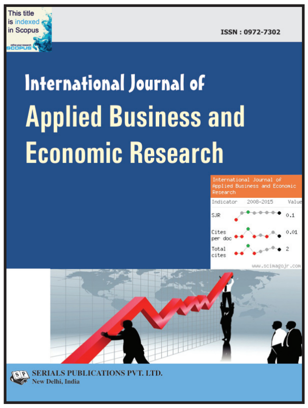

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Pricing Agricultural Water Case Study of Pishin Dam, Sistan and Baluchistan, Iran

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ABSTRACT

The present study was carried out to estimate pricing of agricultural water in farmlands of Sarbaz, Sistan Baluchistan, which are under irrigation network of Pishin dam. Technical coefficients belong to crop year of 2013-2015, obtained by randomized stratified sampling among 400 regional users. Results showed that the water is not used efficiently and the same Volume of available water can be used for farming in larger extent; moreover water price received from the farmers is much lower than water economic price. Regarding excess available water, it is recommended that water allocation management be performed in such a way that cultivated area is extended and water pricing is equal to economic value. Moreover, due to lack of planting pattern, responsible bodies should set appropriate economic farming patterns for improvement of regional agriculture according to climatic condition, agricultural policies, water capacity and relative advantage of crops.

Keywords: Pricing Water, water allocation, Pishin Dam.

1. INTRODUCTION

Attention of global centers to the concept of water economic value has been formed since early 1990's and there have been a number of investigations in this area conducted by ministry of power since 1370's and the topic has been accentuated in long term development strategies of the country [1]. Regarding location of Iran in North 30', low level of precipitation and inappropriate temporal and spatial distribution of rainfall, the country is considered as arid or semi-arid one, and requires better management and planning for retention and reduction of water loss in water resources plans. Iran will meet water shortage if no plan is set for water resources according to sustainable development. Since a large portion of available water is used in agriculture section, an important research topic concerns with investigation on water and irrigation in agriculture for management of water resources.

Allocation of 91% of water to agriculture and low level of its price compared to other sectors have result in a large loss of water in this field especially in regions with water shortage; and water price in this sector shows only a small portion of water economic value [2]Moreover, water is a common resource whose ownership determination is difficult and it doesn't meet the requirements for exchange. This situation has resulted in water shadow price or a value different from its market value, requiring pricing such inputs based on their economic value [3].

Sarbaz state and regions under Pishin dam are regarded as crop production hub in Sistan and Baluchistan province. These regions are arid and semi-arid and continuity of multi-year droughts and low level of precipitation during recent years has caused water shortage. A possible option to address water shortage in this region is adjustment of water use system, optimal allocation and pricing the water according to its economic value which may save the water and prevent loss of this critical resource.

2. INVESTIGATION EXTENT

The investigation was conducted in basin of Pishin dam located at cross point of Sarbaz and Pishin rivers. Sarbaz and Pishin basins are indeed basin of Bahoo river at southern part of Sistan and Baluchistan. This river system forms a wide basin whose water is depleted in to Guatr gulf. Dam reservoir is mainly used to irrigate farmlands of irrigation and drainage network of BahooKalat located 50km downstream the dam. Water released from the dam reservoir flows in the Bahoo river bed and also irrigates the margins along the river. The water is deviated to irrigation and drainage channels at Shirgoaz dike and thereafter is used for agricultural usages of Bahookalat plain. It should be mentioned that the dam itself is located in Sarbaz, while irrigated areas are located at Sarbaz and Chabahar.

3. LITERATURE REVIEW

Many investigations have been conducted on application of goal programming models in the field of water allocation and valuation. [4]used integer goal programming for selecting water multi-purpose design models and maintained that is design selection is influenced by political motivations, lack of information about future and risk of financing, application of goal programming can improve decision making process. Other investigations carried out on goal programming include those conducted by[5] on land and water allocation [6] on pricing agricultural water [7] on determining water economic value, [8] on allocation of river water and farmland, [9] on water and land efficiency and allocation of agricultural water, and.[10] There have been some studies conducted in Iran on this topic.[11] studied the lands under Doroodzan dam in Shiraz [12] studied the lands under Jiroft dam, [13] studied the farm of faculty of Agriculture of Mashhad [14] studied the lands under Taleghan dam in which, Typical linear programming technique was used for water pricing. To determine economic value of agricultural water in Saveh central plain applied second order flexible production functions estimation (direct method) for each main crop [15] determined optimal planting pattern of agricultural beneficiaries in Darab province using linear and goal programming and compared the results of the two methods. Using linear and ideal planning, [16] determined economic value and water allocation of Shirvan Barzu dam during various months based on optimal planting pattern [17] investigated the proportion between multi-criteria decision making simulation for evaluating irrigation water demand in Doroodzan basin, Fars province. Using ideal planning, [17] determined optimal plan for agronomic and livestock activities in combination with other activities in Fasa region, Fars province. Studies conducted by [18] in Eghlid state of Fars province,[19] in Sarpaniran of Farsin Mazandaran province and are some of other studies in this field. Most of these studies only emphasized on water economic value and, with exception for few cases, they neglected water allocation. [20]

4. METHODOLOGY

Data were collected by means of questionnaire and interviewing with farmers of Pishin dam basin which is categorized in to two strata as river margin and Bahookalat; simple randomized stratified sampling was used in each stratum. Sample size was 2240 people for statistical population, 130 people for Bahookalat, and 200 persons for river margin.

Goal Programming Model

Goal programming is a multiple criteria decision making model in the field of linear algebra which simultaneously deals with multiple objectives and is set based on minimizing deviation from objectives [7]. This model is a kind of Linear programming well able to make decision about an objective with some criteria or multiple purposes and ideals. Assumptions of this model include variable, independent and crisp variables, limited resources and decision making under certainty which resembles those of Linear programming [15]. In this method, a series of ideals is proposed by designer which includes objective function as well, thus all conditions and objective function are placed under limitations and objective function of the model includes minimizing the deviations from this ideal [8]. Goal programming was first proposed by [2]. They investigated minimization of sum of absolute values of deviations from personal intentions and proposed three approaches for goal programming that included weighted, prioritized and Chebyshev, [19]. Later, details of such approach were investigated and extended by Igeiri and Lee In general, goal programming deals with considering optimized mathematical models logic with intentions of decision makers in addressing personal purposes of different purposes, [20]. Structure of an goal programming model is presented below [15].

$$\min \text{D} = \sum_{j=1}^{k} h_j (d_j^- + d_j^+) \quad (1)$$

s. to:

$$g_i(x) \le b_i \quad i = 1, 2, ..., m$$

$$f_j(x) + d_j^- - d_j^+ = b_j \quad j = 1, 2, ..., n$$

$$x, d_i^-, d_i^+ \ge 0$$

$$d_j^- \cdot d_j^+ = 0$$

Where, D denotes for purpose function, $g_i(x)$ stands for systemic limitations, $f_j(x)$ shows ideal limitations, and d_i^+ and d_i^- stand for positive and negative deviation from ideal; respectively.

Explaining activities, limitations and availability of resources: The main activities in current condition of the region include cultivation of watermelon, corn, banana, citrus and mango; and model limitations include cultivated area, water availability, labor, cash investment cost, fertilizer, chemicals, self-sufficiency demands and crop rotation.

Variables used in the model and decision making include: (X_i) index for various crops cultivated in the region of study including watermelon (X_1), onion (X_2), tomato (X_3), corn (X_4), wheat (X_5), barley (X_6), alfalfa (X_7), banana (X_8), palm (X_9), jujube (X_{10}), mango (X_{11}), citrus (X_{12}), chikoo (X_{13}) and guava (X_{14}).

Limitations and resource availability: Limitations of goal programming include systemic and ideal constraints. Systemic limitations applied in both ideal and Linear programming are often concern with production resources and include:

Farmland limitation: Water land under irrigation of Pishin dam is considered as land limitation. Equation for irrigated cultivation area for each region is as follows:

$$0 \geq T_x - \sum_{i=1}^{14} X_i \tag{2}$$

Where, X_i stands for cultivated area for cultivated area for product i in each region and T_x indicates total irrigated lands of the region.

Water limitation: Water limitation is the major farming limitation of the region. Cultivation period and water demand of crops and water availability of the region vary during the various months, thus water limitation should be considered separately and the following equation is used to incorporate this limitation.

$$\forall k = 1, 2, \ldots, 12 \quad o \geq \sum_{i=1}^{14} Wx_{ik} X_i - TW_{ik}$$

Where, K is the index for irrigation period which is expressed monthly; Wx_{ik} is water demand for crop i per hectare in month k; and TW_{ik} stands for water allocated per hectare for crop i in the region in month k.

Crop rotation limitation: There is no defined crop rotation in the studied region; rotations used in this investigation are those widely used by the local farmers as follows:

For Bahookalat region (the first rotation): cereals, fallow, garden crops; For river margin (the second rotation): cereals, summer crops, garden crops and alfalfa.

Equations of rotation limitation are incorporated in to model as follows:

The first rotation:

$$\sum_{i=5}^{6} X_i + X_t - X_1 = 0 \tag{3}$$

Where, X_t stands for fall fallow.

The second rotation:

$$\sum_{i=5}^{6} X_i + \sum_{i=2}^{3} X_i + X_7 - X_1 - X_7 = 0 \tag{4}$$

Self-sufficiency limitation in different regions: Crops such as wheat, barley and alfalfa are cultivated to supply demands of local population, livestock and poultry, and also for providing seeds for cultivation in next year. Thus, the least cultivated area for above mentioned crops was calculated based on experts' comments. Equations of self-sufficiency limitation are incorporated in to the model as follow

$$TX_k \leq \sum_{i=4}^{6} X_i \tag{5}$$

TX_k denoted for least cultivated area devoted to the crops for self-sufficiency.

Cash investment limitation:

$$\sum_{i=1}^{14} I_i X_i \leq TI \tag{6}$$

Where, I_i denotes cash investment costs per hectare required for crop i in the region and T_i stands for total investment available in the region.

Ideal limitations: Ideal objectives are incorporated in to the model based on their priorities:

1. **Economic ideal:** Ideal for accessing to favorable profit level in farmlands under irrigation network

   $$G_1 : \sum_{i=1}^{14} C_i X_i + d_r^- - d_r^+ = b_1 \qquad r = 1$$

   is net profit of crop i per hectare, X_i cultivated area for crop i, b_1 is economic ideal level, d_r^+ stands for negative deviation from ideal r, and d_r^- stands for positive deviation from ideal r.

2. **Social ideal:** Ideal for accessing to favorable employment level in farmlands under irrigation network

   $$G_2 : \sum_{i=1}^{14} L_i X_i + d_r^- - d_r^+ = b_2 \qquad r = 2$$

   L_i stands for labor required for crop i per hectare during one cropping season, b_2 is the ideal level of access to employment, and d_r^+ and d_r^- are unfavorable positive and negative deviations from ideals.

3. **Environmental ideals:** Ideal for accessing to favorable level of chemicals used

   $$G_3 : \sum_{i=1}^{14} S_i X_i + d_r^- - d_r^+ = b_3 \qquad r = 3$$

   S_i shows the rate of chemicals required per hectare for crop i, b_3 level off accessing to minimum application of chemicals; and d_r^+ and d_r^- are unfavorable positive and negative deviations from ideals.

4. **Ideal for accessing to favorable level of fertilizer:**

   $$G_4 : \sum_{i=1}^{14} K_i X_i + d_r^- - d_r^+ = b_4 \qquad r = 4$$

   K_i shows the rate of fertilizer required per hectare for crop i, b_4 level off accessing to minimum application of fertilizer; and d_r^+ and d_r^- are unfavorable positive and negative deviations from ideals.

These limitations together with systemic ones are regarded as limitations of weighted goal programming model and are solved separately for each region.

5. CONCLUSION AND RECOMMENDATIONS

Results regarding cultivation pattern and profit for both regions are presented in Table 5.1. For margin region, these results suggest Linear programming model for cultivation of crops such as watermelon, tomato, wheat and chikoo for maximizing regional profit and weighted goal programming model for cultivation of watermelon, tomato and banana for maximizing the profit and consideration of environmental, social and economic ideals. In Linear programming model, crops such as onion, tomato and corn are omitted from the proposed optimal pattern and cultivation area of barley, banana, guava, mango, date palms and citrus remains fixed regarding self-sufficiency limitation and their perennial nature (rather than profit obtained by their culture). In goal programming model, crops including onion and corn are eliminated from the proposed pattern and cultivation area of wheat, barley, alfalfa, mango, guava, jujube, palms and citrus is due to their perennial nature and self-sufficiency limitation as observed for Linear programming model. Profit is 25515340$ in the current model which is increased to 28841880$ in Linear programming model, and to 3185667$ in goal programming model. Enhanced profit in both models suggests that current cultivation pattern is not efficient regarding optimal allocation of the resources.

Table 5.1
Results of profit and cultivation pattern (hectare)

Region	*Variable*	*Goal programming*	*Linear programming*	*Present status*
River margin region	X_1	329.7	1078.5	800
	X_2	0	0	300
	X_3	9.52	264	40
	X_4	509.27	112	1000
	X_5	50	497	50
	X_6	20	20	20
	X_7	100	100	100
	X_8	1148.5	1000	1000
	X_9	300	300	300
	X_{10}	280	280	280
	X_{11}	200	200	200
	X_{12}	60	60	60
	X_{13}	163	263.5	163
	X_{14}	220	220	220
	Benefit $	3185667	28841880	25515340
River margin region	X_1	254.9	1826.7	3200
	X_4	0	0	300
	X_8	1040.3	1880	450
	X_{11}	100	100	100
	X_{12}	20	20	20
	Benefit $	4115878	34766100	32927000

Reference: author's findings

In Bahookalat region, Typical Linear programming model suggests watermelon and banana for maximizing regional profit and goal programming model suggests the same crops for maximizing the profit and considering environmental, social and economic ideals. Profit level in the current model is 32927000 $, which is enhanced to 34766100$ in Linear programming model and to 4115878$ in weighted goal programming model. Enhanced profit in both models indicates that current cultivation pattern is not efficient regarding optimal allocation of resources and profit can be improved by reallocation and alteration of cultivation pattern.

In Table 5.2, exploitation level of various inputs in the two regions as a result of applying the two models is compared to current condition. by application of cultivation pattern of Linear programming model in river margin, consumption of garden land inputs, water in July, water in September, water in October, water in November, water in December, water in January , water in February, water in March ; and in Bahookalat region consumption of garden land inputs, water in April, water in June, water in July, water in August, water in September, water in October, water in December, water in January and water in February is enhanced which is due to use of garden land; consumption of other inputs such as farmland and water of other months is reduced. These changes are due to alteration of cultivation pattern of farm and garden crops. In implementing goal programming model in river margin region, consumption of water in July, August, September and October and garden land is increased due to changes caused by alteration of garden and farm crops. Consumption of other inputs such as garden land, capital and water of other months is decreased due to change of cultivation pattern. In Bahookalat region, consumption of inputs including garden land, water in June, water in July, water in August, water in September, water in October, water in November, water in December, water in January, water in February and water in March is increased; while consumption of inputs namely farm land, water in April and May and capital is reduced as a result of changes in cultivation pattern of farm and garden crops.

Table 2
Exploiting rate of various inputs

Input	*Unit*	*Bahookalat region*			*River margin region*		
		Goal programming	*Linear programming*	*Present status*	*Goal programming*	*Linear programming*	*Present status*
Garden Land	Hectare	1160.4	2000	570	2371.45	2323.465	2223
Farmer Land	Hectare	509.7	3653.5	6400	1960	1960	3020
Capital	$	1721586.005	4195.8	3475346.67	15911547.2	30834196.67	3083419.667
April Water	M^3	1691199	1658035	2152661	1266806	1424505	5892670
May Water	M^3	2161620	2161620	2954122	1761320	1761320	8461460
June Water	M^3	1870085	1488673	1733041	1655675.25	1534765	7409190
July Water	M^3	1351566	674451.6	220941	1101276.13	1101276	3679820
August Water	M^3	1321962.6	657608.4	208173	1014727.7	1010558	3388240
September Water	M^3	1367989	693652	211541.8	961695.8	962698.3	3198110
October Water	M^3	1356792	691428	205228	863152.8	899308	2868770
November Water	M^3	1147933	582569	169914	688614.5	773074.6	2420830
December Water	M^3	921867	701716.8	370772	452156.7	595942	1690380
January Water	M^3	1008296.7	509708.8	141999	484694.13	696940.9	1792900
February Water	M^3	900417	535975	303932	498765.8	713255	1977570
March	M^3	1285546.5	1014525	1082552	813314.2	919173	3493310

Reference: author's findings

Analyzing sensitivity of objective function coefficients and right side of limitations: Results concerning sensitivity analysis in river margin are presented in tables 3 and 4 and show that if profit of watermelon, tomato, wheat and chikoo is changed in to 521.315, 479.869, 241.7619 and 623.1463333 $; respectively in Typical Linear programming model; their cultivation are is reduced in the proposed cultivation pattern. If profit of each of these activities exceeds 125478.533, 686980.667 and 310592.5 $, their contribution in cultivation pattern is enhanced. Corn cultivation area is reduced from 1000 hectares to 112 hectares, but is its profit exceeds 622052 $, its cultivation area will be enhanced. Onion, alfalfa and barley and horticultural crops except for chikoo are not incorporated in the pattern due to lack of efficiency and their corresponding values is due to self-sufficiency limitation and their perennial nature. If profit of onion exceeds 385363.667, alfalfa 244007.5, barley 889302.333, banana 964221.667, palms 854252.333, jujube 899899.333, mango 948677, and guava 677187$, they are incorporated in to the cultivation pattern.

By implementing weighted goal programming model it was revealed that if revenue per hectare obtained by watermelon is reduced from 94.03946667, that of tomato from 291.6836667, that of corn from 1207.519567 $ and that of banana is reduced to unlimited level, their cultivation area is reduced and if their profit exceed 502.1433333, 29.59456667, 134.4057667and 1012.9929 $, their cultivation area will be enhanced. However, wheat, barley, alfalfa and horticultural crops but banana are not incorporated in to the pattern and these values is due to self-sufficiency limitation and their perennial nature; however if their revenue exceeds the values presented in Table 5.3, they are incorporated in cultivation pattern which will change correspondingly.

Table 5.3
Sensitivity analysis of objective function coefficients in river margin; unit: $

Activity	*Goal programming*		*Linear programming*		*profit per hectare*
	Allowable Decrease	*Allowable Increase*	*Allowable Decrease*	*Allowable Increase*	
x_1	−94.03946667	502.1433333	521.315	125478.533	70000
x_2	−1314.926067	∞	∞	385363.667	38333.33333
x_3	−291.6836667	29.59456667	479.869	686980.667	48333.33333
x_4	−1207.519567	134.4057667	∞	622052	36666.66667
x_5	−978.4393333	∞	241.7619	310592.5	24666.66667
x_6	−13.79333333	∞	∞	244007.5	15333.33333
x_7	−1624.449167	∞	∞	889302.333	41333.33333
x_8	∞	1012.9929	∞	964221.667	292173.913
x_9	−7663.057333	∞	∞	854252.333	15333.33333
x_{10}	−5266.083	∞	∞	899899.333	60000
x_{11}	−8954.216	∞	∞	948677	63000
x_{12}	−8867.11	∞	∞	674944.667	53333.33333
x_{13}	−5641.592	∞	623.1463333	∞	70000
x_{14}	−5841.592	∞	∞	677187	60000

Reference: author's findings

Regarding sensitivity analysis of limitations according to Table 5.4, it can be concluded that in Typical linear programming model, water of all months but May and July is not fully used and increase in their right side has no influence on cultivation pattern and shadow price which is equal to zero. However, by subtracting them from reducible value, a shadow price is created for them and correspondingly, cultivation pattern is changed. Capital and water of May and July have been fully consumed and in fact they met limitation and had shadow price. Shadow price for capital and water of May and July was 0.001396667, 0.346153333 and 0.79305 $; respectively indicating their economic values.

In weighted goal programming model, water of all months but that of May and July was not fully used and increase in their right side has no influence on cultivation pattern and shadow price which is equal to zero. However, by subtracting them from reducible value, a shadow price is created for them and correspondingly, cultivation pattern is changed. Water shadow price in May and July was 0.332466667$ and 0.402486667 $ respectively; indicating their economic values.

Table 5.4
Sensitivity analysis of right side of limitations in river margin

Activity	*Goal programming*			*Linear programming*		
	Allowable Decrease	*Allowable Increase*	*Main value*	*Allowable Decrease*	*Allowable Increase*	*Main value*
April Water	1266806	∞	1266806	1424505	∞	1424505
May Water	1589099.6	1769669.7	1761320	1701628	1916735	1761320
June Water	1655675.13	∞	1655675.25	1534765	∞	1534765
July Water	1054200.8	1104660.8	1101276.13	1054201	1170217	1101276
August Water	1014727.7	∞	1014727.7	1010558	∞	1010558
September Water	961695.8	∞	961695.8	962698.3	∞	962698.3
October Water	863152.8	∞	863152.8	899308	∞	899308
November Water	688614.5	∞	688614.5	773074.6	∞	773074.6
December Water	452156.7	∞	452156.7	595942	∞	595942
January Water	484694.13	∞	484694.13	696940.9	∞	696940.9
February Water	498765.8	∞	498765.8	713255	∞	713255
March Water	813314.2	∞	813314.2	919173	∞	919173
Capital	261605.1	∞	1591154.723	293451.5667	333553.6667	308341.9667

Reference: author's findings

Results of sensitivity analysis of Bahookalat are presented in Tables 5.5 and 5.6, indicating that in Typical linear programming model, if profits of water melon and banana is reduced from 334.8543333 and 566.3346667 $, their cultivation area in the proposed optimal cultivation pattern is reduced and if revenue of either of the crops exceeds 1891.610333 and 559.4763333 $, their cultivation area in the proposed optimal cultivation pattern is enhanced. However, corn, citrus and mango are not incorporated in the model due to inefficiency and this value for citrus and mango is due to limitation rising from their perennial nature. Corn, citrus and mango will be incorporated in optimal cultivation pattern if their corresponding revenues exceed 518.291, 942.999 and 1411.767333 $.

Table 5.5
Sensitivity analysis of objective function coefficients in Bahookalat; unit: $

Activity	*Goal programming*		*Linear programming*		*Profit per hectare*
	Allowable Decrease	*Allowable Increase*	*Allowable Decrease*	*Allowable Increase*	
x_1	−2103.291	1010.328333	334.8543333	1891.610333	840
x_4	−1146.552333	∞	∞	518.291	380
x_8	∞	559.4763333	566.3346667	∞	892.6666667
x_{11}	−826.6136667	∞	∞	1411.767333	766.6666667
x_{12}	−1126.606333	∞	∞	942.999	616.6666667

Reference: author's findings

In weighted goal programming model, if revenue per hectare of watermelon is reduced from 2103.291 and to unlimited level, their cultivation area in optimal pattern is decreased. If revenue of either of the crops exceeds 1010.328333 and 559.4763333 , their contribution in the proposed cultivation pattern is enhanced. Other crops follow the same trends of Typical linear programming model.

Table 5.6
Sensitivity analysis of right side of limitations in Bahookalat; unit: cube meter

Water Resources	*Unit*	*Goal programming*			*Linear programming*		
		Allowable Decrease	*Allowable Increase*	*Main value*	*Allowable Decrease*	*Allowable Increase*	*Main value*
April	M^3	1691199	∞	1691199	1658035	∞	1658035
May	M^3	1481215.5	2304320	2161620	768057.3	2304320	2161620
June	M^3	1870085	∞	1870085	1488673	∞	1488673
July	M^3	696300	∞	1351566	674451.6	∞	674451.6
August	M^3	1321962.6	∞	1321962.6	657608.4	∞	657608.4
September	M^3	1367989	∞	1367989	693652	∞	693652
October	M^3	1356792	∞	1356792	691428	∞	691428
November	M^3	1147933	∞	1147933	582569	∞	582569
December	M^3	921867	∞	921867	701716.8	∞	701716.8
January	M^3	1008296.7	∞	1008296.7	509708.8	∞	509708.8
February	M^3	900417	∞	900417	535975	∞	535975
March	M^3	1285546.5	∞	1285546.5	1014525	∞	1014525
Capital	$	1721586	∞	1721586	4195800	∞	4195800

Reference: author's findings

Regarding limitations sensitivity analysis, it can be concluded that in both the models, water in all months but May is not fully consumed and increase in their right side has no effect on cultivation pattern and shadow price which is equal to zero. However, by subtracting them from reducible value, a shadow price is created for them and correspondingly, cultivation pattern is changed. water of May was fully used in both models, met limitation and had shadow price.

Monthly optimal allocation of water is presented in Table 5.7. By implementing cultivation pattern of Linear programming in river margin, allocated water in April, May, June and March is reduced compared to current condition and is increased in the other months due to enhanced cultivation area. By implementing cultivation pattern of weighted ideal planning, allocated water in April, May, June, November, December, January , February and March is reduced compared to current condition and is increased in the other months due to alteration of cultivation pattern.

By implementing cultivation pattern of Linear programming in Bahookalat, allocated water in April, May, June and March is reduced compared to current condition and is increased in the other months due to enhanced cultivation area. On the other hand, by implementing cultivation pattern of weighted ideal planning, allocated water in April and May is reduced compared to current condition and is increased in the other months.

Table 5.7
Optimal monthly allocation of water resources, unit: cube meter

Region	*Water Resources*	*Change rate as to the present status*		*Goal programming*	*Linear programming*	*Present status*
		Goal programming	*Linear programming*			
River margin region	April	–15.3904	–15.3904	1266806	1424505	1683621
	May	–27.144423	–27.144423	1761320	1761320	2417550
	June	–27.499615	–27.499615	1655675.25	1534765	2116906
	July	4.4654672	4.4654672	1101276.13	1101276	1054201
	August	4.3883997	4.3883997	1014727.7	1010558	968075.6
	September	5.3577487	5.3577487	961695.8	962698.3	913742.3
	October	9.7182707	9.7182707	863152.8	899308	819652
	November	11.770327	11.770327	688614.5	773074.6	691663.7
	December	23.392378	23.392378	452156.7	595942	482965.2
	January	36.053598	36.053598	484694.13	696940.9	512254
	February	26.236025	26.236025	498765.8	713255	565017.6
	March	–7.9067097	–7.9067097	813314.2	919173	998089.2
Babookalat	April	–22.977422	–22.977422	1691199	1658035	2152661
	May	–26.82699	–26.82699	2161620	2161620	2954122
	June	–14.100532	–14.100532	1870085	1488673	1733041
	July	205.26294	205.26294	1351566	674451.6	220941.4
	August	215.89495	215.89495	1321962.6	657608.4	208173.7
	September	227.90428	227.90428	1367989	693652	211541.8
	October	236.90724	236.90724	1356792	691428	205228.2
	November	242.86109	242.86109	1147933	582569	169914
	December	89.258089	89.258089	921867	701716.8	370772
	January	258.95435	258.95435	1008296.7	509708.8	141998.6
	February	76.347012	76.347012	900417	535975	303932
	March	–6.2839476	–6.2839476	1285546.5	1014525	1082552

Reference: author's findings

Table 5.8 represents monthly economic value of water and prioritization of water consumption among Pishin dam regions in months encountering water shortage. River margin region meets water shortage during May and July by implementing cultivation pattern of Linear programming model and addition of each water unit increases farmers' revenue by 0.03461333 and 0.079305 $; suggesting monthly economic value of water during May and July months. Implementing cultivation pattern of weighted goal programming model causes water shortage in May and July. Addition of each water unit increases farmers' revenue by 0.03324667 and 0.04025333 $, suggesting monthly economic value of water during these months.

Table 5.8
Prioritization of water use among various regions; unit: square meter and $

Model	*Water Resources*	*Bahookalat region*			*River margin region*		
		Priority	*Economic value*	*Surplus*	*Priority*	*Economic value*	*Surplus*
Linear programming	Water April	2	0	2266725	1	0	1774295
	Water May	1	1.101	0	2	0.346133333	0
	Water June	1	0	680507	2	0	232715
	Water July	2	0	677114.4	1	0.79305	0
	Water August	2	0	1134382	1	0	449582
	Water September	2	0	1234668	1	0	608541.7
	Water October	2	0	1204782	1	0	645752
	Water November	2	0	1258291	1	0	726885.4
	Water December	2	0	2249113	1	0	1808438
	Water January	2	0	2302881	1	0	1594799.1
	Water February	2	0	565895	1	0	184565
	Water March	2	0	605745	1	0	401047
Goal programming	Water April	2	0	2234601	1	0	1931994
	Water May	1	0.629	0	2	0.332466667	0
	Water June	2	0	29909	1	0	111804.8
	Water July	1	0.894	0	2	0.402533333	0
	Water August	2	0	470028	1	0	445412.3
	Water September	1	0	560351	2	0	609544.2
	Water October	1	0	539418	2	0	681907.2
	Water November	1	0	692927	2	0	811345.5
	Water December	2	0	2028963	1	0	19522223
	Water January	1	0	1804294	2	0	1807046
	Water February	1	0	201453	2	0	399054.2
	Water March	1	0	334724	2	0	506905.8

Reference: author's findings

In Bahookalat region, implementation of cultivation pattern of Linear programming model causes water shortage in May and addition of each water unit in this month, increases farmers' profit by 0.1101 $. By implementing weighted goal programming model in this region, water shortage happens in May and July. Addition of each water unit during April and September enhances farmers' profit by 0.0629 and 0.0894 $; showing monthly economic value in months meeting water limitation.

The regions were prioritized based on monthly economic value of water and considering limitation or excess rate of the regions; however, in region with the same economic value, prioritization was performed based on variation range and extra water amount of that month, meaning that in the target month, higher priority is devoted to region with lower extra amount.

6. RECOMMENDATION

According to results obtained in this study, the following issues are recommended to beneficiaries and responsible bodies for management and amendment of water resource use.

1. Determining water price as economic value so that it finds its real value and become able to compensate minimum cost of plans maintenance.
2. Regarding excess water available in the region, water distribution in various months be regulated with an accurate management so that firstly, no shortage happens during summer, and secondly, wider area can be cultivated using the same Volume of available water.
3. Control of seasonal rivers and providing vegetation for feeding subterranean water resources
4. Offering suitable cultivation pattern according to crops with lower water demands by experts.
5. Informing local people on the consequences of water shortage and its accompanying risks by f experts and general media
6. Enhancing public participation in supplying, retention and consumption of water.
7. Following planting pattern of crops with lower water demand by farmers and regarding the water as a rare input.
8. Farmers should avoid overuse of chemicals and fertilizer for achieving higher yield and consider environmental aspects and health of human and livestock. April September

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