THE ECONOMIC VALUE OF CROP WATER IN IRAN- 2019

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Water resource management is one of the challenges that societies have faced in recent decades; The growing shortage of fresh water to meet the demand of various sectors of the economy droughts, floods and quantitative and qualitative reduction of water resources, engineering "water supply" on the one hand and population growth, urbanization and the growing of water consumption, Management of the "water demand" side, on the other hand, makes it necessary. The price is considered one of the main tools of demand management, which protect the water resources, its storage and sufficient income for the public water service unit. The main purpose of this study is to determine the economic value of water. For this purpose, 28 crops in 31 provinces of the Iran are considered and the economic value of these crops are obtained using translog production function method. The results of the research show that, in 2019, the economic value of water of these crops in the Iran was 17100 Rl per cubic meter. The elasticity of crop production with respect to water is also 21%, which shows that a one percent changes in water consumption, increases crop production by 21% assuming other conditions are constant.

Keywords: economic value of water, crops, translog production function

1.Introduction

Economics is the study of the allocation of limited and scarce resources between unlimited uses and needs. According to the definition, an economic goods is a commodity that has utility for the society and is somewhat scarce compared to the demand. It is scarcity that creates value, willingness to pay and opportunity cost; and if a commodity can be valued, it can be traded in the market and valued using some form of money.

Before the 20th century, due to the abundance of water resources compared to the demand and the lack of population pressure and other types of water demands, water resources were known as a low value and free commodity; But after that, due to rapid population growth, economic development that requires development in all economic sectors and the formation of new types of demand, rising living standards, responding to all types of water demand, etc., its consumption increased sharply. It caused the attention of managers and policy makers as a rare commodity and was considered as an economic commodity and a limited input; In this direction, water economy was formed, which includes topics such as the application of economic principles in the management and exploitation of water resources, the economy of water resource development plans, the description of different methods to improve the efficiency of water economy, the evaluation of water sector policies and allocation systems pay. In fact, the economic dimension of water is an important feature in the integrated management of water resources, and the two important goals of this management are maximizing the economic value of water and investing in the water sector in order to justice and environmental sustainability.

Iran is one of the countries that is most vulnerable to water shortage, being located in the least watery region of the world. More than 90% of Iran's population and gross domestic production are in areas where withdrawal of water resources is more than sustainable exploitation (World Bank, 2017). 61% of the country's area is in dry and ultra-dry climates, which is 1.3 times the global percentage. The most important feature of these climates is that their average annual rainfall is less than 50 millimeters (Ministry of Agriculture of Iran, 1400). Of course, the level of these areas also depends on the climatic conditions and human factors of desertification, such as population increase, excessive grazing, withdrawal of water from underground water resources, groundwater pollution through industrial, urban and agricultural waste water, land use change, improper management of pastures and unprincipled management of agricultural lands are increasing. Therefore, the importance and value of water in this territory is very high.

Water pricing is effective in increasing productivity and reducing water consumption when, in addition to knowing the cost of providing water as the lower limit of pricing, the economic value of water as the upper limit of pricing is also known.

This study was compiled with the purpose of determining the economic value of water. For this purpose, the registered data of the Information and Communication Technology Center of the Ministry of Agriculture and the Iran Water Resources Management have been used. The geographical scope of the research is at the level of the whole country(Iran) in 2019. The organization of this article is that after the introduction, in the second part of the literature, the theoretical foundations and background of the research are stated. The third part is dedicated to the introduction of statistical data and the research method, the fourth part is the results and discussion and the final part is dedicated to concluding remarks and recommendations.

2-Theoretical foundations and background of research

Iran is facing a severe water crisis. Despite this, the price of water in urban areas of Iran is among the lowest prices in the world (World Water Council, 2016), so it does not warn about the value of water and the need to save. At the same time, water suppliers are limited in providing water, forcing the government to pay huge subsidies for water supply, production and maintenance. Along with the scarcity of water resources, the country's environment suffers the most damage.

Demand management is the implementation of strategies aimed at influencing demand, in order to efficiently and sustainably obtain a scarce resource, which, in addition to efficiency, should also promote environmental justice and integrity. The category of water management is dynamic, and with the increasing scarcity of water resources and the increase in economic competition for it, the role of economics in water allocation and management has become increasingly important. However, the cultural and environmental characteristics of water, the economic tools and principles in its allocation and exploitation, face problems in practice. Water has unique characteristics such as public goods, private goods, vital goods, environmental goods, etc., which are necessary to know in water management in order to achieve social and environmental goals. These characteristics make water more complicated than other goods and affect its market as well. The characteristics of water supply and demand and the inability of the market, make the economy unable to solve the water problem alone and need a comprehensive approach should be created in terms of environmental, technical and institutional factors along with economic criteria and principles.

In the absence of a water market or real water pricing, the value of irrigation water is often determined using shadow prices (Ziolkowska, 2015). The shadow price of water shows the value of the products produced by the final unit of water consumption and other inputs such as labor and machinery, and it means the income (production equal to the market price) created with the last cubic meter of water consumption (Bierkens et al., 2018). The shadow price is the marginal value of water (Young and Loomis, 2014), which represents the value that water has for the farmer or the maximum price that the farmer is willing to pay for the last cubic meter of irrigation water used. Producers use an input until its price is equal to the additional value of using one unit of the input (Williams et al., 2017).

Valuing water, on the one hand, contributes to the efficiency, equitable allocation and proper distribution process and reduces the harmful environmental effects with economic tools, on the other hand, it increases market awareness, so that policy makers consider the importance of ecosystems or natural resources and reconsider the investment decisions that cause damages in the long term and have adverse effects on the natural environment and human livelihood. It also reduces the scope of market failure and causes farmers to change their traditional irrigation to low-consumption irrigation, reconsider their product selection and change their product pattern with other products with higher economic efficiency and less water requirement.

The contribution of the value added of the agricultural sector in Iran in 2019 was 8.6% and the contribution of labor force (15 years and older) in this sector was 17.9%. If this sector is divided into sub-sectors such as planting crops (cultivation and horticulture), animal breeding, forestry and fishing, it can be seen that cultivation and horticulture have the highest contribution of value added in the agricultural sector in 2019 and It was 68.4 percent (SCI[7], 2019).

[7] Statistical Center Of Iran

Growing crops is the science and technology of cultivation and exploitation of water, soil and annual plants, and the contribution of labor force in this sub-sector was 37.2% of the total agricultural sector. In the crop year 2018-2019, the area of crops was about 12 million hectares, of which 51.8% were Irrigated agricultural area and 48.2% were rain fed agriculture.

In this crop year, about 82.7 million tons of crops have been harvested, so that 90.6% of crop production belongs to Irrigated agricultural area and 9.4% of the rest belongs to rain fed agriculture. Growing crops is one of the most influential groups in the economy, especially the agricultural sector. In 2019, the contribution of water consumption in the manufacturing, agriculture and services sectors was 5.1%, 83.1% and 11.7% of the total water consumption, respectively. The agricultural sector has the largest contribution; And this is while 77% of water consumption in the agricultural sector belongs to the cultivation of crops(Iran Water Resources Management &SCI). The set of these factors causes more attention to the control of water consumption in the cultivation of crops.

One of the methods of determining the value of water is the function of production, and the economic value of water is obtained through the marginal product of water input in the production process. In the production function method, water input is considered as an independent variable and after estimating the function, the value of the marginal product of water input is determined as its economic value. When the purpose of estimating a production function is to use its parameters to calculate the economic value of a production input, this calculation can be used as the basis for determining its price.
If "Y" represents the amount of production, "W" is the volume of water input and "X" is other inputs. The value of the marginal product of water is equal to multiplication marginal product of water and the price of the product, which is the optimal point of using the input and is the economic value of water (Chambers, 1988). So:

$$Y=f\ (W, X) \quad (1)$$

$$P_w = \left(\frac{\partial Y}{\partial W}\right) \times P_y = Mp_w \times P_y = Vmp_w$$

So that in the above equation, Vmp_w is the value of marginal product or the economic value of water, Mp_w is the marginal product of water input and P_y is the price of the product whose water input is used in its production process. The elasticity of crop production with respect to water or the percentage of changes in the amount of production to the percentage of volume of water changes can be obtained from the following equation;

$$E_w = \frac{\partial Y}{\partial W} \times \frac{W}{Y} = \frac{\partial Ln(Y)}{\partial Ln(W)} \tag{2}$$

And the marginal product is displayed as follows;

$$Mp_w = \frac{\partial Y}{\partial W} = E_w \times AP_w = \frac{\partial Ln(Y)}{\partial Ln(W)} \times AP_w \tag{3}$$

The studies conducted are in a wide range in terms of method, value and measurement units. Estimated values are also assigned to monetary units and different measuring units such as acres or feet. The estimated values in these studies indicate that the inconsistencies resulting from these results cannot be explained only by technical considerations related to the methods, and institutional considerations (business space and different exploitation and production systems) also explain this inconsistency, must be considered.

Among the studies in the field of irrigation water pricing and its allocation effects, we can mention Tsur, Y. and A. Dinar in 1995. According to them, the water pricing policy is a sufficient incentive for the effective use of water resources, and as a result, it contributes to the environmental goals of water.

In 2002, Arriaza and his colleagues estimated the water input demand functions of different groups of farmers in southern Spain by using the mathematical programming method, and by considering different scenarios of fixed and exogenous water supply, they estimated the marginal product value of different groups of farmers for the water input. They has been used its inequality between different groups to determine the type of participation in the market and to exchange water and transfer it between groups. After estimating the equilibrium price of water from the intersection of the water supply and demand curve in the market, they calculated the volume of exchanges in the market, the volume of exchanges and the value of exchanges and investigated the economic and social effects of creating a water market in the region.

In 2009, Liu et al., in an article entitled "Evaluating and Predicting Shadow Prices of Water Resources in China and Its Nine Major River Basins", they used input-output tables of the nine Chinese major river basins, and combining input–output analysis method with linear programming method.They developed a linear programming model with restrictions on the final demand, total output, trade balance and water availability and estimated the water shadow prices for industrial water and productive water for the nine Chinese major river basins.The results were compared with the real price of industrial water and productive water, using Gauss-Newton nonlinear simulation method, two nonlinear models that are related to the ratio of the volume of water used to the total volume of water resources with shadow prices and used to predict the shadow price of industrial water and productive water in 2020 and 2030 in China and the nine great river basins of China.

Bierkens et al showed in 2018 that one of the reasons for the reduction of underground water resources is the price that users pay for water, which does not reflect its scarcity and value. One way to evaluate the value of water is to calculate the shadow price or its marginal product value, which was estimated in this research for five products and eleven countries. To determine the shadow price, the method of production functions and the global hydro logical model were used, and the results show that the fluctuations of the shadow prices for the main products are very high in several countries, which indicates the inefficient economic use of water resources, including non-renewable underground water. Also, the effects of reallocating irrigation water between crops show that changes in water allocation can lead to an increase in the economic efficiency of water consumption or a decrease in irrigation water consumption.

3- Statistical data and the research method

The production process is a flow or process that converts production inputs into production goods and services (products) for consumption or investment, and the production function is a technical relationship between factors and production inputs and the product. It represents the maximum product that can be obtained from the set of inputs assuming that other conditions are constant. In the production function method, water input is considered as an independent variable and after estimating the function, the value of the marginal product of water input is determined as its economic value. When the purpose of estimating a production function is to use its parameters to calculate the economic value of a production input, this calculation can be used as the basis for determining its price.

Since the parameters of the water production function are effective in policies and the estimation value of these parameters is affected by the shape of the production function, before any action to estimate the model, it is necessary to decide on the shape of the production function. Functions used in production are divided into two categories: flexible functions and inflexible functions. Inflexible functions impose restrictions on model parameters, so that the collected information and statistics cannot freely describe the behavior of economic producers (Samuelson, 1979).

Flexible functions do not impose restrictions, and as a result, show the real behavior of economic factors in a more appropriate way (Diewert, 1971). The use of flexible functional forms, which can also represent the third area of production, are preferred over inflexible functional forms and are considered as superior forms. Of course, the flexibility of a function is not enough to directly select it as a production function, and it is necessary to estimate different functional forms and choose the best form based on econometric tests and criteria.

The characteristics of the production function of neoclassical economics include monotony, concavity, essentiality, non-negativity, continuity, twice-differentiability, which define the general framework of the behavior of production functions. Therefore, the forms of the function that provide these characteristics can be considered as the desired function to express production relations (Chambers, 1988).

Based on the Monotony condition, the form of the production function should be such that with the increase in the consumption of an input, its total production will also increase, and as a result, the final product, which is the first derivative of the function, will be positive. Despite the concavity feature, the final product of the production function is decreasing. Accordingly, linear functions cannot be considered. The different forms of production functions show the production technology and the way of combining different inputs, and the difference in the conditions of production and management of farmers causes them to combine production inputs in different ways. Therefore, there is a need for functions that show this difference better.

Translog production function was first proposed in 1972 by Christensen-Jorgenson and Lau. This function is actually the logarithmic transcendental production function in which substitution and production elasticities change according to the level of consumption of inputs. Also, in addition to the parameters of the main variables of the coefficients, this function also estimates the interrelationships of the variables (Debertin, 2016). Translog function provides all the features of neoclassical economics production function. Another characteristic of this function is that it allows substitution elasticities and production elasticities to change depending on the level of consumption of inputs. In addition, the first derivative of this function has no restrictions in terms of sign (positive or negative). In other words, translog function shows all three production areas and the final production is increasing, decreasing or negative. The essentiality condition is not defined in this function, and by having translog form, it is possible to test whether this function can be converted to Cobb Douglas or not; Therefore, the Cobb-Douglas function is considered a special case of this function (Griffin et al., 1987). If there are n inputs, the number of parameters of this function is n/2) n+3).

$$Y = \alpha \prod_{i=1}^{n} x_i^{\beta i} \prod_{i=1}^{n} x_i^{0.5 \sum_{j=1}^{n} \gamma_{ij} lnxj} \qquad i \neq j \qquad \gamma_{ij} = \gamma_{ji} \tag{4}$$

$$Ln(Y) = \alpha + \sum_{i=1}^{n} \beta_i Ln(x_i) + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} (Lnx_i)(Lnx_j) \tag{5}$$

$$Mp_i = (\beta_i + \sum_{j=1}^{n} \gamma_{ij} (Lnx_j))(\frac{Y}{x_i}) \tag{6}$$

$$Ex_i = \beta_i + \sum_{j=1}^{n} \gamma_{ij} (Lnx_j) \tag{7}$$

In the above production functions, x_i are production inputs, Y is the product amount, α ،β_i و γ_{ij} are model parameters and Ln is the natural logarithm.

Restrictions of translog production function

The restrictions of the model are as follows:
1-Condition of constant return to scale;

$$\sum_{i=1}^{n} \beta_i = 1$$

2- Homogeneous conditions (Boisvert, 1982);

$$\sum_{i=1}^{n} \beta_i = 1 \tag{8}$$

$$\sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} = \sum_{i=1}^{n} \gamma_{ij} = \sum_{j=1}^{n} \gamma_{ij} = 0 \tag{9}$$

3- Homothetic condition (Tzouvelekas, 2000);

$$\sum_{i=1}^{n} \gamma_{ij} = 0 \tag{10}$$

Production function variables

The variables used to determine the economic value of water in crops and to estimate production functions are as follows;

- The price of each kilogram of production per hectare in Rials (Y)
- The volume of water consumption per hectare in cubic meters (W)
- The consumption value of each kilogram of other inputs including chemical fertilizers, chemical poisons and seeds per hectare in Rials (O)
- The number of workers per hectare per day (L)
- The average cost of using machinery in one hectare in Rials (M)
-The average selling price of one kilogram of agricultural crops in Rials (P)

In this study, the economic value of water in agricultural crops is estimated using production function method and translog function form. The estimation of parameters has been done by OLS method and through Eviews software. The significance coefficient of the total regression (F), the significance coefficient of each of the coefficients (t), the coefficient of determination or explanatory power of the model, the specification error, the Heteroscedasticity, Residual Normality will also be examined and compared in the model.

The form of the production function and the value of the marginal product of crop water is as follows:

$$Ln(Y) = \alpha + \beta_1 Ln(W) + \beta_2 Ln(O) + \beta_3 Ln(L) + \beta_4 Ln(M) + 0.5\gamma_{11}(LnW)^2 + 0.5\gamma_{22}(LnO)^2 + 0.5\gamma_{33}(LnL)^2 + 0.5\gamma_{44}(LnM)^2 + \gamma_{12}(LnW)(LnO) + \gamma_{13}(LnW)(LnL) + \gamma_{14}(LnW)(LnM) + \gamma_{23}(LnO)(LnL) + \gamma_{24}(LnO)(LnM) + \gamma_{34}(LnL)(LnM) \tag{11}$$

$$Vmp_w = Mp_w \times P_y = \left(\frac{\partial LnY}{\partial Lnw}\right)\frac{Y}{w} \times P_y \tag{12}$$

$$Mp_w = (\beta_1 + \gamma_{11}(LnW) + \gamma_{12}(LnO) + \gamma_{13}(LnL) + \gamma_{14}(LnM)) \times \frac{Y}{w} \tag{13}$$

$$E_w = \beta_1 + \gamma_{11}\,(LnW) + \gamma_{12}\,(LnO) + \gamma_{13}\,(LnL) + \gamma_{14}\,(LnM) \tag{14}$$

Research is a systematic process of collecting and analyzing information (data) in order to find facts or deep understanding of issues. For this purpose, the researcher needs appropriate tools to achieve this goal. The source of the required statistical information regarding the determination of the economic value of crop water is the registered data of the Information and Communication Technology Center of the Ministry of Agricultural of Iran and the Iran Water Resources Management. The geographical scope of the research is in the whole country in 2019. Information is collected separately for 31 provinces and for 28 crops.

It should be noted that the water consumed by each product was calculated through the NETWAT software; The NETWAT software, which is also known as the National Water Document, is used to estimate the water requirements of garden and agricultural plants in Iran, and the output and result of the project is the "net irrigation requirement of Iran's agricultural and garden crops" which was carried out by the Ministry of Agricultural of Iran and Meteorological Organization has done. In this software, information related to evaporation, transpiration and net irrigation requirement in terms of cubic meters per hectare of cultivated plants is available in 620 plains of Iran.

4. Results and discussion

With the aim of determining the economic value of water for crops that consume the most volume of water among other agricultural products, the production function was first estimated. The model is estimated with 316 observations and through cross-sectional data and has 15 coefficients. The whole model is significant at a significance level of 95%. The restrictions of the translog function are tested in order to be able to transform it into the Cobb-Douglas production function. The test used is the Wald test and the test result of each restrictions is shown in the table below.

Table.1

The result of Wald's test for model restrictions

Restriction	H_0	Value	Probability	Result
Constant return to scale	$\sum_{i=1}^{n} \beta_i = 1$	8.5	0.0037	reject the null hypothesis
Homogeneous	$\sum_{i=1}^{n} \beta_i = 1$ $\sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij} = 0$	4.5	0.0048	reject the null hypothesis
Homothetic	$\sum_{i=1}^{n} \gamma_{ij} = 0$	4.8	0.0009	reject the null hypothesis

Source: research findings

The results of the test show that the applied restrictions are not correct and the intended function is a non-Homogeneous and non-Homothetic and has not constant return to scale.

In the next step, since the data are cross-sectional and there is a possibility of Heteroskedasticity, White's test is performed. According to Table 2, the result of the test shows the existence of Heteroskedasticity. The result of Jarque-Bera statistic in this model shows residual normality, and the result of Ramsey Reset statistic also shows that there is no specification errors in model.

Table.2

The result of model tests

White Test		Jarque-Bera Test		Ramsey Reset Test	
stat	**Prob**	**F-stat**	**Prob**	**F-stat**	**Prob**
2.22	0.00	0.6	0.7	1.8	0.18

Source: research findings

In order to fix Heteroskedasticity, the weighted method (WLS) with Standard deviation weight is used. The result of the model is presented in Table 3.

Table.3

The result of estimating the model after fixing Heteroskedasticity

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-117.7326	19.57805	-6.013501	0.0000
LW	5.369124	2.138296	2.510935	0.0126
LL	-4.714167	0.635792	-7.414642	0.0000
LO	7.319318	1.312412	5.576996	0.0000
LM	7.854923	2.018278	3.891894	0.0001
0.5*(LW^2)	0.184386	0.155540	1.185459	0.2368
0.5*(LL^2)	-0.006862	0.021854	-0.313977	0.7538
0.5*(LO^2)	-0.004281	0.069521	-0.061580	0.9509
0.5*(LM^2)	-0.096155	0.147163	-0.653390	0.5140
LW*LL	0.151316	0.036050	4.197428	0.0000
LW*LO	-0.259963	0.095539	-2.721021	0.0069
LW*LM	-0.188413	0.112112	-1.680584	0.0939
LL*LO	0.079219	0.034276	2.311227	0.0215
LL*LM	0.155195	0.041671	3.724289	0.0002
LO*LM	-0.336580	0.080617	-4.175025	0.0000
F-statistic	26.19839	**R-squared**	0.549251	
Prob(F-statistic)	0.000000	**Adjusted R-squared**	0.528286	
		Durbin-Watson stat	1.434983	

Source: research findings

Finally, according to the obtained coefficients, the marginal product of water is obtained. Since the dependent variable is the value of each kilogram of production per hectare, the amount of the marginal product is actually the value of the marginal product of water and it does not need to be multiplied again by the selling price of the product. The elasticity of crop production with respect to water is also calculated. Table 4 shows the results of the relevant calculations.

Table.4

The elasticity of crop production with respect to water and its economic value in Iran-2019

Elasticity(%)	economic value(Rials)	Price of water
21	17100	1447

Source: research findings

The results indicate that the weighted average economic value of crop water[8] in Iran in 2019 was 17,100 Rials. Since the use of underground water and wells in Iran is free and the water tariff is different according to the type of product, the geographical location of cultivation and the amount of harvest, it is not possible to use a specific tariff to evaluate the obtained value. Therefore, in order to compare this value and the real price of water, the criterion of the income from the sale of agricultural water is used. According to the statistics and information of Iran Water Resources Management, this year, the total income from the sale of water to the agricultural sector was 5,519,258 million Rials, which according to the volume of water consumption, the average rate of selling water to farmers in the country is 1,447 Rials per cubic meter.

The elasticity of crop production with respect to water is equal to 21%, which shows that a one percent change in water consumption increases crop production by 21% assuming other conditions are constant.

5. Concluding remarks and recommendations

With the increase in the price of water, due to the decrease in its consumption and the subsequent decrease in crop yield, the economic efficiency of farmers decreases, therefore, in order to respond to these changes, farmers change their cultivation pattern towards rain fed crops. On the other hand, farmers choose the hydroponics model that has high economic benefits compared to other crops.

Paying subsidies to the energy consumption of the agricultural sector makes the extraction of water from deep wells and the relocation of wells cost-effective, and to a large extent causes the discharge of underground water. Although some actions have been taken, such as increasing the price of energy and expanding the network for monitoring the misuse of underground water tables, the trend of agricultural water consumption has not changed (Madani, 2014). According to several studies, the demand for irrigation water at low water prices is less elastic, and if the price increase is insignificant, it is not possible to expect a decrease in consumption, and it is necessary to increase the price significantly.

The reform and elimination of subsidies in Iran in 2009 showed that policies that are properly adjusted can affect consumer behavior. The appropriate change of water price structures creates a balance between production costs and the necessity of economic efficiency along with justice and ability to pay. Water pricing is effective in increasing productivity and reducing water consumption when, in addition to knowing the cost of providing water as the lower limit of pricing, the economic value of water as the upper limit of pricing is also known.

Although the studies conducted in Iran confirm the effect of the policy of increasing the price of agricultural water on reducing water consumption and preventing the discharge of underground water, the comparative comparison of the conducted studies show that the policy of increasing the price of water in the agricultural sector is an insufficient policy and actions such as investing in improving water harvesting technologies, amending the laws related to the water sector, education and promotion, determining the optimal cultivation pattern and so on should be taken. In addition, in this pricing system, it is necessary to consider the sources of water used by farmers, the size of the farm, the cultivation pattern, and different periods of time. Pricing should be done

[8] The average selling price of one kilogram of product is considered as weight.

based on the volume of water consumed and not the cultivated area, and the benefits due to the price increase and the lost economic benefits should be compared.

The existence of many institutions related to water affair in Iran has caused that the actions related to coordination and innovation do not go well. The lack of a strong and stable legal framework, weak enforcement and insufficient coordination among relevant institutions hinders the efforts of integrated management of water resources.

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