Identifying Factors affecting Optimal Management of Agricultural Water

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The main purpose of this study was to explore the factors affecting optimal management of agricultural water in Hamadan's area. The statistical population of the study included all Hamadan's farmers. A number of 148 farmers were selected randomly through a proportional sampling method in two phases. Both questionnaire and interview techniques were used in order to collect data. The empirical and face validity of the questionnaire was verified by a panel of experts consisting of faculty members and natural resources specialists. The questionnaires' reliability was tested by Cronbach's Alpha technique and it was 91% (α= 0.91). In addition to quantitative methodology such as descriptive statistics and factor analysis a qualitative methodology was employed for dynamic simulation among variables through Vensim software. In this study, factor analysis technique was used through the Kaiser-Meyer-Olkin (KMO) and Bartlett tests. From the results, four key elements were identified as factors affecting the optimal management of agricultural water in Hamedan area. These factors were institutional and legal factors, technical and knowledge factors, economic factors and social factors.

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1. Introduction

Water is an important resource for human society and protection this natural resource efficiently has become one of the main challenges of this century. According to Iran's geographic information, the country is located in a semi-arid region on the earth. Therefore, it can easily be claimed that the limitation of water resources is one of the major factors in the agricultural development of Iran. The atmospheric precipitation (70% rain and 30% snow) brings the total up to 450 billion cubic meters of water (Goodarzi et al, 2009). In the present situation, about 269 cubic meters of this figure is lost in different forms; however, 30 and 35 percent of this is devoted to urban areas and agriculture respectively (Zehtabian, 2005). On the other hand, 93% of the total water resources are used in agricultural sector, and less than 7% is allocated to municipal and industrial uses. Therefore, the proper water management in this sector is essential and plays a critical role on the sustainable development of agriculture (Keshavarz and Heydari, 2004). Since many countries for years have been faced with a serious crisis due to shortage of water resources on one hand and on other hand due to population growth and economic and social development, it can be said that water problems in the future would be more and more and water would be undoubtedly an important issue (Najafi, 2005). Based on the UN Commission on Sustainable Development, the growth of water demand in 2025 would be equivalent to 212 percent of demand in 1990, which means the need to consume water will be more than of the country's water resource.

Water is a critical resource for farmers, and ensuring access to water is very important for reducing poverty in rural areas because poverty reduction will lead to food security. There is no agriculture and food security without water; this is an important message from a member of the International Federation of Agricultural Producers (International Federation of Agricultural Producers, 2005). Iran, as a developing country, is located in arid and semi arid areas in which water scarcity is a major issue (Foroughi et al, 2006) and regarding to the highest level of water shortage is in the agricultural sector, the need for efficient use, or in other words, management of agricultural water is inevitable. Agricultural water management is a systematic approach to control water in the farm and it leads to the provision of crop irrigation and drainage whilst there are physical, social and governmental problems

in production systems (Forrest, 2002). The aim of the effective management of agricultural water is to increase economic performance with reduced consumption of water and energy (Pandy et al, 2000; Panda et al, 2004). So, agricultural water management in areas that are facing the problem of water shortage seems to be more important to expect maximum efficiency from the minimum water resources.

Undoubtedly, understanding the factors affecting agricultural water management can provide management strategies in agricultural water. About factor affecting the agricultural water management some researches and studies have been conducted both in Iran and worldwide. Below some of these studies are mentioned.

Wijayaratna (2002) believes that the major obstacles of the success of agricultural water management are lack of providing subsidies and financial support for farmers and the users' enterprises. Burak (1999) also acknowledges that having the government technical support is essential, especially for small WUAs (Water User Associations), because they have so many financial challenges in the new irrigation system. Koh et al. (2002) in a study entitled agricultural water in Korea mentions that water use, water quality and integrating the laws which are related to improving water use are all important factors in water management and they believe that comprehensive rules should be developed in the field of water management. Based on the study of Regner et al (2006), failure to provide necessary training to farmers on irrigation management is an important problem in the field of water management success. Pereira et al (2002) also determine the responsibility of farmers for maintenance of canals and water resources as an effective component in water management.

Azizi (2001) divided the components of successful water management in several categories include management, physical (cropping pattern, the number of components, climate, irrigation method, etc.), economy (finance, insurance, difficult access to inputs, etc.), social (consumer behavior, neighbors, responsibility of sponsoring, non-agricultural income, etc.) and institutional components (ownership of water resources, lack of law enforcement, rental of water resource). Davarpanah (2005), in his study, adds to crop insurance agent in the form of economic agent, coordination between governmental organizations in the form of institutional agent, and supportive government policies. Ehsani and Khaledi, (2003), about the role of education in promoting and increasing the efficiency of agricultural water considered the role of extension and education as important. Zehtabian (2005) believes that lack of the irrigation management is due to low irrigation efficiency and he adds that the role of education in promoting and improving irrigation management and irrigation efficiency is remarkable. Farshi (2005), in his study, refers to the role of education and extension in irrigation and increasing farmers' knowledge, development and improvement of modern water transmission and distribution networks, applying new methods of irrigation in increasing irrigation efficiency and water efficiency management. Accordingly, Farzampoor (2001) believes that the following factors are influencing toward agricultural water management: effective pass legislation about water management and government protection from digging wells without permission. Osareh (2006) studied the efficiency of irrigation water on integrated and non-integrated fields on Dez Dam. He found some effective components affecting the increase of irrigation efficiency in Dez Dam such as farmers and consumers participation in water distribution and storage system and also cropping pattern recommended by the officials. Khalilian and Zare Mehrjerdi (2005), in their study entitled the valuation under-ground waters in the agricultural exploitation in the city of Kerman, believe that the government can implement policies restricting withdrawals of groundwater resources and the prevention digging of new wells to prevent the loss of water. Tahamipoor et al (2005) investigated the effect of decline of groundwater in social welfare of Pistachio Producers of Zarand city resulting that the farmers should be aware of the decline in groundwater levels and they must be encouraged in order to optimal water use.

Zehtabian (2005), according to his research in Varamin mentioned the following items as the main causes of low efficiency of irrigation in this area: low level of education of farmers about water, soil and crops, small plots of land and acreage (less than 5 hectares), lack of land leveling, lack of proper management of water and irrigation, and, the use of traditional methods of irrigation. Norouzi (1997) stated the following components as the limitations of the use of pressurized irrigation system: impossibility of using salt water, the relatively high initial investment requirements, training requirements for optimal use of irrigation facilities, being time-consuming (in terms of the evaluation process, selection of appropriate system, design, delivery, installation and commissioning of the system), impossibility of performance and economic justification in small and scattered pieces of land, restrictions on some products, and rapid depreciation of field parts. Mirabolgasemi (1994) states some challenges in the optimal use of water such as lack of inappropriate land leveling and configuration, the

diversity of crops grown on a farm, lack of water requirement to each crop, lack of education and promotion of farmers and water users to make optimal use of water. Forooghi et al (2006) in a research on the status of water resources during droughts in recent years in Fasarud Darab concluded that the lack of proper water management on farm through the penetration and evaporation of water from the rivers and traditional streams, farmers inattention to crop water requirements and using a fixed period irrigation, and change in cropping pattern in order to earn more income (crops with high water requirements), which in recent years has caused a drop in levels of water table, can be regarded as a serious threat in destroying the country's water resources. Khadem Adam (2003) mentions factors such as inappropriate irrigation and flooding of agricultural land and to penetrate the water deep into the earth as the most important problems related to the agricultural water loss.

The purpose of this study was to analyze the factors affecting the optimal management of agricultural water in the Hamadan's area. The objectives of the research include:

• identifying the variables affecting water resources management;
• identifying and analyzing the key components of effective water resources management; and
• surveying the farmers' views on water resources management.

2. Materials and methods

This study was used a surveying methodology. In this way, the frequency, distribution and the relationships among variables were reviewed and evaluated by selecting and studying samples chosen from the statistical population. The study population included the farmers engaged in agricultural work in Hamadan province. Of those farmers 148 were chosen using a proportional sampling method during a two-stage process.

To collect data, a questionnaire was used containing both 19 open-ended and 27 closed questions. The validity of the questions in the questionnaire was first confirmed by a group of experts and specialists and finalized after revising. The reliability of the questions in the questionnaire was tested based on the Cronbach Alpha test and it was 91%. In order to analyze the data both descriptive and analytical statistics were employed. In describing the data, the statistics such as frequency, percent, median, mode, standard deviation, variance, and mean were used. For analyzing data, the factor analysis approach with Kaiser-Meyer-Olkin (KMO) and Bartlett tests were used.

In order to draw a clear model based on the variables obtained from factor analysis method the Vensim software was used. This method was applied to draw a conceptual model based on a simulation approach. This approach with a dynamic figure allows that different behaviors of each variable and its feedbacks be reviewed in different times. This feature plays an important role in the management and appropriate policies regarding the study and understanding the effects of each variable with consideration the dynamics. In this study, after recognizing the main variables affecting the optimal management of agricultural water, the models were drawn to show dynamics of the variables in line of a comprehensive analysis for future policies and decisions.

3. Results and discussion

3.1 Personal characteristics of the farmers

Based on the findings, the farmers' age in average was 42 years. The youngest farmer was 16 and the oldest one was 79 years old. The most respondents were illiterate (36.8%). The working experience of the cases was 14 years. The average of irrigated area among farmers was about six hectares and total irrigated land was 40 hectares. Rain-fed farming in some areas was booming. The average of Rain-fed lands was 14 acres. The Farmers most crops were potato, wheat and barley. For irrigation, 77 percent of farmers were used groundwater such as well, 23 percent used surface water to irrigate their fields. Traditional irrigation method was used more than other methods, so that in 62% of farms conventional method was used for irrigation. The average number of the farmers' land pieces was four pieces with the SD of 6.5. Some farmers owned some small livestock in addition to farms. In order to learn about irrigation methods, 40 percent had visited Agriculture Organizations, 22 percent extension agent, 16 percent Agriculture Research Centers and 22 percent referred to neighbors, magazines and mass media. Regarding ownership of agricultural land, the results showed that about 60% of cases had private lands, 24 percent cooperatives, 11 percent rental and the rest had other ways. 78% of the farmers had participated in extension training courses from which 36 percent related water management and the optimal use of agricultural water.

3.2 Factors influencing optimal water management

Table 1 shows the variables affecting the optimal management of the water in terms of priorities from the farmers' perspective. As it is shown, blocking unauthorized wells on farms (mean= 4.60 and SD= 0.63) is the most important variable that can affect the optimal management of water in the Hamadan. The reality is that unauthorized wells

in the region in recent years, forces a lot of injuries on the ground water resources and threats the sustainability of water resources. On the contrary, in farmers' perspective, shortening the main channels for transporting water has the least effective for optimal use and sustainable water management (mean= 2.17 and SD= 1.21). Reusing of waste and additional water, having strict rules against those farmers who waste the water, penalizing unauthorized well users are other variables can lead to management and optimum use of water. The other variables can be seen in the table.

3.3 Factor analysis results

Factor analysis is considered the queen of analytical methods due to the virility, elegance and its proximity to the core of scientific goal (Kerlinger, 1986). The main purpose of factor analysis is to identify the fundamental or underlying factors of the variables. In this regard, the interface variables in terms of shared variance are identified and then they are designated by the investigator. It should be noted that despite the ability of this method of data analysis, there is the impossibility of using them in every situation. The data used for this kind of analysis must have the needed qualifications to do that. To do so KMO coefficient and Bartlett's test are used, if KMO value is greater than 0.5 it can safely be used in factor analysis. In the present study, the KMO coefficient equal to 0.848, which is a good figure; and, Bartlett's test is significant at 99% level (Sig = 000). After ensuring the suitability of data for factor analysis, the rotation and Verimax was used to achieve significant factor. Extracted factors are shown in table (2). These factors determine 79.21 percent of total variance regarding effective mechanisms in the optimal management of water in the city of Hamadan. In simple terms, considering these four factors can validate 79.21 of the optimum water management in this city.

Table 1. Factors influencing optimal water management in terms of priorities

Priority	Variable	M	SD	SD/M
1	Blocking unauthorized wells	4.60	0.638	0.13
2	Reusing of waste and additional water	4.74	0.664	0.14
3	Having strict rules against those farmers who waste the water	4.31	0.776	0.17
4	Penalizing unauthorized well users	4.44	0.884	0.19
5	Improvement and dredging aqueducts	4.20	0.808	0.19
6	Encouraging farmers who use new methods	4.00	0.808	0.20
7	Increasing government investment in agricultural water management	3.63	0.755	0.20
8	Making the streams ferroconcrete and preventing water waste in canals	3.52	0.762	0.21
9	Paying financial facilities to farmers	4.16	0.911	0.22
10	Encouraging farmers to attend in training courses	3.69	0.821	0.22
11	Installation of meters on water wells	3.74	0.876	0.23
12	Training farmers in order to optimize the use of water resources	3.60	0.880	0.24
13	Enhancing farmers' participation in water management	3.46	0.930	0.27
14	Operations of aquifer	3.52	0.970	0.27
15	Using methods pressurized irrigation	2.87	0.870	0.27
16	Increasing government loans to buy new irrigation systems	3.84	1.16	0.30
17	On-time irrigation	3.26	1.13	0.34
18	Changing cropping pattern	3.34	1.16	0.35
19	Using of drought-resistant crops	3.14	1.16	0.35
20	Forming associations of people or groups	2.98	1.02	0.35
21	Using modern systems on small farms	3.22	1.20	0.37
22	Proper distribution of water in land areas	2.94	1.09	0.37
23	Holding training classes in the field of water management	2.98	1.22	0.41
24	Integration of lands to avoid wasting water	2.26	1.12	0.50
25	Privacy compliance and legal required distance between wells	2.22	1.16	0.52
26	Use products that use less water	2.25	1.25	0.55
27	Shortening basic channels for transporting water	2.17	1.21	0.55

Note: very low=1, low= 2, moderate= 3, much=4, very much= 5; M=mean, SD=standard deviation

Table 2. Number of extracted factors with eigenvalues, percentage of variance and cumulative percentage

Number	Name of factor	Special amount	variance percentage of special amount	Cumulative percentage
1	Institutional and legal factors	11.12	25.64	25.64
2	Technical and knowledge factors	9.64	21.18	46.82
3	Economic factors	7.26	17.12	63.94
4	Social factors	5.43	15.27	79.21

Table 3. Variables related to each of the factors influencing the optimal management of agricultural water and the obtained loading factor from the matrix

Nr.	Factor name	variables	loading factor
First	Institutional and legal factors	Penalizing unauthorized well users	0.579
		Installation of meters on water wells	0.621
		Blocking unauthorized wells of farms	0.532
		Improvement and dredging aqueducts	0.635
		Shortening basic channels for transporting water	0.612
		Privacy compliance and legal required distance between wells	0.711
		Making the streams ferroconcrete and preventing water waste in canals	0.618
		Operations of aquifer	0.518
Second	Technical factor and farmers' knowledge	On-time irrigation	0.645
		Use products that use less water	0.518
		Using pressurized irrigation methods	0.658
		Training farmers	0.632
		Changing cropping pattern	0.548
		Encouraging farmers to attend in training classes	0.532
Third	Economic factor	Increasing government investment	0.716
		Increasing government loans to buy new irrigation systems	0.518
		Using modern systems on small farms	0.518
		Paying financial facilities to farmers	0.605
Forth	Social factor	Forming associations of people or groups	0.518
		Integration of lands to avoid wasting water	0.568
		Encouraging farmers who use new methods	0.645

The loading status of the factors, after rotating based on the placing of the variables with the load factor greater that 0.5 is presented in table (3). As seen, the first factor determines 25.64% of the total variance. In this factor, 8 factors exist with loading factor of more than 0.5. The second factor is technical factor and farmers' knowledge. This factor, by itself, determines 21.18 of total variance and it is in the second priority. Economic factors and social factors are third and forth and each of which determine 17.12 and 15.27 percent of the variation respectively. Since in this research the aim is to access to factors that explain the most of the variance it should be tried that the extracted factors summarized and limited to cause the total variance to be increased. To do such a thing, it is needed to increase the amount of the total variance through removing undesirable variables of which their variance cannot be explained by the main factors (Kalantari, 2008). Thus, in the following factors undesirable variables have been omitted.

The results of factor analysis indicated four factors with a significant role in optimal management of agricultural water. Based on the obtained factors the following items can be suggested:

Institutional and legal factors: As mentioned earlier, this factor alone determines 25.64% of the total variance. In another sense, we can legally achieve 25.64 percent of the objectives of efficient water management. Penalizing unauthorized well users, installation of meters on water wells, blocking unauthorized wells of farms and privacy compliance and legal required distance between wells are of the main variables of among institutional and

legal factors. Each of these factors can help the control of water consumption and optimal water management in the farm. This factor is mentioned in the studies of Azizi (2001), Davarpanah (2005), Farshi (2005), Farzampoor (2001), and Norouzi (1997).

Technical and knowledge factors: This factor determines 21.18 percent of the total variance. In other words, changing and increasing students' knowledge can cause 21.18 percent of efficient water management objectives to be achieved. On-time irrigation, using products that consume less water, changing cropping pattern, encouraging farmers to attend in training classes, using pressurized irrigation methods, etc. are of the other critical variables among technical factor and farmers' knowledge. Research results show efficient allocation of water resources will be better by using modern irrigation systems (Karbasei et al, 2000). Accordingly, the government should identify obstacles to the development of pressurized irrigation systems. Currently, lack of serious cooperation and lack of banking supervision on implementation process of these systems are the main obstacles to its development in Iran (Amiri Ardakanei & Zamanei, 2003).

One of the reasons for the low efficiency of water use in the lands is disproportionate water distribution and water requirements of plants that cause poor product performance in the field (Mamanpoush et al, 2002). Management of soil moisture in the lands can increase water use efficiency and it directly affects the sustainable management of water (Mohammadi, 2005).

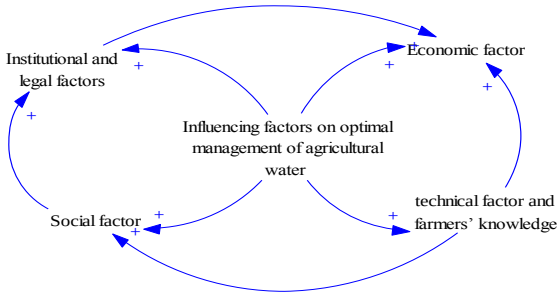
Economic factors: It determines 17 percent of the total variance. The most important variables of this group are: increasing government investment, increasing government loans to buy new irrigation systems, paying financial facilities to farmers and using modern systems on small farms.

Social factors: They explain 15 percent of the total variance. The most important variables of this group are: forming associations of people or groups, integration of lands to avoid wasting water, encouraging farmers who use new methods.

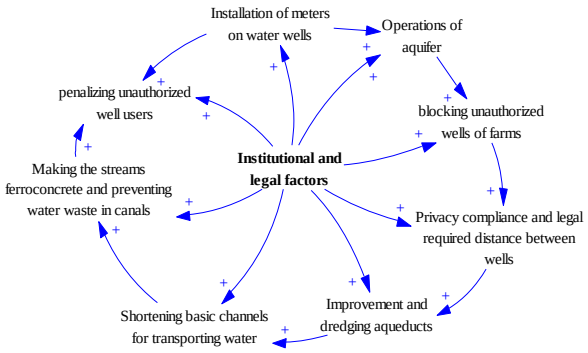
3.4 Dynamic conceptual model

In model 1, the factors affecting the efficient management of water are shown. As seen, the mentioned factors are related to each other and each of them influence on the other ones. And the effects of each of them on optimal water management cannot be investigated individually.

The most important factors affecting the optimal management of agricultural water institutional and legal factors (model 2). Penalizing unauthorized well users, installation of meters on water wells and blocking unauthorized wells of farms leads to equity in water use by farmers and it contributes to efficient management of water; and, it leads to the farmers' participation and their contribution to government in making the streams ferroconcrete and dredging the aqueducts. Moreover, institutional and legal factors improve the farmers' incomes affecting efficient use of water and using modern methods in irrigation. Finally, the farmers' participation will be increased and they will use modern methods of irrigation using the government facilities and paying financial facilities to farmers.

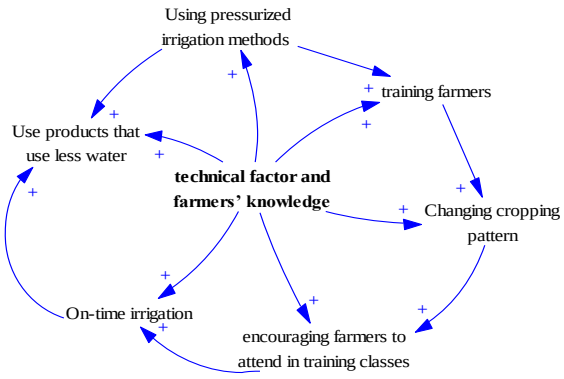


Model 1. Factors affecting the optimal management of agricultural water in Hamadan province

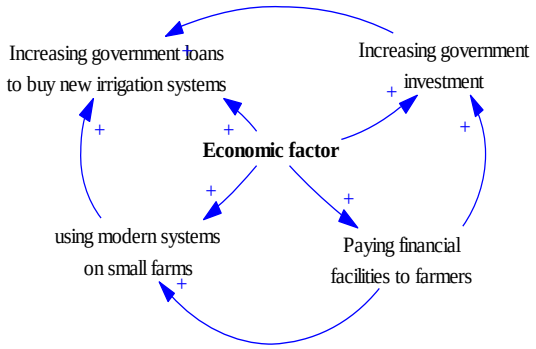


Model 2.Casual-circular model showing the effects of institutional and legal factors affecting the optimal management of agricultural

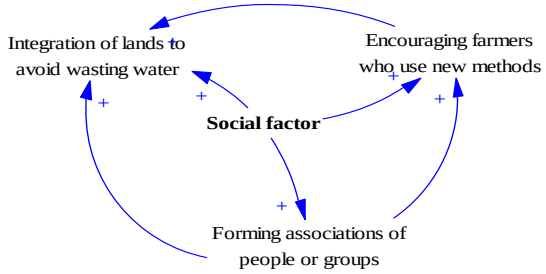
In model 3 technical factors and farmers' knowledge is shown. As it is depicted, 6 major factors are identified that all of these factors influence on each other. And all the factors affect on technical factors and farmers' knowledge, as one of the elements of the efficient management of water.



Model 3. Casual-circular model showing the effects of technical factors and farmers' knowledge affecting the optimal management of agricultural



Model 4. Casual-circular model showing the effects of economic affecting the optimal management of agricultural



Model 5. Casual-circular model showing the effects of social affecting the optimal management of agricultural

In models 4 and 5, social and economic factors are shown. As it is shown, 4 factors in economic factors and 3 factors in social factors are identified. These factors have positively affected each other; and, they totally affected on efficient management of agricultural water. If we have a systemic perspective, we can find that if we take each of these factors into consideration individually so that it may cause insufficient results and we would fail to attain the goal. Thus, all the factors should be considered to achieve and identify factors that affect optimal water management.

4. Conclusion and Recommendations

The results showed that blocking the unauthorized wells of farms is the main variable which can affect the efficient management of water in Hamadan province. The reality is that unauthorized wells in the city in recent years, forces a lot of injuries on the ground water resources and threats the sustainability of water resources. On the contrary, in farmers' perspective, shortening the main channels for transporting water has the least effective for optimal use and sustainable water management. Reusing of waste and additional water, having strict rules against those farmers who waste the water, penalizing unauthorized well users are other variables can lead to management and optimum use of water. The factorial analysis results identify four factors. On the whole, these factors determine about 79 percent of dependent variable variance or the efficient management of the agricultural water. The results showed that nearly 21 percent of the components affecting the optimal management of agricultural water are still unknown and additional research is needed in order to complete the information. These 4 extracted factors are institutional and legal factors, technical factor and farmers' knowledge, economic factor and social factors. The first component, or institutional and legal factors, is the most important component affecting the optimal management of agricultural that includes some components like: penalizing unauthorized well users, installation of meters on water wells, blocking unauthorized wells of farms, improvement and dredging aqueducts, etc.

Therefore, there is a significant correlation between institutional and legal factors and optimal water management. In other words, probably 99 percent there is a significant relationship between institutional and legal factors and optimal water management. And, there is a significant relationship at level 1 between participating in training classes (the farmers who experienced training classes), agriculture facilities and the efficient management of agricultural water. Regarding this, it can be suggested that the number of these classes should be increased

to have more influences on the efficient management of agricultural water.

On the other side, if we have a systemic look at the factors affecting the optimal management of the agricultural water we would see that these factors are interrelated to each other and they cannot be reviewed separately and individually. So, as mentioned previously, institutional and legal factors affect technical factor and farmers' knowledge while technical factor and farmers' knowledge affect economic factor and economic factor influences social factor and all these factors affect each other like a cycle. For example, improving the farmers' income affects the economic status of them and this, in turn, affects the optimal consumption and using modern method of irrigation. Ultimately, if we keep on this systemic view toward these components and factors we will know that all these elements are interrelated and should not be considered separately.

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