A framework to evaluate the factors influencing groundwater management in Water User Associations: The case study of Tafresh County (Iran)

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A framework to evaluate the factors influencing groundwater management in Water User Associations: the case study of Tafresh County (Iran)

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Abstract

In recent decades, due to the water shortage around the world and the importance of groundwater in agriculture, the role of Water User Associations (WUAs) - well-known farmer associations that manage collective irrigation in agricultural districts - in groundwater management has received much attention. To ensure sustainable groundwater management in these organisations, it is imperative to analyze the effects of the driving mechanisms, such as the “legal and institutional”, “socio-cultural”, “social capital”, “economic”, “infrastructure” and “farmers’ participation” factors, on the collective management of agricultural water. This study proposes a theoretical framework to analyze how and to what extent these factors influence agricultural water management in a case study of WUAs of Tafresh County (Iran), where irrigated agriculture strongly relies on groundwater. To validate this framework, questionnaires with 53 questions/indicators related to these factors have been supplied to 264 associated farmers and then statistically processed using Partial Least Squares - Structural Equation Modeling (PLS-SEM) methods.

The measurement model has confirmed the validity of the questionnaire. The structural model has demonstrated that all the identified factors are significantly effective in driving the WUAs performance. This effectiveness was shown by the high indexes of reliability (over 0.821 against an acceptance limit of 0.7) and convergent validity (over 0.511 against a limit of 0.5). Socio-cultural and social capital factors had a higher impact (confirmed by path coefficients of about 0.80), while the economic factors played a lower effect on groundwater management (path coefficient of 0.534). Moreover, the Pearson matrix showed statistically significant ($p < 0.01$) and positive (R^2 = from 0.238 to 0.804) correlations among all the evaluated factors.

Based on this framework, some actions for improving the groundwater management at the collective level are suggested, such as: (i) the implementation of new water management technologies to increase the efficiency in extraction, distribution, and consumption of irrigation water; ii) strengthening the importance of social and cultural participation in the management of WUAs, in order to create formal and informal contexts for enhancing individual participation in the short and long-term; iii) designing appropriate financing factors and diversification of the sources of revenue to execute projects on shared water resources.

Keywords: Collective irrigation; legal and institutional factors; socio-cultural factors; social capital factors; economic factors; infrastructural factors; farmers' participation factors; Partial Least Squares - Structural Equation modeling.

1. Introduction

Water availability plays a vital role in the development of agricultural lands of several developing countries (e.g., in the Middle East, North Africa, Indian sub-continent) and self-sufficiency in food production, poverty reduction, and adaptation to climate change in these countries (Aggarwal and Singh, 2010; Connolly-Boutin and Smit, 2016; Connor, 2015). The effective use of irrigation water has a vital role in reducing the effects of water scarcity due to global warming (Kartal et al., 2019; Kartal et al., 2020), and allows increasing crop production efficiency at a low cost (Arslan et al., 2019). In some countries, low efficiency in agricultural water management is one of the most important reasons for water shortage due to a lack of infrastructure and suitable management systems (Grey and Sadoff, 2007). Since the production units are mainly small-scale and low-income farms and much of the production is destined for self-consumption, these countries must face great food insecurity due to their crop production vulnerability. This is the case of the arid and semi-arid areas of Middle East countries, which suffer from a severe water deficit and are rich in a history of water wars (Biswas, 2004; Gürsoy et al., 2014). For instance, in Iran's agricultural lands, the dramatic water scarcity affecting the irrigated agriculture mainly depends on the inadequacy of the water distribution and irrigation systems due to infrastructural, operation, and organization inefficiency (Faramarzi et al., 2010). It has been estimated that in Iran, nearly 90% of the food needs require 92% of the total freshwater resources, and this country shows the lowest water productivity and economic efficiency among the Middle East countries (Mesgaran et al., 2017; Zargan et al., 2016). The need to increase water productivity and the profitability of agricultural activities requires moving towards collective water management. In many countries' collective organizations, such as irrigation associations, cooperatives, and farmer unions, have been appointed of supplying, conveying and distribution of water resources for irrigation; their importance increases in areas where irrigation water is scarce (Kartal and Forestry, 2021). Collective water management is often a forced solution when groundwater is the main water resource for irrigation in those areas with scarcity of surface water bodies (Gorton et al., 2009; Van Steenbergen, 2006). Since the '1980s, water resources management has progressively shifted from government-centric to collective and participatory irrigation policies by non-governmental organizations, such as Water User Associations (WUAs) and other private institutions, in more than 60 countries, including Iran (Garces-Restrepo et al., 2007). Moreover, the creation of associations to exploit groundwater has been encouraged in several national programs and laws (Lopez-Gunn and Cortina, 2006).

WUAs are worldwide well-known types of farmers' associations that manage collective irrigation in agricultural districts. The main purpose of these local organizations is the supply, distribution, and delivery of irrigation water to the associated farmers (Zema et al., 2018a; Zema et al., 2018b). Often farmers participate in water management activities, such as irrigation planning, water allocation, construction, and maintenance of water facilities, and this participation is believed to increase the overall infrastructural and economic performances of WUAs (Arslan et al., 2020; Uysal and Atış, 2010; Zema et al., 2015; Zema et al., 2019). According to Burger (1998) and Bosa (2015), if WUAs are well managed, the farmers' coordinated activities add a surplus to individual management. Therefore, WUAs play a crucial role when groundwater management adopts a participatory approach (Connor, 2015; Pan and Xu, 2018). Iran has a long and successful history in managing and allocating water in the agriculture sector, but the participatory approaches are relatively young since WUAs were first established in 1996.

The efficiency of agricultural water management at the collective level depends on several factors, such as the legislation, farmers' participation, socio-economic situation, infrastructure, and so on. Several pieces of research have highlighted the importance of some of these factors on the collective management in the irrigation sector and the related impacts of the management operations of WUAs for sustainable water resources exploitation (Gunchinmaa and Yakubov, 2010; Nazari et al., 2018; Osooli et al., 2011; Pan and Xu, 2018; Rezadoost and Allahyari, 2014; Samian et al., 2015). To summarize some of these studies, in France, Rouillard and Rinaudo (2020) assessed that formulation of water allocation by WUAs improves the environmental, economic, and social performance of water management since users consider their local economic and social priorities, the temporal and spatial dynamics of local groundwater resources, as well as considering the efficiency and equity in water distribution. In Iran, Nazari et al. (2018) identified the most critical factors of water management, which mainly suffers from the low level of social factors, lack of a comprehensive plan to prioritize social capital, lack of sufficient economic and non-economic incentives in agriculture, and dependence of financial support on the government. According to Abdelgalil and Bushara (2018), in Sudan, WUAs fully participate in water distribution but partially contribute to financing provision. Concerning social capital, Nilsson et al. (2012) stated that low social capital leads to less trust among members of farmers' cooperatives, which implies less participation and cooperation with an inability to solve collective action problems and hence severe impacts on the performance of the agricultural cooperatives. The study conducted by Gunchinmaa and Yakubov (2010) in Uzbekistan, Tajikistan, and the Kyrgyz Republic found that newly-established institutional structures and internal activities in the irrigation field and other important factors, including the farm profitability and a broader economic background, have a decisive effect on overall irrigation performance.

However, this large body of literature has so far investigated such impacts individually or limited the attention to no more than one or two factors; in addition, groundwater resources' participatory management has been neglected. Therefore, it is necessary to evaluate the comprehensive impacts of the socio-cultural, legal, institutional, infrastructural, and economic factors driving groundwater management efficiency for irrigation purposes at the collective level. A broader and better understanding of these factors and their sub-elements is useful to prepare effective strategies to improve the collective management of groundwater in the irrigated croplands and, more in general, the overall WUA's performances.

To fill this gap, this study proposes a theoretical framework to analyze the factors that influence groundwater management in WUAs. This framework was tested between February and April 2020 in Tafresh County (Iran), where the WUAs rely almost totally on groundwater management for irrigation through a farmer participatory approach but show the possibility of improvements in collective irrigation sustainability. The proposed framework consists of the following steps: (i) a preliminary investigation on the socio-cultural and agricultural characteristics of the individual farms of the analyzed WUAs; (ii) identification of the management factors ("legal and institutional", "socio-cultural", "social capital", "infrastructural", "economic", and "participatory") that impact on groundwater management through questionnaires; and (iii) statistical analysis based on Partial Least Squares - Structural Equation Modeling (PLS-SEM) methods, combining principal component analysis and multiple linear regression of the relationships among these factors and their effects on the WUAs performance. The two working hypotheses are the following: (i) all the identified factors are significantly effective in driving groundwater management; and (ii) all factors have direct and positive effects on each other.

2. Material and methods

2.1. Study area and Water User Associations (WUAs)

Tafresh County is located in the Markazi Province of Iran, about 222 kilometers southwest of Tehran. The county consists of 101 villages with 3364 farmers, surrounded by Iran's central mountain crown from the east, south, and west (Figure 1). The average annual precipitation and temperature of the area are 303 mm and 13.4 °C, respectively.

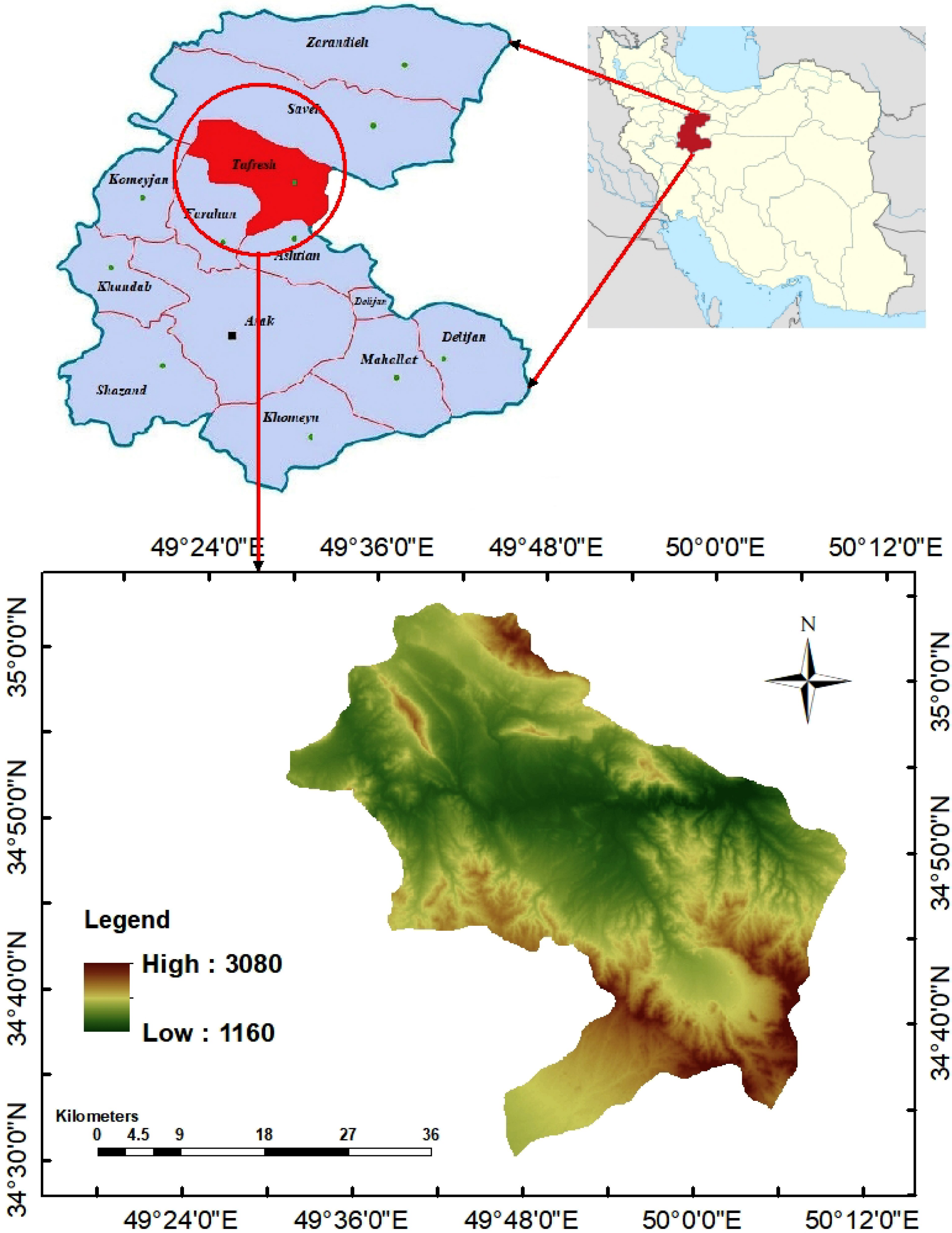

Figure 1 - Location and altimetry of the study area (Tafresh County, Markazi Province, Iran).

The agriculture in Markazi Province is thriving, thanks to the fertile soil. The main herbaceous crops are wheat, barley, and alfalfa, and the main fruit products include almonds, walnuts, apples, cherries, and grapes. Drought and frost in recent years have caused severe damage to the productions, which in turn, has brought economic hardship for farmers due to the small-scale productions.

The studied WUAs are thirty with a total of 914 associated farmers and cover a total area of 5853 km^2. Each WUA has a board of five trustees, who coordinate and oversee water management (SCI, 2018). The cultivated area is split into 3571 plots, each one of approximately 16 hectares. Of these plots, 661 plots are dryland (4500 hectares), while the remaining 2910 plots are irrigated (11500 hectares), which shows the great importance of water in this area (SCI, 2018). Water is supplied and delivered to croplands by a total of 355 wells (with depths from 20 up to more than 50 m), 419 springs (285 permanent, 134 seasonal), and 324 Qanats (240 active and 84 inactive). A Qanat is an underground canal that transports water from the aquifer or water well to the surface and lower lands. Farmers use the Qanats based on a document of ownership and water-right in circulation.

2.2. The conceptual framework

Following the indications of literature (Khalkheili and Zamani, 2009; Nazari et al., 2018; Pan and Xu, 2018; Takayama et al., 2018), the evaluation framework of factors influencing groundwater management in WUAs proposed in this study consists of the following six categories (Figure 2 and Table 1):

1) Legal and institutional factors
2) Socio-cultural factors
3) Social capital factors
4) Infrastructural factors
5) Economic factors
6) Participatory factors.

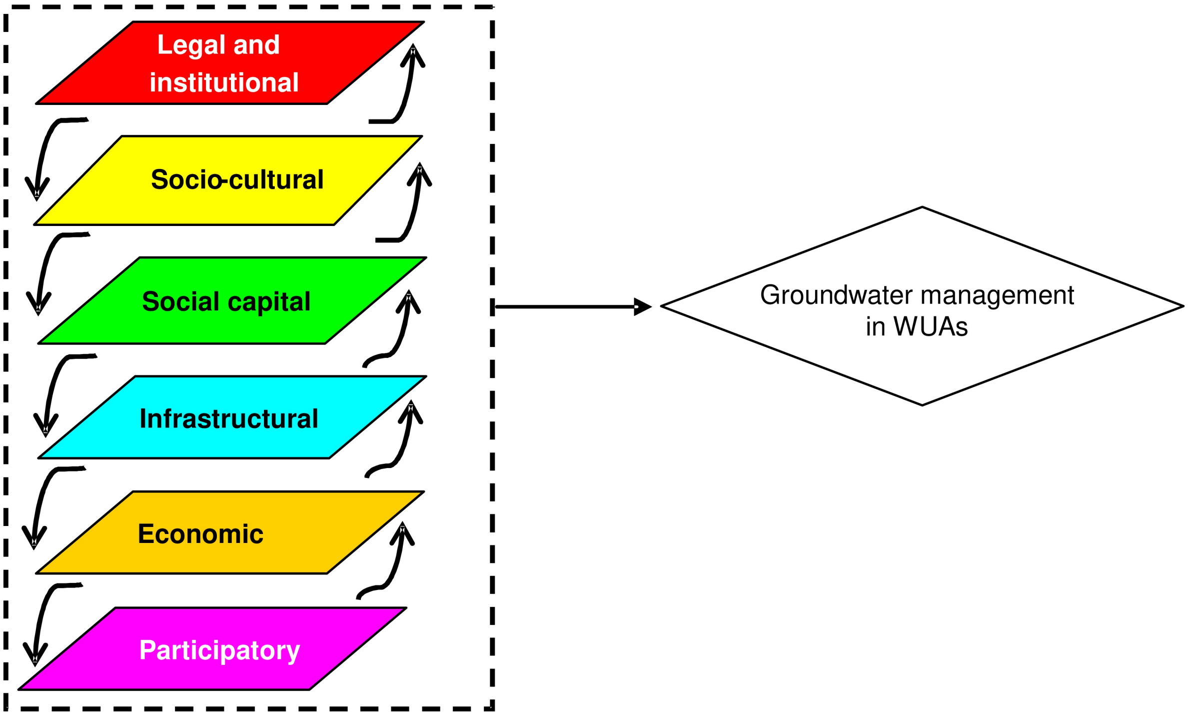

Figure 2 - The theoretical framework proposed to evaluate the factors influencing groundwater management in WUAs.

2.2.1. Legal and institutional factors

The "Legal and institutional factors" consist of institutionalization and approval of rules and regulations necessary for water users' participation in the optimal irrigation network management (Joy, 2007). These factors are based on the "Tragedy of the Commons Concept", which was started by (Hardin, 1968). According to this concept, users of a common resource are unable to prioritize the collective interest over their benefits; therefore, the resource's position is constantly threatened by a behavioral response. Hardin also suggested that the common resource must be shared either between members or left to the government. However, this theory has not been accepted worldwide. Contrarily to Hardin's theory (Ostrom, 2010) showed that people with common sense are able to manage shared resources if rules have features, which are "defined authorities and responsibilities", "designed at the local level by using the knowledge of users", "transparent and acceptable to users" and "able to manage local conflicts and violations". To ensure that all participants follow social rules, local people will automatically be responsible for managing resources, resulting in active participation in maintaining and making optimal use of shared resources (Ostrom, 2010; Schlager and López-Gunn, 2006).

Table 1 - The six classes of factors adopted in the proposed theoretical framework to evaluate the factors influencing groundwater management in WUAs.

Legal and institutional factors		***Socio-cultural factors***		***Social capital factors***	
LI1	Clarifying the powers and responsibilities of government bodies in the water affairs	CS1	Increasing the trust among landowners	SC1	Increasing the trust between the WUA members in water supply and distribution
LI2	The stability of laws and regulations for water resources management	CS2	Improving the farmer's awareness of water supply and distribution and collected fees	SC2	The use of farmers' views for water management decisions
LI3	The legal status of WUAs in the current laws	CS3	Visiting the on-farm demonstrations	SC3	Increasing intimate meetings and conversations among members outside of the WUAs
LI4	Meetings in the WUAs to evaluate actions related to water supply and facilities	CS4	Resolving local conflicts and disputes between landlords in using water	SC4	Improving the spirit of collaboration in irrigation operations
LI5	The capability of pricing water and irrigation services by farmers	CS5	Improvement of the landlords' awareness about their rights as members of the WUAs	SC5	Neglecting personal interests towards the benefit of others in irrigation
LI6	Strengthening the water dispute resolutions between owners	CS6	Participating in group activities related to water supply and	SC6	Guaranteeing other farmers to get loans for irrigation

			distribution		
		CS7	Accessing mass media and its cultural-educational programs	SC7	Feeling comfortable in terms of acceptance from other farmers (if not native)
		CS8	Enhancing farmers' knowledge and skills in water management	SC8	Increasing the trust among farmers to entrust the irrigation process in the absence of the persons
		CS9	Attending educational courses on water management improvement	SC9	Helping to solve the deliberated sabotage by some members of the WUAs with the Board of Trustees and make them act independently
		CS10	Enhancing training on familiarising farmers on how to manage creeks, canals or wells	SC10	Contributing to resolving disagreements over daily irrigation issues
		CS11	Resolving local conflicts and disputes between landlords (socially, ethnically, being native of a village, etc.)	SC11	Increasing the trust of the board of trustees and landowners in the government
		CS12	Preventing inappropriate water extraction practices such as water theft	SC12	Strengthening and exchanging water management information with the board of trustees

Infrastructural factors		Economic factors		Participatory factors	
T1	Faster construction of creeks, canals, and Qanats	E1	Attracting state aids for Qanat reconstruction	P1	Collecting the irrigation fees
T2	The replacement of open channels with plastic pipes for conveying water	E2	The amount of credit to cover and dredge the creeks, Qanats, and canals	P2	Repairing and rebuilding valves
T3	The percentage of metallic water distribution valves along the waterway	E3	Increasing farmers' income	P3	Repairing and dredging creeks
T4	Modifying the structure of the creeks	E4	Reducing management costs by enlarging the WUAs	P4	Pursue blocking illegal wells dug in the Qanat area
T5	The number of valves along the waterway	E5	Obtaining credit and banking facilities and receiving incentives such as tax breaks for active water companies	P5	Prevention of digging of illegal wells
T6	Observing time in water distribution			P6	Contacting government authorities to resolve Qanat affairs
T7	Preventing damage to the creeks			P7	Handling landowners' problems in water supply affairs
T8	Suitability of valve installation along the waterway			P8	Holding training courses on agricultural water management
				P9	Participate in meetings with government

			agencies and express landowners’ views on water management
		P10	Cooperation of farmers with the Water and Agricultural Organization to implement regulations related to water management

2.2.2. *Socio-cultural factors*

In order to manage and protect water resources, special attention should be paid to personal characteristics and socio-cultural factors that influence farmers' intentions to adopt behaviors and technologies related to water protection (Huang et al., 2016). These "socio-cultural factors" consist of those relationships among the members of a local association, who are engaged in communication, educational, and cultural activities related to the interests of that community; these activities can establish a sense of social belonging and social motivation between members via their participatory actions and activities. This can be considered as a catalyst for a sense of individual responsibility and, ultimately, greater social cooperation and participation (which is an essential dimension of social capital) in participatory irrigation management (Anselin and Griffith, 1988; Chandran and Chackacherry, 2006; Cicognani et al., 2008; Hayami, 2009; Nakano et al., 2015; Putnam; Putnam, 1993). The result of this engagement in socio-cultural activities is the success of any collective action that, in the case of WUAs, improves their management (Abedi, 2006).

2.2.3. *Social-capital factors*

The "social-capital factors" consist of a formal and informal network along with common norms, beliefs, thoughts, values, and perceptions that can support the sustainability of natural resource management in communities at the local level, in addition to appropriate technologies (Rasmussen and Meinzen-Dick, 1995). In this network, simplified collaborations within and between groups based on mutual trust, altruism, goodwill, sacrifice, empathy, and social interaction enable participants to be more effective in achieving common goals (Coleman, 1988; Durlauf, 2002; Hassanzadeh et al., 2016; Healy and Côté, 2001; Putnam, 1993; Woolcock, 1998). Therefore, by recognizing, using, and directing these social capitals in the desired direction, it is possible to increase social interactions and help members' active participation in WUAs for groundwater management (Collier, 2002; Nilsson et al., 2012).

2.2.4. *Infrastructural factors*

The lack of adequate irrigation infrastructure and systems due to infrastructural and financial constraints worsens irrigation management's performance and leads to poor irrigation water efficiency. The "infrastructural factors" consist of those irrigation factors that refer to the infrastructural, managerial, and financial participation of water users in proper maintenance and operation of irrigation and agricultural infrastructure. These factors are important since the world's irrigation networks have been destroyed due to various reasons, such as mismanagement. The latter has weakened irrigation networks' performance and reduced their useful life, resulting in low irrigation water efficiency.

2.2.5. Economic factors

The "economic factors" consist of those factors that are essential in strengthening the managerial capabilities of WUAs, control, and provide irrigation services that, in addition to sustainability and conservation of water resources, lead to economic productivity (Facon, 2000; Peter, 2004).

2.2.6. Participatory factors

The overall efficiency of water resources management in irrigation areas is mainly influenced by improving the management environment and strengthening farmers' participatory factors (Pan and Xu, 2018). The "participatory factors" consist of those factors linked to the public participation of stakeholders in water management, which should lead to social development, economic growth, environmental stability, and equal access to water, which are critical goals of water resources management (Jingling et al., 2010; Perret et al., 2006). According to Pretty and Ward (2001), people can properly manage water resources when they are collectively involved in managing that resource. The benefits of farmers' participation in resource management include reducing government spending on repairing and maintaining the infrastructure needed, increasing the sense of ownership and responsibility, improving farmers' irrigation knowledge and water efficiency (Qiao et al., 2009).

2.3. Validation of the evaluation framework in the case study

2.3.1. Data collection

In the present study, the survey was carried out between February and April 2020 in Tafresh County.

First, a questionnaire was prepared to measure farmers' aptitudes and opinions about the impact of the framework factors on groundwater management improvement in the WUAs in Tafresh County. This questionnaire consisted of six questions (hereinafter indicated also as "indicators") about legal-institutional factors, twelve for indicators socio-cultural and twelve for social capital factors, ten for participatory factors, eight for infrastructural factors, and five for economic factors (Table 1).

This questionnaire was given to the target population (N = 914), consisting of Tafresh County farmers. To achieve the desired samples, fitting the features of the farmers of Tafresh County, a simple two-stage random sampling was used. Since the total statistical population of the study area was not clear, (Cochran, 1963) formula has been utilized to designate the sample size using the following equation:

$$n = \frac{t^2 pqN}{[(N-1)d^2 + t^2 pq]}$$

where N is the size of the statistical population or the number of farmers, t is the statistic considered at the 95% confidence level, p and q are equal to 0.5, d is also the desired precision (equal to 0.05), and n is the sample size.

Therefore, by employing this equation, the desired sample size was determined as 270. To increase the accuracy of calculations, we gathered 300 questionnaires through face-to-face, in-depth interviews, of which 264 were fully completed. Furthermore, to exclude any ambiguities in the wording of the questions, we did a pilot survey at first. For this purpose, the questionnaire was provided to the members of the Department of Agricultural Management and Development of the University of Tehran to test its reliability and efficacy, and the suggestions given by the staff were included in the revised questionnaire. Another additional test for the questionnaire was carried out as a pilot of 30 farmers to remove possible ambiguities in the wording of questions.

2.3.2. Questionnaire characteristics

The questionnaire consisted of two parts. The first part contained the professional and socio-economic characteristics of the individual farms/farmers, and the second part contained six classes of factors for a total of 53 indicators (Table 2). Each question was quantitatively evaluated using the Likert-type scale with five points ranging from 1 ("very low") to 5 ("very high"). Likert-scale questionnaires are the most commonly used type of instruments for measuring variables such as motivation and self-efficacy, since these questionnaires allow researchers to easily gather large amounts of data (Nemoto and Beglar, 2014).

2.3.3. Data processing

Each indicator was first analyzed by descriptive statistics (mean, standard deviation, maximum, and minimum values). Then, a confirmatory factor analysis (Harrington, 2009) was carried out to identify possible relationships between "latent" variables and confirm all model assumptions.

Finally, a Pearson correlation analysis was adopted to evaluate the dependency levels among the variables and their reciprocal impacts. The resulting correlation coefficients were evaluated using Davis' conventional description as follows (Davis, 1971):

- Poor = 0.01 – 0.09
- Weak = 0.10 – 0.29
- Medium = 0.30 – 0.49
- Strong = 0.50 – 0.69
- Very strong > 0.70.

This data analysis was carried out using SmartPLS software, which, also thanks to a user-friendly graphical interface, implements variance-based structural equation modeling (SEM) by the partial least squares (PLS) path modeling method.

2.3.4. Confirmatory factor analysis

Confirmatory factor analysis is a method based on quantitative data that examines the validity of a prior hypothesis (Mueller and Hancock, 2001). In applying this method to this study, the underlying premises were the following:

- each factor represents a "latent variable", that is, a variable that cannot be directly measured but could be identified by tracing its effects on one or more "observed variables" (Alasuutari et al., 2008);

- each latent variable is associated with "observed variables", i.e., the variables that can be measured directly (in our case, the indicators of each factor).

Therefore, the confirmatory factor analysis can be considered as a validation tool of the questionnaire, and therefore it may represent the validity of a "measurement model". In other words, the latter determines whether and how the latent variables can be measured in the form of a larger number of observed variables. A "structural model" is also assumed, which instead assesses the latent variables' causal relationships (Schreiber et al., 2006).

In our study, first, the accuracy of the relationships in the measurement model was tested using "reliability" and "validity" criteria. The fitting level of the measurement model to the questionnaire was assessed using a "reliability index" as well as "convergent validity" and "divergent validity" criteria. The reliability index includes the (ii) Cronbach's alpha (C_α); (ii) composite reliability (CR); and (iii) ρ coefficient.

In more detail, C_α provides an estimate of reliability based on the internal correlation of the indicators. If C_α is greater than 0.7, the questionnaire indicators have a good internal correlation and are thus reliable (Hair Jr et al., 2016). CR is calculated according to the correlation of the individual factors. The appropriate value of CR is above 0.7 (Hair Jr et al., 2016). ρ, which is basically a coefficient of determination between the indicators, must be over 0.7.

As criteria to measure the convergent and divergent validity, the Average Variance Extracted (AVE) and the Fornell and Larcker (1981)'s criteria (FaL) were used, respectively. The standard value of AVE is above 0.5 (Henseler et al., 2009). With regard to FaL, these authors suggested that the divergent validity is acceptable when the AVE for each factor is higher than the shared variance between that factor and the other factors in the model. This control is performed by a matrix, in which each cell contains the correlation coefficient between the factor and the square root of the AVE value of each factor.

After checking the reliability and validity of the measurement model, the causal relationships between the factors (the latent variables) in the structural model were examined, using three criteria: (i) t-values; (ii) R^2; and (iii) Q^2 or Stone-Geyser-Stone criterion (Geisser, 1974; Stone, 1974).

In more detail, if the t-value is greater than 1.96, the relationship between the factors is accurate, and thus the research hypotheses can be confirmed at the 95% confidence level. R^2 is used to connect both the measurement and structural models, showing how predictive the structural model factors are. Chin (1998) introduces three values, 0.19, 0.33, and 0.67, for the criteria of R^2, which indicate weak, medium, and strong prediction capacity. For Q^2 or Stone-

Geisser criterion, Henseler et al. (2009) suggested three values of 0.02, 0.15, and 0.35 as weak, moderate, and strong predictive power, respectively.

For the models' overall fit, the Goodness of Fit (GoF) criterion, as the geometric mean of the average communality and average R^2 for all latent variables, was used. This criterion determines the overall predictive power of the large complex model by accounting for both measurement and structural parameters' performance. According to Chin (2010), this indicator provides the PLS model performance in both measurement and structural modeling with a focus on the overall performance of the model prediction (Tenenhaus et al., 2004) and also indicates how much of the variability of the indicators are explained by the related factor (Akter et al., 2011). GoF is defined as:

$$GoF = \sqrt{AVE \cdot R^2} \qquad (1)$$

where the overlined symbols indicate the mean of the variables. The GoF is strong, if higher than 0.36, acceptable, if lower than 0.36 but higher than 0.25, and weak if lower than 0.25 (Akter et al., 2011; Wetzels et al., 2009).

Finally, the path coefficients (or β-values) of the factors were examined to test our study's two main hypotheses. The path-coefficient analysis represents the dependent variable's response to a unit change in an explanatory variable when other variables in the model are kept constant. A positive path coefficient means that a unit increase in the measure of one structure leads to a direct increase in the measure of structures it projects to, which is proportional to the size of the coefficient; conversely, a negative coefficient means that an increase in the measure in one structure leads to a direct and proportional decrease in the measure of structures it projects to (Mclntosh and Gonzalez-Lima, 1994).

All the coefficients and indicators calculated in this study, except GoF, were directly calculated by SmartPLS software.

2.3.5. Pearson correlation analysis

Pearson analysis was targeted to evaluate what effect a factor plays on another factor and whether this effect is synergistic or not, which is the purpose of the second hypothesis of this study.

To perform Pearson correlation analysis, the questionnaire's indicators were given scores, and the correlation coefficients above the related factors were computed. According to Swinscow and Campbell (2002), the correlation was considered "very strong", "strong", "moderate", "modest" or "weak", if the correlation coefficient is between 0.80 and 1.00, 0.60 and 0.79, 0.40, and 0.59, 0.20 and 0.39 or 0 and 0.19, respectively.

5. Results

5.1. Analysis of descriptive statistics

The mean age of farmers was 54 years, while their mean length of stay in their village was 49.4 years. The farmers had a work experience of 21.1 years with the title of ordinary members of WUAs for 21 years on average. Some farmers were on their board of trustees for, on average, 16 years. Each farmer worked on an average number of 7.7 plots of arable land with a mean area per plot of 0.48 hectares. The farms were of low income since their average income was about 19 million Rials per year, corresponding to about 456 dollars (Table 2). Most of the farmers (76.9%) had an undergraduate education (less than a diploma). In comparison, only 7.5% had a bachelor's degree or higher education level. Agriculture was the main occupation (62.5%) of the farmers, while, for the remaining part (37.5%), it was a part-time job.

Table 2 - Main characteristics of farmers associated with the thirty WUAs of Tafresh County, Iran (n = 264).

Characteristics	**Mean**	**Min**	**Max**	**Standard deviation**
Age (years)	54	25	90	1.32
Work experience in agriculture (years)	21.1	3	72	1.49
Duration of stay in village (years)	49.5	8	90	14.76
Number of children	2.9	0	11	2.06
Land area (hectares)	0.48	0.12	3.8×10^5	2.34
Number of land plots	7.7	1	91	8.53
Number of members of WUAs	29.6	8	124	1.64
Duration of regular membership in the WUA (years)	21	3	72	1.49
Duration of membership in the WUA's board of trustees (years)	16	3	24	1.30
Total monthly income (Rial[1])	1.9×10^7	4×10^6	1×10^8	1.14×10^6

The descriptive statistics about the structure of the WUAs in Tafresh County (Iran) showed a long farmers' experience managing WUAs. However, farmers are getting old at the same time, which indicates a decrease in generational substitution and a lack of inclination of the younger generation towards agriculture (Molina et al., 2006). Due to their low capacity for using updated knowledge, the farmers have little motivation to transform the WUAs' structures according to modern science. Therefore, the association of young human resources with higher education levels could be an occasion to renovate the structure of the existing WUAs and the methods of water management.

Since the farmers are, in general, smallholders, the consequent great number and dispersion of plots are another factor of the poor agriculture productivity, which the descriptive results have indicated. Therefore, for reasons such as low production, product fluctuations, and input price in the marketplace, a low-income level has complained. As a consequence of the

[1] In May 2020, USD 1 ≈ Rial 17200; Rial 1000 ≈ USD 0.024

WUAs' life, farmers are less inclined to economic participate in improving water management due to income risks and financial weakness.

These results reflect a traditional, small, and illiterate community among farmers in Tafresh County. Therefore, local authorities should optimize their informal training methods for groundwater management following farmers' characteristics and conditions (Kumar et al., 2008). Hence, the first step may be the assessment of the educational needs of farmers, such as "familiarity with modern pressurized irrigation methods", "groundwater feeding methods", "familiarity with the principles of application of irrigation economics", "familiarity with how to use advanced irrigation equipment (compatible with dispersion and small-scale farming)" and "familiarity with the water demands of agricultural products, irrigation program, and maintenance skills and the use of irrigation systems" (Burton et al., 2007; Kaplan et al., 2003; Ojo et al., 2011; Rai and Singh, 2016). To carry out the training and transfer of professional knowledge of agricultural water management, the principles of adult education, from educational methods to high interaction, such as "face-to-face visits", "on-farm demonstration", and "training workshops", should be used. Otherwise, training on issues related to agricultural water management could lose its efficiency and effectiveness.

5.2. Analysis of the questionnaires about the factors and indicators

5.2.1. Legal and institutional factors

"Clarifying the powers and responsibilities of government bodies in the water affairs", "the stability of water resources management laws and regulations", and "the legal status of WUAs in the current laws" were the first to third priority for the interviewed farmers, while "enhancing the water dispute resolution institutions between owners" was the last choice (Table 3).

Table 3 - Ranking of the indicators about the different groundwater management factors in Tafresh County, Iran.

Indicators		**Mean (*)**	**Standard deviation (*)**	**Coefficient of variation**	**Ranking**
Legal and institutional factors					
LI1	Clarifying the powers and responsibilities of government bodies in the water affairs	4.01	1.16	0.2	1
LI2	The stability of water resources management laws and regulations	3.45	1.06	0.31	2
LI3	The legal status of WUAs in the current laws	3.55	1.14	0.32	3
LI4	Meetings in the WUAs to evaluate actions related to water supply and related facilities	3.59	1.16	0.32	4
LI5	The capability of pricing water and irrigation services by farmers	3.27	1.12	0.34	5
LI6	Strengthening the water dispute resolution institutions between owners	3.16	1.12	0.36	6
Socio-cultural factors					
CS1	Increasing the trust between landowners	3.90	0.21	0.31	1
CS2	Improving the farmer's awareness of procurement, water distribution, and collection fees	3.33	0.07	0.32	2
CS3	Visit of the on-farm demonstration	3.56	1.31	0.36	3
CS4	Help to resolve local conflicts and disputes between landlords in terms of using water	3.31	1.23	0.37	4
CS5	Improvement of the landlords' awareness about their rights as a member of the	3.09	1.21	0.39	5

	WUAs				
CS6	Participation in group activities related to irrigation and water supply	3.85	1.14	0.40	6
CS7	Access to mass media and its cultural-educational program (to inform and encourage farmers to participate more in water management)	3.05	1.23	0.40	7
CS8	Enhancement of farmers' knowledge and skills in water management	2.81	1.17	0.42	8
CS9	Participate in extensional and educational courses on water management improvement	2.87	1.21	0.42	9
CS10	Enhancement training on familiarising farmers with how to manage creeks, canals, or wells	2.71	1.18	0.43	10
CS11	Help to resolve local conflicts and disputes between landlords (socially, ethnically, being native of a village, etc.)	2.76	1.26	0.45	11
CS12	Preventing inappropriate water extraction practices such as water theft	2.37	1.22	0.52	12
Social-capital factors					
SC1	Increasing the trust between the members' of WUAs in water sharing and distribution	4.34	0.82	0.19	1
SC2	The use of farmers' views for water management decisions	4.21	0.89	0.21	2
SC3	Increasing intimate meetings and conversations of members outside of the association were the most important factors	3.90	0.96	0.25	3
SC4	Improvement of the spirit of helping each other in irrigation operations	3.92	1.03	0.26	4
SC5	Irrespective of personal interests for the benefit of others in irrigation operation	3.62	0.98	0.27	5
SC6	Guarantee other farmers to get loans to improve irrigation operations	3.35	1.12	0.34	6

SC7	Feeling comfortable in terms of acceptance from other farmers (if not native)	2.90	1.10	0.38	7
SC8	Increasing the trust between farmers to entrust the irrigation process in the absence of the person	2.92	1.12	0.38	8
SC9	Helping to solve the deliberate sabotage of some members of the WUAs with the Board of Trustees and make them act independently	2.87	1.21	0.41	9
SC10	Contributing to resolving disagreements over daily irrigation issues	2.92	1.20	0.41	10
SC11	Increasing the trust of the board of trustees and landowners in the government	2.75	1.17	0.42	11
SC12	Strengthening and exchanging water management information with the board of trustees	2.83	1.24	0.44	12
Infrastructural factors					
T1	Faster construction of creeks, canals, and Qanats	3.69	1.18	0.32	1
T2	The use of thin polyethylene films pipes for conveying water to the farm instead of the creek	3.62	1.24	0.34	2
T3	The percentage of metallic water distribution valves along the waterway	3.41	1.20	0.35	3
T4	Modifying the structure of the creeks in order to irrigate the covered lands better	3.08	1.16	0.38	4
T5	The proper number of valves along the waterway	2.94	1.17	0.40	5
T6	Observing time in water distribution	2.99	1.22	0.41	6
T7	Preventing to damage the creeks	3.07	1.26	0.41	7
T8	Suitability of installation of valves along the waterway	3.02	1.30	0.43	8
Economic factors					

E1	Attracting state aid for the reconstruction of the Qanat	3.96	0.95	0.24	1
E2	The amount of credit to cover and dredge the creeks, Qanats, and canals	4.24	1.08	0.25	2
E3	Increasing farmers' income	3.71	1.07	0.29	3
E4	Reducing management costs by increasing the number of members of WUAs	3.68	1.12	0.30	4
E5	Obtaining credit and banking facilities and receiving incentives such as tax breaks for active water companies	3.49	1.12	0.32	5
Participatory factors					
P1	Collecting the association's shared costs	4.03	0.93	0.23	1
P2	Repairing and rebuilding valves	3.96	0.99	0.25	2
P3	Repairing and dredging creeks	3.92	1.04	0.27	3
P4	Pursue blocking illegal wells dug in the Qanat area	3.84	1.09	0.29	4
P5	Prevention of digging of illegal wells	3.83	1.15	0.30	5
P6	Contacting government authorities to resolve Qanat affairs	3.70	1.15	0.31	6
P7	Handling landowners' problems in water supply affairs	3.56	1.19	0.33	7
P8	Holding training courses on agricultural water management	3.28	1.18	0.36	8
P9	Participate in meetings with government agencies and express landowners' views on water management	3.44	1.26	0.36	9
P10	Cooperation of farmers with the Water and Agricultural Organization to implement regulations related to water management	3.07	1.24	0.40	10

Note: * value of the Likert-type scale with five points.

5.2.2. Socio-cultural factors

The questions of “increase of trust between landowners”, “improvement of farmer’s awareness of procurement”, “water distribution and collected fees”, and “visiting the on-farm demonstration” ranked first to third, respectively. Moreover, “helping to resolve local conflicts and disputes between landlords (socially, ethnically, being native of a village, etc.)” and “preventing inappropriate water extraction practices such as water theft” were identified as the latest (eleventh and twelfth) priorities (Table 3).

5.2.3. Social-capital factors

From the farmers’ point of view, the indicators “increasing the trust between the members’ of WUAs in water sharing and distribution”, “the use of farmers’ views for water management decisions”, and “increasing intimate meetings and conversations of members in the outside of the association” were the most important (ranks one to three). By contrast, the indicators “contributing to resolving disagreements over daily irrigation issues”, “increasing the trust of the board of trustees and landowners to the government” and, finally, “strengthening and exchanging water management information with the board of trustees” were less important with the eleventh and twelfth priorities (Table 3).

5.2.4. Infrastructural factors

According to Table 3, “faster construction of creeks, canals, and Qanats”, “the use of thin polyethylene films pipes for conveying water to the farm instead of the creek” and “the percentage of metallic water distribution valves along the waterway” were considered the most important infrastructural factors, while the indicator “suitability of installation of valves along the waterway” was in the last (eighth) rank.

5.2.5. Economic factors

Among the economic factors, “attracting state aid for the reconstruction of the Qanat”, “the amount of credit to cover and dredge the creeks, Qanats, and canals” and “increasing farmers’ income” ranked first to third, respectively. The indicator “obtaining credit and banking facilities and receiving incentives such as tax breaks for active water companies" was instead the fifth and last priority (Table 3).

5.2.6. Participation factors

The interviewed farmers were mainly involved in "collecting the association's shared costs", "repairing and rebuilding valves", and "repairing and dredging creeks", respectively (first to the third rank). Conversely, the level of "cooperation of farmers with the Water and Agricultural Organization to implement regulations and water management" was the lowest (tenth) priority (Table 3).

5.3. Confirmatory factor analysis

According to Table 4, The values of the reliability and convergent validity indicators evaluated for each factor (latent variable) is over the acceptable limits; as a matter of fact, the minimum values of C_α, ρ and CR are is over 0.821, 0.826, and 0.874, respectively, thus all over 0.7. Therefore, we conclude that the measurement model is reliable for the research.

Table 4 - Indexes of reliability and convergent validity of the questionnaire (measurement model) provided to the farmers of WUAs of Tafresh County, Iran.

Factors	**Reliability indexes**			**Convergent validity index (AVE)**
	C_α	**ρ**	**CR**	
Legal and institutional	0.890	0.895	0.916	0.647
Socio-cultural	0.912	0.916	0.926	0.511
Social capital	0.920	0.923	0.932	0.536
Infrastructural	0.884	0.885	0.908	0.552
Economic	0.821	0.832	0.874	0.583
Participation	0.924	0.826	0.936	0.569
Groundwater management	0.940	0.943	0.945	0.597

Notes: acceptance limits for the indicators: 0.7 for C_α, ρ and CR and 0.5 for AVE.

Table 4 shows that AVE, whose minimum value was 0.511, is over the acceptance limit of 0.5. From Table 5, it is evident that the square root of the AVE value of each factor was higher than the squared variance between the factor and the other factors in the model; therefore, the convergent and divergent validities of the measurement model are proven.

Table 5 - Divergent validity matrix by Fornell and Larker criterion applied to the questionnaire (measurement model) provided to farmers of WUAs of Tafresh County, Iran.

Factors	**Social-cultural**	**Economic**	**Legal**	**Participation**	**Social capital**	**Infrastructural**
Social-cultural	**0.715**					
Economic	0.297**	**0.764**				
Legal	0.389**	0.554**	**0.804**			
Participation	0.547**	0.526**	0.616**	**0.772**		
Social capital	0.518**	0.238**	0.366**	0.562**	**0.732**	
Infrastructural	0.423**	0.208**	0.336*	0.432**	0.376**	**0.743**

Note: the Cronbach's alpha index is displayed in bold on the diagonal; * p< 0.01; ** p < 0.001.

All the t-values of the relationships between the factors and indicators were higher than 1.96 (Figure 3); thus, the corresponding relations are significant at the 95% confidence level. Moreover, R^2 is higher than 0.33 (Figure 4), and Q^2 is higher than 0.35 (Figure 5). Therefore, all these indicators measure with reliability the factors predicted in the questionnaire; thus, the relationship among the factors is accurate, and the factors in the structural model show an acceptable predictive capacity, confirming that the structural model has strong predictive power.

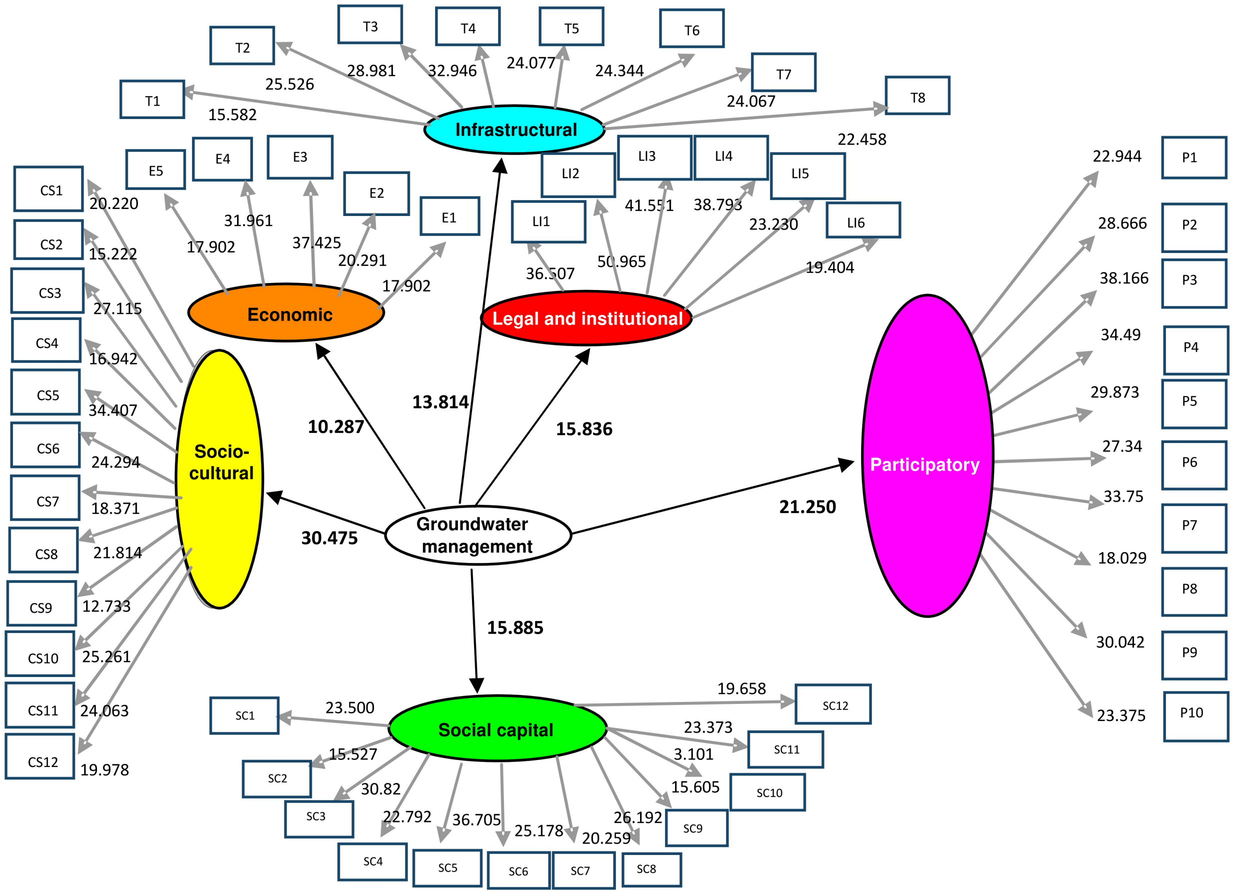

Figure 3 - The t-values of the relationships between the factors and indicators in the structural model to evaluate the factors influencing groundwater management in the WUAs of Tafresh County, Iran.

Notes: rectangles = indicators (questions, observed variables); circles = factors (latent variables); grey arrow (from latent variables towards the indicators) = measurement error; black arrow = effect of a factor on groundwater management.

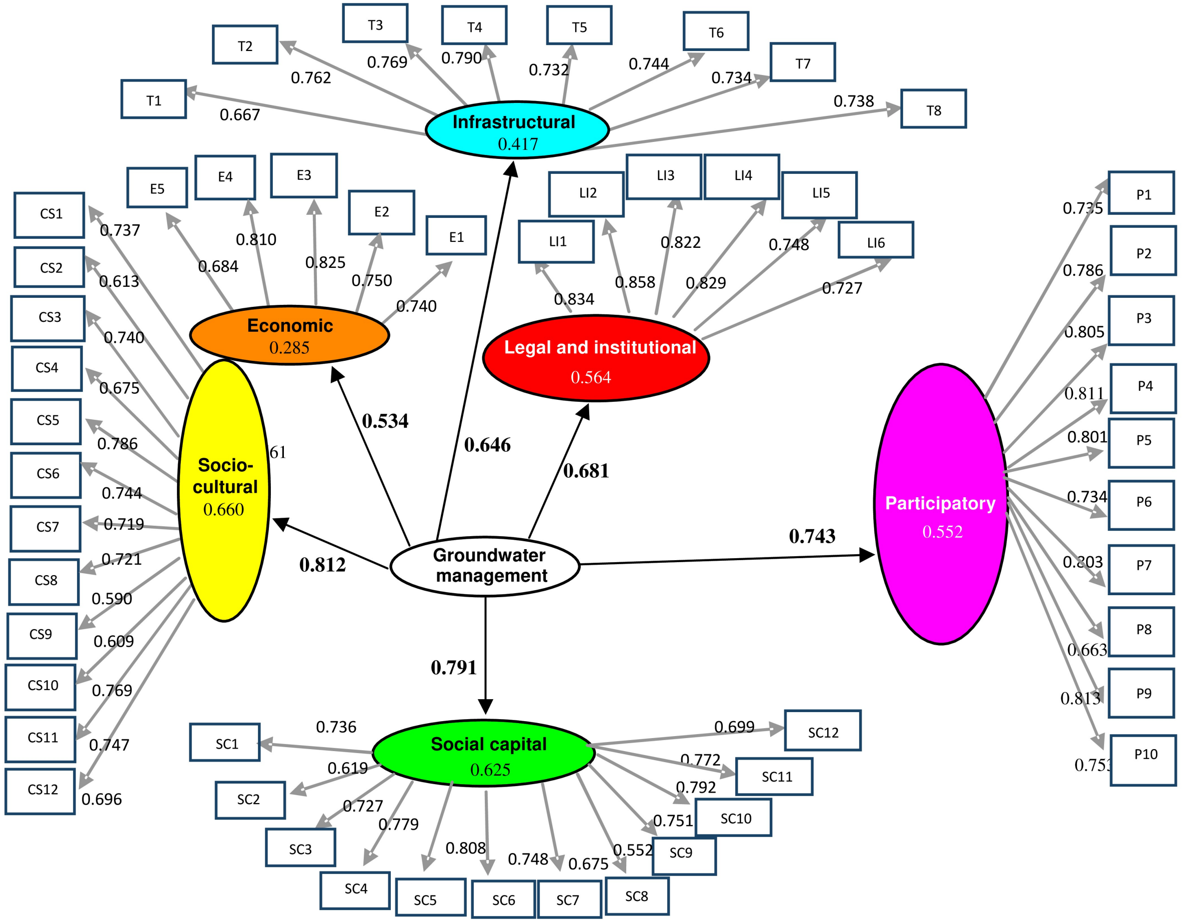

Figure 4 - The R^2 values of the relationships between the factors and indicators in the structural model to evaluate the factors influencing groundwater management in the WUAs of Tafresh County, Iran.

Notes: rectangles = indicators (questions, observed variables); circles = factors (latent variables); grey arrow (from latent variables towards the indicators) = measurement error; black arrow = effect of a factor on groundwater management.

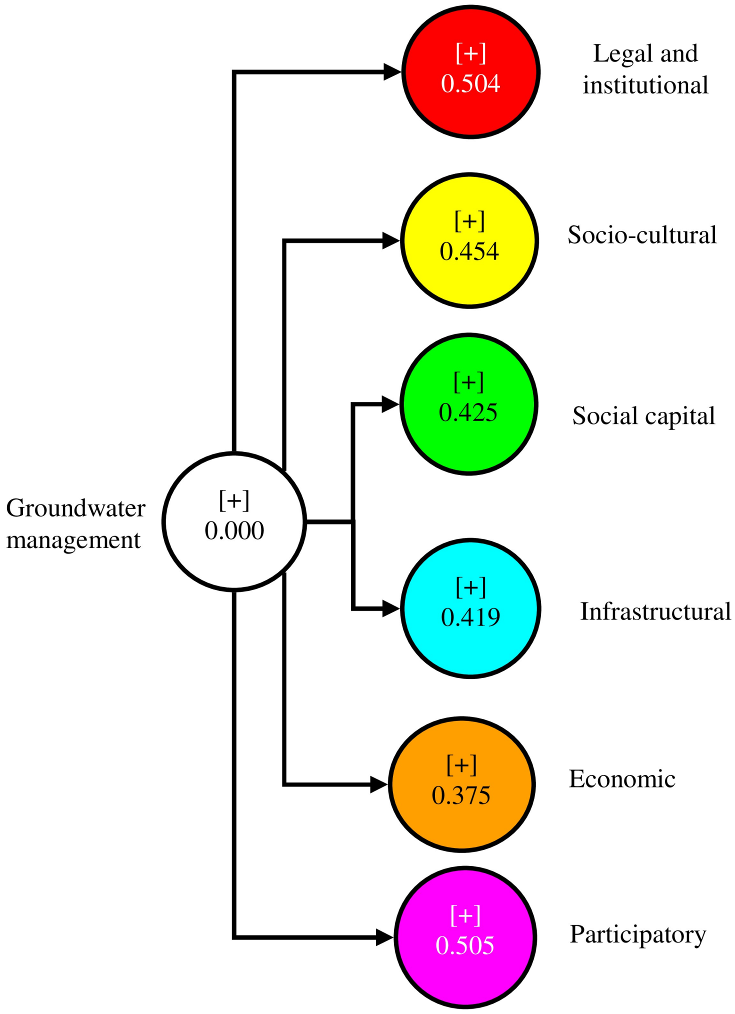

Figure 5 - The Q^2 values of the relationships among the structural model factors to evaluate the factors influencing groundwater management in the WUAs of Tafresh County, Iran.

Finally, the overall fit of the model (GoF) is equal to 0.51, and therefore it is higher than the critical point of 0.36, defined by Wetzels et al. (2009).

The socio-cultural and social capital factors had the highest path coefficients (β = 0.812 and 0.791, respectively) within the factors related to groundwater management. In contrast, the economic factor (β = 0.534) had a minimum direct effect on groundwater management. Therefore, the relationships among the groundwater management on one side and legal and institutional, socio-cultural, social capital, infrastructural, economic, and participation factors on the other side were significant, indicating that groundwater management is influenced directly and positively by all these factors.

Table 5 - Path coefficients and t-statistics in the structural model to evaluate groundwater management factors in the WUAs of Tafresh County, Iran.

Factors	Mean	Standard deviation	t-value	P-value	Standardized β
Groundwater management → Legal and institutional	0.683	0.043	15.836	< 0.0001	0.681
Groundwater management → Socio – cultural	0.812	0.027	30.475	< 0.0001	0.812
Groundwater management → Social capital	0.791	0.035	22.756	< 0.0001	0.791
Groundwater management → Infrastructural	0.646	0.047	13.814	< 0.0001	0.646
Groundwater management → Economic	0.533	0.052	10.287	< 0.0001	0.534
Groundwater management → Participation	0.744	0.035	21.250	< 0.0001	0.743

5.4. Pearson's matrix analysis

The correlations between the groundwater management factors of WUAs showing their reciprocal impact on each other were statistically confirmed at a 95% confidence level (at $p < 0.01$). The highest correlation coefficients were detected between the farmers' participation factor and the legal and institutional factor ($r = 0.603$), which can only be considered "strong". The other coefficients were lower and "moderate" only for the correlations among the farmers' participation on one side and the social capital ($r = 0.559$), socio-cultural ($r = 0.535$), and economic ($r = 0.521$) factors on the other side as well as for the couples of legal and institutional and economic factors ($r = 0.553$), social capital and socio-cultural factors ($r = 0.489$) and socio-cultural and infrastructural factors ($r = 0.421$) (Table 13). All the remaining correlations were modest or weak.

Table 5 - Matrix of correlation coefficients among the factors influencing groundwater management in Tafresh County, Iran.

	Factors	*Legal* and *institutional*	*Socio – cultural*	*Social capital*	*Economic*	*Infrastructural*	*Participation*
	Legal and *institutional*	1					
	Socio – cultural	0.385	1				
	Social capital	0.365	0.489	1			
	Economic	0.553	0.292	0.238	1		
	Infrastructural	0.332	0.421	0.370	0.203	1	
	Participation	0.603	0.535	0.559	0.521	0.431	1

Note: All correlations were significant at p-level < 0.01 (2-tails).

5. Discussions

Among the institutional and legal factors, the "clarifying the powers and responsibilities of government bodies in the water affairs" indicator was the first priority in our study, since this factor regulates the effects of all duties and actions related to water, whose clarity would be of interest for both the governance and water users.

"The stability of water resources management laws and regulations" (second priority among the analyzed institutional and legal factors) ensures a long-lasting implementation of these laws among WUAs and government organizations, but also the sustainability of environmental resources in organized management of the irrigation networks (Boyer et al., 2011). For instance, irrigated agriculture in Iran suffers from the aggressive use of water resources and wells' continuous deepening. This is mainly due to the knowledge of laws and regulations related to irrigation water management by those poor farmers whose only occupation is agriculture is not enough. This insufficient knowledge can lead to the instability of water resources and agricultural production. In this case, the rules must be set in such a way as to prevent an exceeding extraction of water from wells compared to the permitted amounts, which causes water shortage and instability of water resources (Nazari et al., 2018).

"The legal status of WUAs in the current laws" is the third prioritized indicator within the institutional and legal factor because the associated farmers are aware of sufficient rights and powers to exercise management. This awareness undoubtedly gives farmers a strong incentive to conserve water resources (Pan and Xu, 2018). As a result, this leads to the provision of appropriate irrigation services, sustainable use of water resources and irrigation facilities, and the promotion of agricultural water productivity (Gunchinmaa and Yakubov, 2010).

Finally, the "strengthening the water dispute resolution institutions between owners" indicator, which has been considered of great importance in the studies of Speelman et al. (2010) and Boyer et al. (2011), gained the last priority in our research, presumably because to the high social capital among Tafresh farmers. They usually resolve disputes between themselves without asking for external help.

Paying attention to socio-cultural factors, the farmers prioritized "increasing the trust between landowners" because a high trust in efficient groundwater management in farmers paves the way for cooperation and group actions among associated individuals, who are satisfied with the various water management operations (Boyer et al., 2011). This is confirmed by the high rank of the "improving the farmer's awareness of procurement, water distribution, and collected fees" indicator that was the second priority among the socio-cultural factors. The "visit of the on-farm demonstration" indicator, which was the third priority in this study, leads the members of the associations to larger access to knowledge resources, such as the modern irrigation methods (Samian et al., 2015), towards optimal use of water and an increased farm production (Osooli et al., 2011). "Preventing inappropriate water extraction practices such as water theft" was the last priority among the socio-cultural factors, presumably due to the high security of farmers in this area and their close and friendly relations with each other.

Concerning the social capital factors, "increasing the trust between the members of WUAs in water sharing and distribution" ranked the first priority because this commonality in agricultural water management leads to the creation of a dialogue among the farmers and expansion of social relations with other people in the community (Biresaw, 2019; Nilsson et al., 2012; Rasmussen and Meinzen-Dick, 1995). This indicator's importance is further stressed by another indicator within the social capital factors - "increasing intimate meetings and conversations of members outside of the association" - that ranked as the third priority. As a matter of fact, the exchange of information between farmers can make their participation in water management more conscious also in the social life out of the work approaches

(Takayama et al., 2018). “The use of farmers’ views for water management decisions” is another crucial social capital indicator, and it got the second priority because it makes the associated users aware of the benefits of decisions and requirements for the implementation of agricultural water management and encourages farmers to participate more actively in the implementation of these decisions. On the other hand, “strengthening and exchanging water management information with the board of trustees” was the last rank and thus is considered a less important factor. This is a critical issue in the WUAs and deserves more attention because the exchange of information among farmers and trustees would make farmers aware of the board’s decisions and monitor and cooperate in implementing management actions. Moreover, thanks to this information exchange, board members could know the legal, infrastructural, economic, and even social problems of farmers and make their own management decisions with more insight and effectiveness.

Among the infrastructural factors, the “faster construction of creeks, canals, and Qanats”, “the use of thin polyethylene films pipes for conveying water to the farm instead of the creek”, and “the percentage of metallic water distribution valves along the waterway” are the first to third priority, because all these actions ensure promptness in providing irrigation water to croplands, reduces water losses for evaporation from free surface networks (preventing water wastage and thus increasing water consumption efficiency in Qanats and canals) and avoiding lowering Qanats. These factors, if implemented with effectiveness and promptness, allow a significant increase in the volume of available water resources for the production cycle with a presumable improvement of quality and quantity of the agricultural production (Gunchinmaa and Yakubov, 2010; Rezadoost and Allahyari, 2014; Samian et al., 2015). The last priority attributed by farmers to “the suitability of the installation of valves along the waterway” is that most of the canals in this area are made of earth, and irrigation uses surface methods that do not require valves. There are farmers in the area who do not use modern irrigation equipment (e.g., pressured networks with valves instead of free surface canals) for economic reasons or lack of familiarity.

Among the economic factors of water management, “attracting state aid for the reconstruction of the Qanat”, “the amount of credit to cover and dredge the creeks, Qanats, and canals”, and “increasing farmers’ income” were first, second, and third priorities, respectively, and these results were somewhere expected. Improving the condition of aqueducts and irrigation canals enhances water access and distribution among farmers and ultimately increases the net worth of water resources (Wichelns, 2002). However, due to the high costs required by the improvement actions and the diffuse condition of low-income smallholder for most of the farmers interviewed, attracting financial assistance from the government, increasing fund availability from the credit, and saving part of product revenues for the renovation of Qanats and irrigation canals are considered of the utmost importance. "Obtaining credit and banking facilities and receiving incentives such as tax breaks for active water companies" was the last priority, although this would increase the level of welfare of farmers (Rezadoost and Allahyari, 2014; Samian et al., 2015) and lead to more investments in irrigation systems (Pan and Xu, 2018). However, due to the "very high costs of modernization of irrigation facilities and the lack of legal support in the financial support of water user organizations by the government", the renovation of these canals and irrigation equipment and its financing by the government was the first priority. According to the Iranian laws about the WUAs' support policies, it is stipulated that to invest in infrastructures, 0.85% of the expenses should be provided by the government and the remaining 0.15% by the WUAs' members. However, based on the Agricultural Organization experts' comments in Tafresh County and the landlords, the government will cover about 40 percent (or more) of the repair costs as much as possible, and the rest will be the responsibility of the WUAs' members. Although in the case of a government budget deficit, all estimated costs will be covered by the owners.

Therefore, it takes precedence over tax incentives and incentives for farmers. Especially due to the "high administrative bureaucracy in Iran" and "lack of knowledge about the benefits of tax breaks", access to banking facilities and tax exemptions is difficult for the old and illiterate farmers of the county. The outcomes of interviews about the prioritization of farmers' participation factors show that "collecting the association's shared costs" (first priority), "repairing and rebuilding valves" (second priority), and "repairing and dredging creeks" (third priority) is of the highest importance in agricultural water management for farmers. Since low government budgets and facilities do not cover the high costs of water management, strengthening farmers' participation in reconstruction and improvement of the irrigation systems - also by a personal involvement through the provision of infrastructural services, including the family working - would lead to the enhancement of the irrigation performance, increase in the operational efficiency of WUAs and finally improvement of water management in WUAs. Moreover, an efficient collection of due water fees as payment of the irrigation service provided by WUAs is considered essential to fund the WUAs, and this is in close accordance with the results of the studies carried out elsewhere (Zema et al., 2018a; Zema et al., 2015; Zema et al., 2018b), which demonstrated how the financial self-sufficiency of WUAs is able to ensure an efficient collective irrigation service. "Cooperation of farmers with the Water and Agricultural Organization to implement regulations related to water management" was the last priority of these factors, presumably due to the lack of farmers' knowledge of the related benefits.

The confirmatory factor analysis to test the main hypothesis revealed that all factors positively and significantly affect groundwater management. Among these factors, based on the SEM results, socio-cultural, social capital, participation, legal and institutional, infrastructural, and economic factors have the greatest impact, respectively. As a result, the main hypothesis that these factors improve groundwater management can be confirmed. However, the relationships among these factors show that the county infrastructural current agricultural situation is not a favorable environment for implementing efficient and desirable water management, and this situation requires more attention and a particular focus on these factors (Boyer et al., 2011). More specifically, precise planning to strengthen socio-cultural and improve social capital relations among farmers, creation of economic incentives and financial and credit support from relevant agencies, solving problems and inadequacies of irrigation systems, the infrastructural and principled maintenance of irrigation networks through increased participation of users, and a more efficient water fee collection from the associated farmers could be suggested by this analysis to improve groundwater management and the sustainability of WUAs (Nazari et al., 2018; Osooli et al., 2011; Pan and Xu, 2018). On the other hand, social capital and legal and institutional factors among farmers must be renovated to avoid gradual obsolescence and inefficiency with the implementation of formal education in the local communities, as stated by some relevant studies about the impacts of social capital factors on the improvement of water resources systems (Akolgo et al., 2020). Moreover, according to Khalkheili and Zamani (2009), social factors are not related to farmers' participation.

Regarding the impact of economic factors, undoubtedly all factors may indirectly affect water management (Zema et al., 2020), but the analysis of the indirect relations among these factors went beyond the scope of our study. For instance, it should be important to analyze whether all factors affect groundwater management through the economic factor, which would require separate and more complete research.

Pearson correlation analysis, which tested the second hypothesis that all factors would directly and positively affect each other and showed significant relationships among all six factors, showed significant relationships between all six factors. It should be noted that the correlation coefficient between two variables can show the type and extent of the relationship between the two variables linearly but cannot be used to show the effect of one variable on another variable. However, we find that the results of this test give WUAs the ability to make more informed decisions to improve water management in WUAs by knowing the degree of correlation between the factors shown in the research framework. It also gives managers the ability to predict changes in other variables by examining changes in each model factor. The critical point is the degree of correlation and strong relationship between “participation” and the “legal and institutional” factors. This relationship points out that, in order to better promote water management in WUAs and improve their performance in water management planning, politicians must invest more than anything else in the legal and institutional, and participation factors.

Overall, the confirmation of both working hypotheses suggests comprehensive attention to all the evaluated factors as a management strategy to enhance the optimal management of agricultural water in WUAs.

6. Conclusions

The study has shown that in the WUAs of Tafresh County (Iran) the “legal and institutional”, “socio-cultural”, “social capital”, “infrastructural” factors as well as the “farmers’ participation” not only are strongly interrelated but are also able to improve groundwater management. The analysis of the indicators nested into these factors has indicated the need for actions to strengthen an efficient use and share of irrigation resources, which should be implemented according to the priorities socio-cultural > social capital > participation > legal and institutional > infrastructural > economic factors, as given by the confirmatory factor analysis.

Therefore, from this study, it is evident that, in the case study, the prerequisites for improving the management of the WUAs are basically four: i) providing members with new water management technologies (that can be provided directly or through the government), in order to increase the efficiency in extraction, distribution, and consumption of irrigation water; ii) strengthening the role and importance of social and cultural participation in the management of WUAs through a better understanding of the barriers to the social involvement and the impact of cultural capital, in order to create formal and informal contexts for enhancing individual participation in the short and long-term; iii) designing appropriate financing factors and diversification of the sources of revenue to execute projects on shared water resources; (vi) involving young human resources with higher education levels into the existing WUAs and agricultural water management.

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