EFFECT OF OPTIMUM WATER ALLOCATION TO AGRICULTURAL ACTIVITIES FOR INCREASE IN WATER PRODUCTIVITY (CASE STUDY: NARMAB RIVER DOWNSTREAM – GOLESTAN PROVINCE)

EFFET D'ALLOCATION OPTIMUM D'EAU AUX ACTIVITES AGRICOLES POUR AUGMENTER LA PRODUCTIVITE DE L'EAU (ETUDE DE CAS : EN AVAL DU FLEUVE NARMAB – PROVICNE DE GOLESTAN)

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ABSTRACT

The population growth promotes increase of demand in foodstuffs, then causes resources limitation (especially water), which is used for the foodstuffs production. In this condition, increase in the productivity of factors are the best methods to enhance the agricultural production. The water limitation is the most important in arid and semi arid regions. The three factors consisting of efficiency, scale and improvement of technology have major effects on the productivity of inputs. Improvement in these factors increase productivity of inputs and consequently will increase the average quantity of production. In most countries, the building of dams is an important method for controlling water supply and overcoming the water limitations. The dams store water behind them and availability and use of this stored water in the irrigation-drainage networks increase the efficiency of irrigation. Allocation of controlled water supply with high efficiency of irrigation to optimum crop pattern will increase water productivity of agricultural activities. In the present study, optimum crop pattern (optimum allocation) will be assumed with mathematical programming models from point of view financial, economical and nutritional pattern indices. The NARMAB dam and related irrigation and drainage network as well as optimum allocation of water improves the water productivity in comparison with pre-dam condition.

Key words: *Mathematical programming, Optimum allocation, Water productivity.*

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RESUME

La croissance démographique augmente la demande des produits alimentaires et ensuite cause la disponibilité limitée des ressources (particulièrement l'eau), qui est utilisée pour la production alimentaires. Dans ce scénario, l'augmentation des facteurs de la productivité est la meilleure méthode d'améliorer la production agricole. La disponibilité limitée de l'eau est un facteur important dans les régions arides et semi arides. Les trois facteurs – efficience, échelle et amélioration de la technologie – affectent la productivité des contributions. L'amélioration de ces facteurs augmente la productivité des contributions et par conséquent augmente la quantité moyenne de production.

Dans la plupart des pays, la construction des barrages est une méthode importante de contrôler l'approvisionnement en eau et de surmonter la disponibilité limitée de l'eau. Les barrages mettent en réserve l'eau et l'utilisation de cette ressource dans les réseaux d'irrigation et de drainage augmente l'efficience d'irrigation. L'allocation d'approvisionnement en eau contrôlée accompagnée de haute efficience d'irrigation pour optimiser l'assolement augmentera la productivité de l'eau des activités agricoles. Dans cette étude, l'assolement optimum sera pris en compte avec les modèles de programmation mathématique de point de vue des indicateurs financiers, économiques et nutritifs. Le barrage NARMAB et les réseaux d'irrigation et de drainage ainsi que l'allocation optimum de l'eau augmente la productivité de l'eau par rapport à la condition qui existait avant la construction du barrage.

Mots clés : *Programmation mathématique, alloction optimum, productivité de l'eau.*

1. INTRODUCTION

Increase in the production and services and suitable distribution of income are the necessities for economic welfare of the society. Every country would select appropriate technology for production of various crops upon availability of resources. But production increase is adherent with some of the shortages in production inputs. In this condition the effective technology for production increase would be that, which would maximize the efficiency of use of the scarce input resources production.

Increasing productivity of production factors has been considered as one of the most important solutions for production of various crops and services which are the needs of the society. According to economic literature, the productivity is the mean of production from every input, and productivity increase means enhancement of the input use efficiency. Considering the climate of Iran, the amount of water input has been considered as one of the most restricted entities for agricultural production. Thus in this sector the solution which promotes water use efficiency, would increase the agricultural productivity. Constructing dams has been assumed as one of major strategies of the government to combat water deficit and ensuring the availability of this input in required amount and at the time of its need has been assumed as a main solutions.

The concept of productivity of water in agriculture sector is scale-related. Sharma, (2006) indicated that, the productivity from the point of view of farmer is the mean crop production per unit consumption of water; and in the regional and national perspective, it is economic value of the produce for every cubic meter of water consumed to produce it. The ICID, 22 has introduced the concept of the amount of production of calories (from point of view of nutritionists) and the amount of produced agricultural production (from the point of view of farmers) upon every cubic meter of consumed water as indicators of productivity (Feddes, 2007).

In the present study, the effect of constructing dam upon productivity increase in agriculture has been discussed briefly. The main aim of the study is to evaluate the volume and duration of supplying water to agriculture upon constructing the dam and its effect on productivity indexes of water. The productivity of water would be evaluated on the basis of economic and nutrition indicators.

2. MATERIAL AND METHODS

The present study is on how to achieve optimum allocation of water to agricultural activity and measuring financial productivity indexes and nutrition indexes under with-dam and without-dam conditions. The dam referred here is on NARMAB River in Golestan province, Iran. The optimum allocation of water has been achieved using a mathematical model.

To determine the index of financial productivity of consumed water, the net income derived from water allocation to various activities is divided upon consumed quantity of water. To calculate the nutritional productivity index, the amount of individual daily nutrition derived from allocation of water has been divided by total consumed water. To determine the amount of individual nutrition per day derived from agricultural products, the desired nutritional pattern was achieved on the basis of related references of the studies by the nutritional institute on food-stuff. On the basis of studies of nutritional institute, the required energy quantity for each individual un desired pattern of nutrition is somewhat 3262 kilo calories, which the amount of lipids in such quantity is 22 percent, the proteins 10.7 percent and carbohydrates 67.3 percent (Anonymous, 2006).

3. DATA AND MATHEMATICAL PROGRAMMING MODEL

A linear programming model was used in present study. The goal in this model is to maximize financial benefits and/or maximize foodstuff production. The limiting factors of the model are the quantity of water available in NARMAB RIVER, arrived at on the basis of 32 water years statistics (Anonymous, 2009) and the limitation arising from the volume of water stored in the reservoir behind the dam.

The activities of the model are the agricultural products grown in the area. The model has been provided in such a way that the quantum of water transferred from the reservoir is a function of the volume of water stored there from time to time.

The technical coefficient of water consumption by different crop and the amount of nutrient content in different crops in the overall cropping pattern and amount of person-day nutrition from one hectare are shown in Tables 1 and 2. Also, the technical coefficient of goal functions are shown in Table 3.

Table 1. The technical coefficient of water consumption by different crop *

Activities	Month												sum
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	
Wheat	0	0	0	0	0	797	2670	4540	2160	0	0	0	10167
Rice	0	0	0	0	0	0	0	188	6440	4773	4628	3095	19125
Corn	3023	443	0	0	0	0	0	0	0	1873	4033	4787	14160
Clover	1047	160	0	0	283	700	2600	4033	2873	0	0	0	11697
Soybean	2947	570	0	0	0	0	0	0	0	2697	4787	4607	15607
Cucumber	0	0	0	0	0	0	177	2213	5327	3233	0	0	10950
Watermelon	0	0	0	0	0	0	137	1190	5030	6503	4680	0	17540
Tomato	0	0	0	0	0	0	163	1607	6167	7077	4250	0	19263
Barley	0	0	0	0	0	717	2403	4086	1944	0	0	0	9150
Rapeseed	0	0	0	0	0	876	2937	4994	2376	0	0	0	11183

* Farshi et al., 1997. Values in the Table are in Cubic meter (m^3)

Table 2. The amount of nutrient content in different crops of cropping pattern and amount of person-day nutrition from one hectare

Titles		Wheat	Rice	Corn	Soybean	Cucumber	Watermelon	Tomato	Barley	Rapeseed
Nutrient contents (%)	Protein	11.7	7.7	10.05	40	0.9	0.9	5	10.6	0
	Lipid	2	0.4	4.76	21	0.1	0.1	0.1	2.1	40
	Carbo-hydrates	69.3	75.2	38.17	34	2.5	2.5	4	71.8	0
Yield (Kg ha-1)*		4832	4415	9000	3000	30000	55000	25000	4000	4832
Content per hectare (kg)	Protein	565	340	905	1200	270	495	1250	424	0
	Lipid	97	18	428	630	30	55	25	84	1933
	Carbo-hydrates	3349	3320	3435	1020	750	1375	1000	2872	0

- Anonymous. 2003.
- Noormohammadi et al., 2006.

Table 3. The technical coefficient of goal functions

Coefficient of goal functions	Wheat	Rice	Corn	Soybean	Cucumber	Watermelon	Tomato	Barley	Rapeseed
Net Value (Million Rials per hectar)	2.750	7.7	2	2.2	4.1	4	4.3	1.69	2.7
Energy (Kilo cabries)	2647	2589	2792	998	611	1121	922	2263	215

The linear programming model (Hazell, 1986) has been used in the study and it may be expressed as:

Max

$$AV = \sum_{t=1}^{32}\sum_{i=1}^{9} x_{it} \times av_i$$

or

$$PN = \sum_{t=1}^{32}\sum_{i=1}^{9} x_{it} \times pn_i$$

Subject to:

$$\sum_{i=1}^{9} w_{im} X_i + wt_{m+1} - wt_{m-1,} \leq W_{mt}$$

$$\sum_{i=1}^{9} X_{it} \leq 24000$$

$$V_t \leq 85000000$$

$$X_{it} \geq 0$$

4. RESULTS AND DISCUSSION

The result given in Table 3 indicates that, regulating the volume and the time of irrigation in ease of with-dam situation, will increase both the goals set in the model but in the goal of maximizing the financial interest is associated with lesser quantity of daily nutrition that the desired values.

Average area suitable for cultivation in case of maximizing the financial interest and with-dam situation will increase up to 3363 ha and in case of the maximizing the quantity of daily nutrition, the required area increases to 10162 ha. If farmers' financial interest is to be satisfied, the produced product can cover the daily nutrition need of 64688 members.

In the Table 4, the result of the productivity of the water factor is presented on the basis of the optimization model. In case of dam construction verses no dam construction, the productivity of finance and nutrition will increase in both the goals when the dam is constructed.

In maximizing the financial interest, Rls 312/m3 of water and in maximizing daily nutrition, Rls 206/m3 of water could be realized. If every cubic meter of water is used. it will produce food for 160 persons per day, whereas, if daily nutrition is maximized, the daily food can be provided for 231 persons.

Table 4: Productivity of water in different goals

Goals	Conditions	Water consump-tion (MCM)*					Total available water (MCM)*	Water productivity				
		Wheat	Rice	Corn	Soybean	Sum		Net value (Rls/m³)	Carbo-hydrates (Kg/m³)	Lipid (Kg/m³)	Protein (Kg/m³)	Energy (Person per day per m³)
Maximize of net value (financial)	Without dam construction	2929	573	899	926	5327	8,954	140	150	10	34	120
	With dam construction	2859	5088	17	0	7964		312	204	4	28	160
Maximize energy	Without dam construction	2936	362	1886	0	5184		131	166	10	32	132
	With dam construction	4825	4	4125	0	8954		206	289	19	59	231

* MCM: Million Cubic Meter

5. CONCLUSIONS

The national optimum water use is achieved when every unit of water used gived maximum food for most people. In this conditions, the financial prices should be determined corresponding to economical prices, though, price deviation could not produce any deviation in allocation any scarce resources, specially water supplied to agriculture sector. The present study shows that if the system of pricing of agricultural product changes according to their feeding values, it will result in the best use of water and land resources. For such a condition and under with-dam scenario, irrigated land increase up to 39.7%, and food increase up to 71 person/per-day for every cubic meter of available water.

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