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A Survey: Factors Affecting the Sustainable Water Recourses Management (SWRM) in Agriculture under Drought Conditions in Lorestan, Iran

[1]Nooshin Osooli, [2]Mahmod Hosseini, [3]Jamal Farajollah Hosseini and [4]Amir Hamzeh Haghiabi

[1]Department of Agricultural Development,
Science and Research Branch, Islamic Azad University, Tehran, Iran
[2]Faculty Member of Tehran University
[3]Faculty Member of Research and Sciences University of Tehran
[4]Faculty Member of Lorestan University

Abstract: Drought is one of the climatic phenomena that would always cause some damages for human societies. Drought occurs in all climatic regimes of Iran with different intensities. Low precipitation rate has resulted in decreasing river discharge, early exploitation of wells and early aquifer loss in Lorestan Province in recent years. Therefore, it has worsened the drought crisis. The agricultural sector of the province has showed very vulnerable and its crop yield has quite decreased due to inefficient water resources management. As its main objective, the research was conducted to study the factors affecting the sustainable water recourses management in agriculture under drought conditions in this province. This survey was conducted on a number of 220 wetland farmers and 70 experts linked to the subject at Agricultural Jihad Organization and Regional Water Affairs Department in Lorestan Province selected by Cochran Formula and cluster sampling method. The data were analyzed with Confirmatory Factor Analysis (CFA) Method and the LISREL 8.5 Software. The results indicated that all economic, technical, farming, socio-cultural and educational-extensive factors had significant effects on the sustainable management of water resources in Lorestan Province under drought conditions with 99% certainty. Among these factors, technical ones had the highest effect and ranking. However, socio-cultural factors showed the lowest effect and ranking. Moreover, the amounts of the effects produced by the indexes of these factors were based upon the amounts of standardized factor loads and their ranking was on the same basis.

Key words: Sustainable Water Recourses Management · Agriculture · Drought · Lorestan · Iran

INTRODUCTION

Drought is one of the climatic phenomena that would always cause some damages for human societies. Drought occurs in all climatic regimes of Iran with different intensities. The most usual indices, which quantify the intensity of drought, are being studied in a 30 years period, which leads to water year 2001- 2002 and are compared for all sub-basins of Iran. Therefore, according to analysis of precipitation statistics with the indices, meteorological drought characteristics in the field of intensity, magnitude, Continuity and extent have been determined in minor sub-basins of Iran [1].

Iran with average precipitation of 249 mm in a year being one third of universal average is one of the dry countries of the world with limited resources [2]. About %93 of renewable water resources is consumed in watery agriculture. The results of different researches show that water is wasted in different from in irrigation out pot varies between 33 to %37. It means that about %70 of resources is lost in the form of evaporation, percolation losses, drainage run-off and rivers which join the see or exit the country boundaries [3].

The spatial and time distribution of precipitation is quite unsuitable in Iran. It has been facing drought due to specific meteorological conditions for the past years. Most of its provinces currently suffer from severe low water so that it is necessary to pay more attention to better water management and use [4]. Due to the value of water in agriculture, its restricted resources and alternate droughts throughout the country, it seems indispensable to manage water supplies and identify the factors affecting its optimum consumption.

Corresponding Author: Nooshin Osooli, Department of Agricultural Development, Science and Research Branch, Islamic Azad University, Tehran, Iran, E-mail: noshin_osoli@yahoo.com.

Faraz argues that one way to maximize irrigation efficiency is to use sprinkler and drip irrigation. Among the advantages of these kinds of irrigations are to water consumption saving, reduction in number of workers, possibility of irrigation on high gradient lands, irrigation of different types of soil and prevention of erosion [5]. Keramat zade proposes that suitable water pricing is a motivating tool for water consumption saving and prevention from its loss [6]. Mc Cartney proposes that water storage is a strategy to deal with water storage. They introduce many ways for storing water in agriculture sector such as artificial ground water recharge of water table, pools or individual or family made tanks, water storage in soil, dams, small resources and rain water storage [7].

There are many technologies available that can reduce a farmer's vulnerability to drought. These include water capture, storage and irrigation as well as improved techniques for soil preparation and management and improved crop planting, planning and production methods. Additionally, there are more resistant strains of seed s available and animals selected for increased production o f eggs, meat and honey. All of these technologies allow for greatly reduced vulnerability. They can produce results like those from "another climate." In particular, water storage has allowed for improved access to drinking water and irrigation of crops [8].

Owis and Hachum propose some strategies for water management under the condition of water shortage including drainage management, reconsuming of water in farms, water pricing, rain water consumption and plant inbreeding [9]. Panahi considers near distance among deep wells and semi deep as a factor in decreasing ground water and drying semi deep wall. She believes that water consumption problems in agricultural sector are related to water loss during delivery from resources to farm and through the farm and plots [10]. Afshar argues that the main challenges in optimal consumption of water are small - scale land possession, lack of land leveling and shaping, policies in pricing water rate and lack of skilled man power, who are specialized in water consumption management in state organizations and institutions [11].

Decision-making aimed at the evaluation of the water management processes deals with:

- Complexity of structures of processes;
- Multiple subsystems with complex mechanism interacting as internal or external parts;
- Time and space/geographical dependencies;
- Great volume of data acquired from the processes;
- Multi-criteria decision-making [12].

MATERIALS AND METHODS

The statistical population included two groups: (1) A number of 61,584 wetland farmers in Lorestan Province of whom a number of 220 people were selected by Cochran Formula as well as cluster sampling method and studied. (2) A number of 70 experts at Agricultural Jihad Organization and Regional Water Affairs Department in Lorestan Province, whose major or work field were related to water management in agriculture.

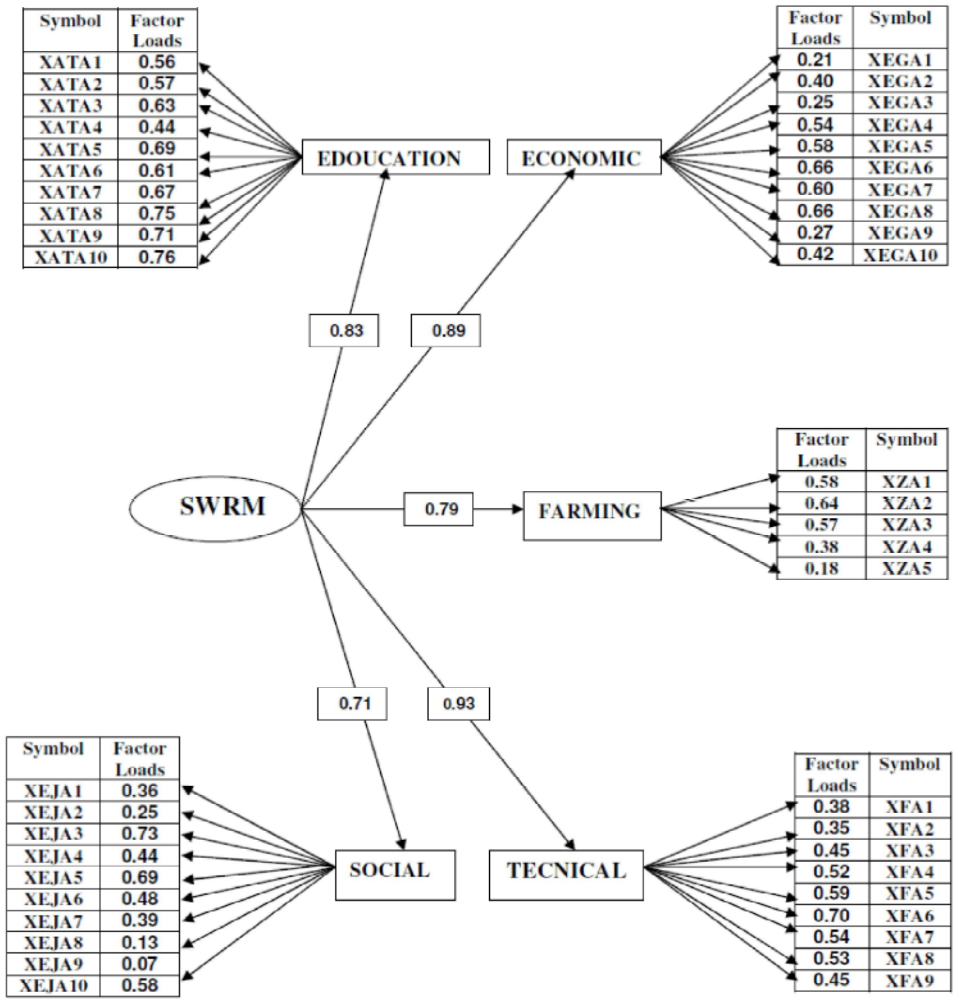
In order to sample the farmers and select 220 people, three cities (i.e. Azna, Kouhdasht and Poledokhtar) were selected throughout the province. Then, three rural districts in each city, three to five villages of each rural district and finally some farmers from each village were randomly selected and questioned.

The research method was quantitative and of survey type. Questionnaire was the main data collection tool, accompanied by observation and interview. There were two types of questionnaires, one for the farmers and the other for the experts. However, they were quite similar except for the parts allocated to their personal and vocational information. The professors and the specialists confirmed the validity of the questionnaires. The reliabilities of the questionnaires were also estimated as 0.96% for the experts' questionnaire and 0.87% for the farmers' questionnaire by Cronbach's Alpha Coefficient, indicating their high validity. The LISREL 8.5 Software was used for analyzing the data. Moreover, Confirmatory Factor Analysis (CFA) was applied as the statistical method.

RESULTS AND DISCUSSION

In order to study the importance of every factor affecting the sustainable water resources management (SWM) in agricultural sector under drought conditions from the viewpoints of farmers and experts and the influence of their indexes, Confirmatory Factor Analysis (CFA) method was applied.

The model was designed by the LISREL 8.5 Software. The root mean square error of approximation (RMSEA) was 0.038 in this model. If the statistic is less than 0.05 in a fitted model, it is said to have a good fitting [13]. According to other fitting indexes shown in Table 1.1, the model enjoys a good fitting and is confirmed. Therefore, the estimated parameters may be considered reliable and used for testing the research hypotheses. The model fitting must be acceptable; therefore, the estimation of the parameters is studied.

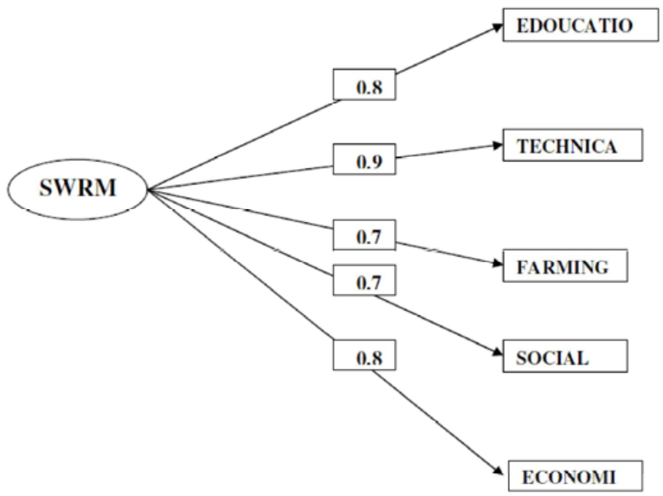


Model 1.1: Basic CFA Model for factors affecting the sustainable water recourses management (SWRM) in agriculture under drought conditions from the viewpoints of farmers and experts. (The symbols in this model are introduced in the tables 2.1 and 4.1 to 8.1 during the text)

Table 1.1. Fitting indexes of the basic CFA Model for the second-order factors affecting the sustainable water management in agriculture

Fitting Indexes	Standards	Reported Values
Normal Theory Weighted Least Squares Chi-Square	Significance Level: 0.00 - 1284.64	
Root Mean Square Residual (RMR)	0.00 -1:00	0.07
Goodness of Fit Index (GFI)	0/85<	0/86
Adjusted Good of Fit Index (AGFI)	0/80<	0/80
Normed Fit Index (NFI)	0/80<	0/91
Non-Normed Fit Index (NNFI)	0/80<	0/96
Incremental Fit Index (IFI)	0/90<	0/96
Comparative Fit Index (CFI)	0/90<	0/96
Root Mean Square Error of Approximation (RMSEA)	0/08>	0/04

Values of the Standard Parameters in the Structural CFA Model for the Structures Affecting the Sustainable Water Management in Agriculture under Drought Conditions: The relationship between the first order structures, i.e. factors and second order factors is called gamma coefficient. Therefore, in the structural model below, the values of the factor loads (i.e. gamma values) are presented through the structures. According to these values and their significant ones determined by the t-value, we may separately identify the ranking and proportion of each factor affecting the sustainable water management in agriculture.



Model 2.1: Structural CFA Model for factors affecting the sustainable water recourses management (SWRM) in agriculture under drought conditions from the viewpoints of farmers and experts. (The symbols in this model are introduced in the table 2.1)

Table 2.1: Values of standard parameters in the Structural CFA Model for the structures of the factors affecting the sustainable water management in agriculture

Second Order Structure	First Order Structures (Factors)	Symbol in Model	Standardized Factor Loads	Standard Error	T	R^2	P-Value
Sustainable water resources management in agriculture under drought conditions	Economic factors	Economic	0.89	0.230	3.31	0.79	0.000**
	Technical factors	Technical	0.93	0.160	6.07	0.87	0.000**
	Agricultural factors	Farming	0.79	0.100	8.22	0.63	0.000**
	Socio& Cultural factors	Social	0.71	0.140	5.26	0.50	0.000**
	Educational& Extensive factors	Education	0.83	0.088	8.99	0.69	0.000**

Ranking the Factors Affecting the Sustainable Water Management in Agriculture under Drought Conditions Based upon Factor Loads and T Significance Level: Standardized factor loads play an important role, among factor analysis outputs, for the interpretation of factor analysis results. These loads show the correlation between each observed variable and its related factor. The more the value of this factor load is, the higher the correlation between the observed variable and its related factor is.

In addition to factor loads, t-statistic has a major role in determining the significance level and is, therefore, studied. When $t > 1.96$, the relationship between the observed variable and the related factor is significant at 0.05 level (with 95% certainty). If $t > 1.56$, the relationship between the observed variable and the related factor is significant at 0.01 level (with 99% certainty).

Hypotheses I:

H0 = Technical factors are not affecting the sustainable water resources management in agriculture under draught conditions.

H1 = Technical factors are affecting the sustainable water resources management in agriculture under draught conditions.

According to Table 3.1, due to t-value (6.07) with 99% certainty, technical factors are effective on the sustainable management of agricultural water resources under drought conditions. Thus, H_0 Hypothesis is rejected whereas H_1 hypothesis is acceptable.

Also, technical factors have the highest effect and the first ranking among those factors affecting the sustainable water management in agriculture under drought conditions due to the value of the standardized factor load.

Hypotheses II:

H0 = Economic factors are not affecting the sustainable water resources management in agriculture under draught conditions.

H1 = Economic factors are affecting the sustainable water resources management in agriculture under draught conditions.

Table 3.1: Ranking the effect of first order structures in the formation of the second order structures based upon the factor load in the independent variable of the factors affecting the sustainable management of water resources

Second Order Structure	First Order Structures	Standardized Factor Loads	t	Ranking
Sustainable water resources management in agriculture under drought conditions	Technical factors	0.93	6.07	1
	Economic factors	0.89	3.31	2
	Educational-extensive factors	0.83	8.99	3
	Agricultural factors	0.79	8.22	4
	Socio-cultural factors	0.71	5.26	5

If t >1.96: significant at 5% level; If t > 2.56: significant at 1% level

According to Table 3.1. due to t-value (3.31) with 99% certainty, economic factors are effective on the sustainable management of agricultural water resources under drought conditions. Thus, H_0 Hypothesis is rejected whereas H_1 hypothesis is acceptable.

Also, economic factors rank second among those factors affecting the sustainable water management in agriculture under drought conditions due to the value of the standardized factor load.

Hypotheses III:

H0 = Educational-extensive factors are not affecting the sustainable water resources management in agriculture under draught conditions.

H1 = Educational-extensive factors are affecting the sustainable water resources management in agriculture under draught conditions.

According to Table 3.1. due to t-value (8.99) with 99% certainty, educational - extensive factors are effective on the sustainable water management in agriculture under drought conditions. Thus, H_0 Hypothesis is rejected whereas H_1 hypothesis is acceptable.

Also, educational-extensive factors rank third among those factors affecting the sustainable water management in agriculture under drought conditions due to the value of the standardized factor load.

Hypotheses VI:

H0 = Agricultural factors are not affecting the sustainable water resources management in agriculture under draught conditions.

H1 = Agricultural factors are affecting the sustainable water resources management in agriculture under draught conditions.

According to Table 3.1. due to t-value (8.22) with 99% certainty, farming factors are effective on the sustainable water management in agriculture under drought conditions. Thus, H_0 Hypothesis is rejected whereas H_1 hypothesis is acceptable.

Also, farming factors rank fourth among those factors affecting the sustainable water management in agriculture under drought conditions due to the value of the standardized factor load.

Hypotheses V:

H0 = Socio-Cultural factors are not affecting the sustainable water resources management in agriculture under draught conditions.

H1 = Socio-Cultural factors are affecting the sustainable water resources management in agriculture under draught conditions.

According to Table 3.1. due to t-value (5.26) with 99% certainty, socio-cultural factors are effective on the sustainable water management in agriculture under drought conditions. Thus, H_0 Hypothesis is rejected whereas H_1 hypothesis is acceptable.

Also, socio-cultural factors rank fifth among those factors affecting the sustainable water management in agriculture under drought conditions due to the value of the standardized factor load.

Values of the Standard Parameter in the Basic CFA Model of the Indexes Related to the Factors Affecting the Sustainable Water Recourses Management in Agriculture under Drought Conditions: In this section, based upon the value of the standardized factor load, the effect rate of each index (explicit variables) related to different factors affecting the sustainable water management in agriculture under drought conditions is determined and the indexes are, therefore, prioritized. Also, the significance or insignificance of the effects is determined based upon t-value.

Table 4.1: Values of the standard parameters of the indexes related to technical factors

Factors (First Order Structures)	Explicit Variables (Indexes)	Symbol in model	Standardized Factor Loads	Standard Error	T	R2	P-Value
Technical Factors	Land consolidation	XFA1	0.38	-	-	0.14	-
	Centralized farming (simultaneous and similar cultivation, management and harvest by all farmers)	XFA2	0.35	0.085	4.34	0.13	0.000**
	Land grading	XFA3	0.45	0.056	5.48	0.20	0.000**
	Land equipment and reconstruction (providing electricity, road construction, regulating form and direction of water supply channels)	XFA4	0.52	0.073	5.27	0.27	0.000**
	Banquettes and removing land gradient (terracing)	XFA5	0.59	0.097	5.57	0.35	0.000**
	Establishing flood wall and collecting runoffs and flood water for the artificial nutrition of groundwater	XFA6	0.70	0.085	5.87	0.49	0.000**
	Constructing dams, weirs and diversion channels over rivers	XFA7	0.54	0.078	5.37	0.29	0.000**
	Constructing water pumping stations over rivers	XFA8	0.53	0.085	4.95	0.28	0.000**
	Preventing unauthorized shaft sinking	XFA9	0.45	0.068	4.96	0.20	0.000**

* & ** show significance at 95% certainty level (0.05 error) and 99% certainty level (0.01 error), respectively

Table 5.1: Values of the standard parameters of the indexes related to economic factors

Hidden Features (First Order Structures)	Explicit Variables (Indexes)	Symbol	Standardized Factor Loads	Standard Error	t	R^2	P-Value
Economic Factors	Water rate payment	XEGHA1	0.21	-	-	0.046	-
	Water rate discount or exemption for farmers with low-level consumption	XEGHA2	0.40	0.18	3.93	0.16	0.000**
	Fining farmers with high-level consumption for water rate	XEGHA3	0.25	0.12	3.74	0.061	0.000**
	Paying bank facilities to farmers for executing water management projects	XEGHA4	0.54	0.17	3.10	0.29	0.000**
	Paying low-interest bank loans	XEGHA5	0.58	0.19	3.11	0.34	0.000**
	Reducing the regulations for getting bank credits (check, bail, etc.)	XEGHA6	0.66	0.26	3.19	0.44	0.000**
	Government's supervising on loan and facilities application	XEGHA7	0.60	0.18	3.23	0.36	0.000**
	Obtaining credits from international organizations	XEGHA8	0.66	0.25	3.26	0.44	0.000**
	Private sector participation in investment on water management	XEGHA9	0.27	0.16	2.67	0.072	0.000**
	Financial support of private sector companies by the government	XEGHA10	0.42	0.23	3.04	0.18	0.000**

* & ** show significance at 95% certainty level (0.05 error) and 99% certainty level (0.01 error), respectively

Values of the Standard Parameter in the Basic CFA Model of the Indexes Related to the Technical Factors Affecting the Sustainable Water Recourses Management in Agriculture under Drought Conditions: According to Table 4.1. among the technical factors affecting the sustainable water management in agriculture under drought conditions, constructing weirs and collecting runoffs and flood water for the artificial nutrition of groundwater has the highest factor load and priority of effect, whereas centralized farming (simultaneous and similar cultivation, management and harvest by all farmers) has the lowest factor load and priority of effect. Also, t-value shows that all the technical factor indexes have significant effects on the sustainable water management in agriculture.

Values of the Standard Parameter in the Basic CFA Model of the Indexes Related to the Economic Factors Affecting the Sustainable Water Management in Agriculture under Drought Conditions: According to Table 5.1. among the economic factors affecting the sustainable water management in agriculture under drought conditions, obtaining credits from international organizations and reducing the regulations for getting bank credits (check, bail, etc.) have the highest factor load and priority of effect, whereas water rate payment has the lowest factor load and priority of effect. In addition, t-value shows that all the economic factor indexes have significant effects on the sustainable water management in agriculture.

Table 6.1: Values of the standard parameters of the indexes related to educational-extensive factors

Hidden Features (First Order Structures)	Explicit Variables (Indexes)	Symbol in model	Standardized Factor Loads	Standard Error	t	R^2	P-Value
Educational-extensive Factors	Holding educational-extensive courses on water management strategies under drought conditions	XATA1	0.56	-	-	0.31	-
	Practical visits of new irrigation systems at model farmlands by farmers	XATA2	0.57	0.049	8.82	0.33	0.000**
	Regular visits of irrigation systems and methods by extension agents under drought conditions	XATA3	0.63	0.060	8.35	0.39	0.000**
	Regular referrals of farmers to agricultural service centers for consultation and solving the problems of optimum water management	XATA4	0.44	0.068	6.51	0.19	0.000**
	Preparing and distributing educational magazines, brochures and CDs on water management	XATA5	0.69	0.082	8.78	0.47	0.000**
	Producing and broadcasting educational programs, animations and ads over the radio and on TV	XATA6	0.61	0.080	8.18	0.37	0.000**
	Educational need analysis of regional farmers on water management	XATA7	0.67	0.071	8.78	0.44	0.000**
	In-service training of experts and extension agents on water management	XATA8	0.75	0.068	9.33	0.56	0.000**
	Better using the potentials of university graduates in water section in the form of private companies and cooperatives	XATA9	0.71	0.066	9.10	0.51	0.000**
	Holding scientific-research seminars on sustainable water management at provincial, regional and national levels	XATA10	0.76	0.081	9.39	0.57	0.000**

Table 7.1: Values of the standard parameters of the indexes related to farming factors

Hidden Features (First Order Structures)	Explicit Variables (Indexes)	Symbol in model	Standardized Factor Loads	Standard Error	t	R^2	P-Value
Farming (Agricultural) Factors	Using improved varieties (resistant to dryness and/or having shorter growth period)	XZA1	0.58	-	-	0.34	-
	Maintaining straw and crop residue of the previous growing year on the ground (to save soil moisture)	XZA2	0.64	0.092	6.74	0.41	0.000**
	Weed control in the field and on riversides	XZA3	0.57	0.053	6.70	0.32	0.000**
	Protective tillage (surface and shallow tillage)	XZA4	0.38	0.079	5.11	0.15	0.000**
	Crop cultivation in greenhouses	XZA5	0.18	0.25	2.51	0.032	0.000**

Values of the Standard Parameter in the Basic CFA Model of the Indexes Related to the Educational-Extensive Factors Affecting the Sustainable Water Recourses Management in Agriculture under Drought Conditions: According to Table 6.1. among the educational-extensive factors affecting the sustainable water management in agriculture under drought conditions, holding scientific-research seminars on sustainable water management at provincial, regional and national levels has the highest factor load and priority of effect, whereas regular referrals of farmers to agricultural service centers for consultation and solving the problems of optimum water management has the lowest factor load and priority of effect. Also, t-value shows that all the educational-extensive factor indexes have significant effects on the sustainable water management in agriculture.

Values of the Standard Parameter in the Basic CFA Model of the Indexes Related to the Farming (Agricultural) Factors Affecting the Sustainable Water Recourses Management in Agriculture under Drought Conditions: According to Table 7.1. among the farming factors affecting the sustainable water management in agriculture under drought conditions, maintaining straw and crop residue of the previous growing year on the ground (to save soil moisture) has the highest factor load and priority of effect, whereas crop cultivation in greenhouses has the lowest factor load and priority of effect. Also, t-value shows that all the farming factor indexes have significant effects on the sustainable water management in agriculture.

Table 8.1: Values of the standard parameters of the indexes related to socio-cultural factors

Hidden Features (First Order Structures)	Explicit Variables	Symbol	Standardized Factor Loads	Standard Error	t	R^2	P-Value
Socio-cultural Factors	Identifying and using the native knowledge of farmers for water management methods	XEJA1	0.36	-	-	0.13	-
	Identifying and using the native knowledge of farmers for meteorology related to drought	XEJA2	0.25	0.075	4.44	0.63	0.000**
	Foundation and reinforcement of water consumption bodies and leaving the irrigation systems exploitation and maintenance with them	XEJA3	0.73	0.13	5.37	0.54	0.000**
	Using local traditions and native rules among farmers for water management	XEJA4	0.44	0.10	4.66	0.20	0.000**
	Involving people in decision-making, execution and maintenance of water management projects in agriculture	XEJA5	0.69	0.12	5.15	0.47	0.000**
	Paving the way for improving water consumption pattern	XEJA6	0.48	0.069	4.77	0.23	0.000**
	Using the experiments and authorities of water-distributors concerning water-related affairs	XEJA7	0.39	0.10	4.52	0.15	0.000**
	Providing Rural Islamic Councils with more power and authorities regarding water problems and its management under drought conditions	XEJA8	0.13	0.097	1.88	0.16	0.000**
	Involving the Councils for the Settlement of Disputes at districts to solve water problems	XEJA9	0.07	0.095	1.11	0.0053	0.000**
	Using local bodies for supervising the allocation, distribution and consumption of the credits for water management in agriculture	XEJA10	0.58	0.13	4.98	0.33	0.000**

Values of the Standard Parameter in the Basic CFA Model of the Indexes Related to the Socio-Cultural Factors Affecting the Sustainable Water Recourses Management in Agriculture under Drought Conditions: According to Table 8.1. among the socio-cultural factors affecting the sustainable water management in agriculture under drought conditions, foundation and reinforcement of water consumption bodies and leaving the small structures maintenance and irrigation systems with them has the highest factor load and priority of effect, whereas involving the Councils for the Settlement of Disputes at districts to solve water problems has the lowest factor load and priority of effect. Also, t-value shows that all the socio-cultural factor indexes have significant effects on the sustainable water management in agriculture.

CONCLUSION

The results indicated that from the viewpoints of farmers and experts with addition to present status: all economic, technical, farming, socio-cultural and educational-extensive factors had significant effects on the sustainable management of water resources in Lorestan Province under drought conditions with 99% certainty Moreover results of this research show that among these factors (economic, technical, farming, socio-cultural and educational-extensive), technical ones had the highest effect and ranking. However, socio-cultural factors showed the lowest effect and ranking. Because from the viewpoints of farmers and experts the technical factors have direct effects on water management in the farm, therefore have the highest effect but socio-cultural factors have indirect effects on water management in the farm therefore have the lowest effect. Also among the technical factors, constructing weirs and collecting runoffs and flood water for the artificial nutrition of groundwater has the highest priority of effect, among the economic factors, obtaining credits from international organizations and reducing the regulations for getting bank credits (check, bail, etc.) have the highest priority of effect, among the educational-extensive factors, holding scientific-research seminars on sustainable water management at provincial, regional and national levels has the highest priority of effect, among the farming factors, maintaining straw and crop residue of the previous growing year on the ground (to save soil moisture) has the highest priority of effect and finally among the socio-cultural factors, foundation and reinforcement of water consumption bodies and leaving the small structures maintenance and irrigation systems with them has the highest factor load and priority of effect on the sustainable water management in agriculture under drought conditions.

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