultivated area | 2.40 | 2 | 0.43 | 3 |
| Preventing the establishment of unrelated businesses and companies in agricultural sites | 2.23 | 2 | 1.03 | 8 |

* Mean range of 1=very low, 2=low, 3=medium, 4=high, 5=very high

Table 7
*Prioritization of Agro-Technical Solutions to Reduce the Vulnerability of farmers and Agricultural Beneficiaries*

| Items | Mean | Mode | Standard deviation | Final rank |
|---|---|---|---|---|
| Using appropriate fertilizers with the area water and soil quality to increase the quantity and quality of the crops | 2.18 | 2 | 0.43 | 10 |
| Using crop and horticultural species compatible with the quality of the area water and soil | 2.14 | 2 | 1.03 | 12 |
| Use of fertilizer well and canal to increase organic matter and water and nutrient storage capacity | 2.37 | 2 | 0.44 | 3 |
| Adopting measures to combat emerging pests and diseases with the aim of controlling and reducing damage | 2.20 | 2 | 0.34 | 8 |
| Observing the cultivation alternate with the aim of reducing pests and diseases and increasing production | 2.16 | 2 | 0.14 | 11 |
| Plant density and reduction of cultivation distance with the aim of increasing yield per unit area and increasing water productivity | 2.36 | 2 | 0.67 | 4 |
| Correcting planting methods (direct cultivation by special machines, single-area cultivation, multiple-area cultivation) to significantly reduce water | 2.40 | 2 | 0.13 | 1 |
| Autumn cultivation of spring crops to increase water productivity and evaporation control | 2.16 | 2 | 0.54 | 11 |
| Developing greenhouse cultivation to increase water productivity and increase production per unit area | 2.36 | 2 | 0.18 | 4 |
| Planting medicinal plants as potential for increasing income and adaptation to climate | 2.23 | 2 | 0.36 | 7 |
| Expanding and developing the cultivation of valuable and exporting plants requiring less water with the aim of increasing revenue | 2.27 | 2 | 0.87 | 5 |
| Removing soil sealing to maintain soil moisture and reduce evaporation | 2.40 | 2 | 0.62 | 1 |
| Prolonging the irrigation circuit and increasing the rate of water consumption at each time with the aim of increased penetration of water and reducing the negative effects of salinity. | 2.23 | 2 | 0.13 | 7 |
| Increasing water storage capacity by implementing conservation agriculture, preserving plant residues, and using humus and mycorrhizal fungi and super-absorbents | 2.18 | 2 | 1.51 | 10 |
| Crust breaking to maintain soil moisture and reduce evaporation | 2.24 | 2 | 0.43 | 6 |
| change in using a plow and using appropriate equipment | 2.18 | 2 | 0.46 | 10 |
| Increasing mechanization coefficient | 2.19 | 2 | 0.37 | 9 |
| Proper nutrition and use of potash fertilizers to increase drought resistance and other environmental stresses | 2.39 | 2 | 0.54 | 2 |

* Mean range of 1=very low, 2=low, 3=medium, 4=high, 5=very high

increase drought resistance and other environmental stresses" third, and "use of fertilizer well and canal to increase organic matter and water and nutrient storage capacity" fourth, in terms of importance, while the latest technical solution in terms of the importance was "using crop and horticultural species compatible with the quality of the area water and soil" averaging 2.14.

A set of economic, financial, and supportive skills by the government in Table 8 suggests that "family members' work in non-agricultural work to meet living costs and to help the family economy" ranked first, "Reducing loan interest rates and extending repayment time" second, "granting loans to start new and alternative businesses" third, and "participation by family members in agricultural work to save labor costs" fourth in terms of importance. Also, "receiving loans to make up for part of the costs" averaging 3.58 ranked last in terms of importance.

Table 8

*Prioritization of Economic, Financial, and Supportive Skills by the Government Solutions to Reduce the Vulnerability of Farmers and Agricultural Beneficiaries*

| Items | Mean | Mode | Standard deviation | Final rank |
|---|---|---|---|---|
| Creating stock markets and pricing and selling water | 3.62 | 4 | 0.55 | 8 |
| Realizing water price | 3.58 | 4 | 0.93 | 10 |
| Guaranteed purchases of water and purchases of water from farmers who do not produce valuable products | 3.63 | 4 | 0.89 | 7 |
| Saving and reducing the prices | 3.66 | 4 | 0.16 | 4 |
| Sale of less-used livestock tools and part of the land to finance | 3.62 | 4 | 0.58 | 8 |
| Receiving loans to make up for part of the costs | 3.58 | 4 | 0.65 | 10 |
| Participation by family members in agricultural work to save labor costs | 3.68 | 4 | 0.77 | 3 |
| Family members' work in non-agricultural work to meet living costs and to help the family economy | 3.74 | 4 | 0.15 | 1 |
| Price stabilization and supply of inputs needed by farmers for doing agricultural activities | 3.65 | 4 | 0.75 | 5 |
| Allocating subsidies to production inputs | 3.63 | 4 | 0.36 | 7 |
| Providing diverse, adequate, and low-interest rate banking facilities to develop new irrigation methods | 3.64 | 4 | 0.49 | 6 |
| Reducing loan interest rates and extending the repayment time | 3.70 | 4 | 0.13 | 2 |
| Increasing insurance obligations for planting the crops requiring low water and imported out of province | 3.63 | 4 | 0.33 | 7 |
| Determining the right price and guaranteeing the purchase of the crops requiring low water and compatibility with the conditions by the government | 3.66 | 4 | 0.15 | 4 |
| Granting loans to start new and alternative businesses | 3.68 | 4 | 0.77 | 3 |
| Increasing insurance obligations for planting the crops requiring low water and imported out of province | 3.61 | 4 | 0.55 | 9 |

* Mean range of 1=very low, 2=low, 3=medium, 4=high, 5=very high

An investigation of social skills to reduce the vulnerability of farmers and beneficiaries in the agricultural sector in Table 9 indicates that "presence of women with education in relevant social organizations" ranked first, while "active participation by other family members in training groups" ranked second. "farmers' risk-taking to invest in cultivating new and drought-resistant crops" ranked last in the averaging 0.62.

## Barriers and challenges to reduce the damages to farmers and beneficiaries in the agricultural sector

Barriers and challenges to reduce damages farmers and beneficiaries sustain in the agricultural sector were identified in three stages of the qualitative study and then categorized into three main groups, including economic-cultural-social challenges, management-agro-technical challenges, and institutional and infrastructural challenges. The mean of all items was greater than zero, indicating the importance of that item for the statistical sample size.

Data on socio-economic barriers and challenges in Table 10 suggests that "low government funding, low and untimely allocation and failure to properly expend" ranked first, "destiny-orientation and belief in the inevitable fate" second, "low water prices and lack of serious attention to water consumption" third, and "collapse of the traditional system and reduced traditional cooperation and partnerships" fourth, while "banks' failure to coordinate and high-interest rates on loans", averaging 2.74 ranked last in terms of importance.

Data in Table 11 on management-agro-technical challenges indicates that "failure to reconstruct and optimize irrigation facilities and water resources" ranked first, "unawareness of soil moisture and of conservation methods" second, "micro-level ownership and impossibility of Integrated agriculture management for better water utilization" third", "managers' non-foresightedness and relying on instant and promotional interests" fourth, while "absence of long-term, integrated and coherent rural development plan" averaging 2.14 ranked last in terms of importance.

Table 9

*Prioritization of Social Skills Solutions to Reduce the Vulnerability of Farmers and Agricultural Beneficiaries*

| Items | Mean | Mode | Standard deviation | Final rank |
|---|---|---|---|---|
| Farmers' risk-taking to invest in cultivating new and drought-resistant crops | 0.62 | 4 | 0.34 | 4 |
| The activities of women of farmer families in the activities of institutions and social groups | 3.58 | 4 | 0.63 | 3 |
| Active participation by other family members in training groups | 3.63 | 4 | 0.18 | 2 |
| Presence of women with education in relevant social organizations | 3.66 | 4 | 0.54 | 1 |

* Mean range of 1=very low, 2=low, 3=medium, 4=high, 5=very high

Table 10

*Prioritization of Economic, Cultural, and Social Challenges to Reduce the Vulnerability of Farmers and Agricultural Beneficiaries*

| Items | Mean | Mode | Standard deviation | Final rank |
|---|---|---|---|---|
| High cost of implementing some solutions | 3.05 | 4 | 0.34 | 5 |
| Low government funding, low and untimely allocation and failure to properly expend | 3.80 | 2 | 0.65 | 1 |
| Low water prices and lack of serious attention to water consumption | 3.22 | 4 | 0.76 | 3 |
| Banks' failure to coordinate and high-interest rates on loans | 2.74 | 2 | 1.03 | 9 |
| Weakness in government support policies such as insurance | 2.90 | 2 | 0.65 | 7 |
| The collapse of the traditional system and reduced traditional cooperation and partnerships | 3.09 | 4 | 0.16 | 4 |
| Encouraging urban living and consumerism and welfare seeking | 2.90 | 2 | 0.54 | 7 |
| Destiny-orientation and belief in the inevitable fate | 3.26 | 4 | 0.88 | 2 |
| The high average age of farmers and lack of entrepreneurial, innovation, and novelty spirit | 2.76 | 2 | 0.34 | 8 |
| Distrust of people in completing supportive projects proposed by the government to change the cropping | 2.91 | 2 | 0.23 | 6 |

* Mean range of 1=very low, 2=low, 3=medium, 4=high, 5=very high

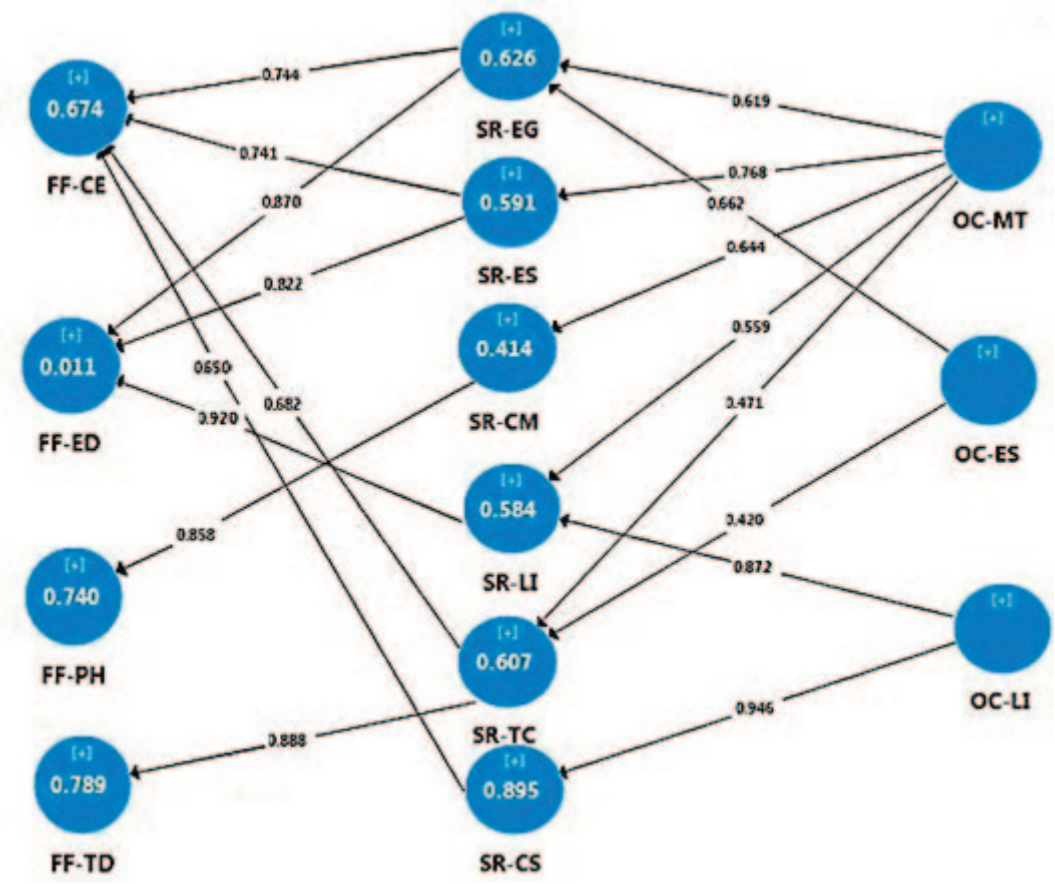


*Figure 2.* Research's experimental model

Table 11
*Prioritization of Management, Technical and Crop Challenges to Reduce the Vulnerability of Farmers and Agricultural Beneficiaries*

| Items | Mean | Mode | Standard deviation | Final rank |
|---|---|---|---|---|
| Improper use of fertilizers and pesticides | 2.18 | 2 | 0.55 | 11 |
| Absence of a long-term, integrated and coherent rural development plan | 2.14 | 2 | 0.33 | 13 |
| Managers' non-foresightedness and relying on instant and promotional interests | 2.37 | 2 | 0.89 | 4 |
| Lack of serious belief in climate change among officials | 2.20 | 2 | 0.13 | 9 |
| Low risk-taking and courage of managers | 2.16 | 2 | 0.98 | 12 |
| Employment of non-specialists in agriculture sector | 2.36 | 2 | 0.56 | 5 |
| Lack of accurate and reliable basic statistics and information in relevant and decision-making organizations | 2.29 | 2 | 0.44 | 6 |
| Lack of using appropriate crop species | 2.16 | 2 | 0.67 | 12 |
| Inappropriate use of water resources | 2.36 | 2 | 0.88 | 5 |
| Lack of proper irrigation system | 2.23 | 2 | 0.15 | 8 |
| Waste of water and inappropriate consumption practices | 2.27 | 2 | 0.49 | 7 |
| Unawareness of soil moisture and of conservation methods | 2.40 | 2 | 0.13 | 2 |
| Low level of mechanization and lack of appropriate local technologies | 2.23 | 2 | 0.33 | 8 |
| Insisting on old and traditional practices and lack of knowledge of modern practices | 2.18 | 2 | 0.34 | 11 |
| Failure to reconstruct and optimize irrigation facilities and water resources | 2.42 | 2 | 0.77 | 1 |
| Low level of knowledge, skills, and technology of farmers in the area of water resources management | 2.18 | 2 | 0.98 | 11 |
| Inappropriate quality of agricultural land in the province in terms of buildings and mineral and organic materials | 2.19 | 2 | 0.45 | 10 |
| Micro-level ownership and impossibility of Integrated agriculture management for better water utilization | 2.39 | 2 | 1.04 | 3 |

* Mean range of 1=very low, 2=low, 3=medium, 4=high, 5=very high

Data on institutional and infrastructural challenges in Table 12 indicates that "arid climate and geographical location of the province" ranked first, "lack of diversity in job opportunities in rural areas" second, "lack of a proper marketing system and the presence of intermediaries" third, and "administrative bureaucracy, paperwork, and unaccountability of relevant departments and agencies" fourth, while "absence of effective forensic systems" with an average of 2.74 in the took the last rank.

## Experimental model of solutions to reduce the vulnerability of farmers and beneficiaries in the agricultural sector

Data from an analysis of the research questionnaire were converted into data using statistical methods and were tested using PLS software to determine the relationships between variables. According to the results of this study, an experimental model of solutions to reduce the vulnerability of farmers and beneficiaries in the agricultural sector to climate change was devised.

As seen in Figure 2, the positive numbers between the research variables indicate a positive and significant relationship between those variables.

Table 12
*Prioritization of institutional and Infrastructure Challenges to Reduce the Vulnerability of Farmers and Agricultural Beneficiaries*

| Items | Mean | Mode | Standard deviation | Final rank |
|---|---|---|---|---|
| Lack of proper development infrastructure in rural areas | 3.05 | 4 | 0.93 | 6 |
| Lack of a service system in accordance with rural and nomadic life style | 2.80 | 2 | 1.1 | 11 |
| Lack of a proper marketing system and the presence of intermediaries | 3.22 | 4 | 1.03 | 3 |
| Absence of effective forensic systems | 2.74 | 2 | 0.73 | 13 |
| Lack of relevant research institutes and lack of research activities | 2.97 | 2 | 0.12 | 7 |
| The weakness of promotion and the lack of sufficient allocation of credits for this sector to increase productivity | 3.07 | 4 | 0.36 | 5 |
| Multiplicity of organizations responsible for rural development works and the need for synergy | 2.97 | 2 | 0.37 | 7 |
| Lack of diversity in job opportunities in rural areas | 3.23 | 4 | 0.43 | 2 |
| Lack of indigenous, non-governmental, and private social organizations dependent on government services and facilities | 2.78 | 2 | 0.52 | 12 |
| Lack of diversity in water resources and lack of alternative water resources | 2.96 | 2 | 0.67 | 8 |
| Administrative bureaucracy, paperwork, and unaccountability of relevant departments and agencies | 3.08 | 4 | 0.82 | 4 |
| Population growth and rising inflation | 2.86 | 2 | 0.55 | 10 |
| The arid climate and geographical location of the province | 3.27 | 4 | 0.33 | 1 |
| Distance from center and communication problems and low relative welfare of farmers | 2.78 | 2 | 0.89 | 12 |
| Resource limitations | 2.94 | 2 | 0.13 | 9 |

* Mean range of 1=very low, 2=low, 3=medium, 4=high, 5=very high

Model fit indices were used to measure the similarity between the experimental model and the theoretical model. In the structural equation model, the model fit indices were used to evaluate the structural part. In the PLS technique, the partial least squares sufficed to fit the model of the technique. The most important model fit index in the least squares technique is the GOF index. Three values of 0.1, 0.25, and 0.36 were introduced as weak, medium and strong values for GOF. This index can be calculated using the geometric mean of the $R^2$ index and the mean redundancy indices in Equation 1.

$$GOF = \sqrt{\text{average (Commonality)} \times \text{average } (R^2)} \quad (1)$$

The output of PLS software for Communality values of R Square values is shown in Table 13.

$$\text{Thus, we have } GOF=\sqrt{0.324\times0.619}= 0.352 \quad (2)$$

The model fit index is equal to 0.352, which is higher than 0.1 and the model fit is confirmed. So, it is concluded that it shows good desirability of the model.

## DISCUSSION AND CONCLUSION

Identifying solutions to reduce damages farmers and beneficiaries sustain in the agricultural sector, as well as investigating the challenges and barriers to implementing the

*Table 13*
*Communality and R Square Values*

| Questionnaire variables | Acronyms | Communality | R Square | $R^2$ |
|---|---|---|---|---|
| | | Average Communality= 0.324 | Average $R^2$=0.619 | |
| Promotional and training solutions | SR-ES | 0.377 | 0.591 | 0.612 |
| Management solutions | SR-CM | 0.353 | 0.414 | 0.509 |
| Institutional and infrastructure solutions | SR-LI | 0.312 | 0.584 | 0.590 |
| Technical and crop solutions | SR-TC | 0.298 | 0.607 | 0.681 |
| Social skills | SR-EG | 0.301 | 0.626 | 0.693 |
| Government's economic, financial, and support skills | SR-CS | 0.342 | 0.895 | 0.901 |
| Economic, cultural, and social challenges | OC-ES | 0.278 | - | - |
| Management, technical and crop challenges | OC-MT | 0.331 | - | - |
| Institutional and infrastructure challenges | OC-LI | 0.324 | - | - |

proposed solutions are a starting point to manage climate change-related risks. The present study aimed to investigate the solutions to reduce the vulnerability of farmers and beneficiaries in Khuzestan province. According to the results, economic-financial-supportive skills by the government and training-promotional solutions can have positive impacts on economic and environmental damages. However, Vasquez-Len et al. (2003) and Zarafshan et al. (2012) all stated that government support and access to facilities could play an important role in reducing economic damages; another study Shewmake (2008) reported that vulnerability had increased for people receiving loans.

Management solutions will also directly affect socio-psychological damages. According to Table 5, it is concluded that investment in research, training, promotion, development, and promotion of insurance support system, using modern technology and laser integration as well as territorial leveling is the most important management strategy. which is confirmed by studies conducted by Gautier et al. (2016) and Shewmake (2008) and Vasquez-Len et al. (2003).

They also considered capital as an important factor to transfer and use new technologies in agriculture. For Sengestam (2009), the existing infrastructure in agricultural fields such as leveling and integration management is the most important variable, stating that capital in the hands of farmers is not used properly and in case integration is made, the required capital can be invested optimally by experts.

Institutional-infrastructural skills can have positive impacts on environmental damages. According to the findings, planning for cloud seeding, surveying, and re-engineering of existing water resources facilities, preventing an increase in the area under cultivation, piping wells, and covering them to control evaporation are seen as the most important institutional-infrastructural solutions. Simelton et al. (2009) demonstrated that improving water supply facilities, preventing an increase in the area under cultivation as well as optimally using water, and the issue of its evaporation plays an essential role in reducing damages. That the results of both studies correspond will also determine the accuracy of the results.

Agro-technical solutions will also affect technical and economic damages. According to the findings of this study, improving the planting method, preserving soil moisture, proper feeding, and using potash fertilizers to increase drought resistance and other environmental stresses can be regarded as the most important technical-agronomic solutions. This result confirmed the findings by Zarafshan et al. (2012) who stated that using drought-resistant species (correcting planting method using the required fertilizers) had a key role in reducing the damage to farmers and agricultural beneficiaries. Also, social solutions will have a direct and positive impact on economic damages. This finding was validated by Sengestam (2009) studies, as he suggested that social capital reduces the transfer and dissemination of information, innovation, mutual trust between individuals, reduces transfer costs, ultimately reducing economic losses.

Indeed, economic-financial-support skills solutions provided by the government, training-promotional solutions, management solutions, institutional-infrastructure, and agro-technical solutions will be affected in the applied dimension by barriers and challenges to agro-technical management.

Economic-financial-supportive skills by the government and technical-agricultural solutions will also be affected by economic-cultural-social challenges in the applied dimension.

Institutional-infrastructural-social solutions to reduce damages to farmers and beneficiaries in the agricultural sector will be affected by institutional-infrastructural challenges in the applied dimension.

Implementing the necessary skills and solutions to reduce damages to farmers and beneficiaries in the agricultural sector requires removing barriers and challenges. To overcome the barriers and challenges related to management-technical-agricultural, it is necessary to provide some suggestions for the statistical population of the research. The most important suggestions include:

- It is recommended that existing irrigation facilities in Khuzestan province be reconstructed and water resources be optimally used;
- It is recommended to train farmers to preserve soil moisture in the long run;
- It is recommended to strengthen the foresightedness of managers;
- It is recommended to train and increase the level of agricultural skills technology and to use expert people specializing in agriculture;
- It is recommended to integrate agricultural management for better utilization of water.

To overcome the barriers and challenges related to Economic, cultural and social challenges, it is necessary to provide some suggestions for the statistical population of the research. The most important suggestions include:

- "Increasing government credits and spending them correctly"
- "Removing the misconception of destiny from the view of the relevant officials"
- "Serious attention to water-saving"
- "Increasing the spirit of cooperation and coordination among farmers and officials"
- "Reducing interest rates on loans by banks"
- "Strengthening government protection policy by issues such as insurance"

To overcome the barriers and challenges related to institutional and infrastructural challenges, it is necessary to provide some suggestions for the statistical population of the research. The most important suggestions include:

- "Creating job diversity and recruitment processes in rural areas"
- "Creating a proper marketing system and the presence of intermediaries"
- "Removing bureaucracy"
- "Enhancing the promotion and allocation of enough funds for this sector to increase productivity"

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