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ECONOMIC ANALYSIS USING LINEAR PROGRAMMING TO DETERMINE THE COMPOSITIONS CROPPING OPTIMUM TO MINIMIZATION OF WATER NEEDS IN IRAQ'S AGRICULTURAL SECTOR

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Abstract

In this study a linear programming model to determine the proposed models of crop structures, which minimize water requirements as an alternative for the compositions of crops, applied in Iraq's agricultural sector during 2012. These models are placed in order to minimizing the water used to irrigate crops order to reach the optimal use of water in Iraq's agricultural sector. The maximum and minimum from the tracts of agricultural activities, which enter in the model during the study period to reach crop composition that, minimize water requirements and at the same time increasing the rest of other economic indicators and compare, the results of these models with the actual crop composition of 2012 in Iraq. It was been reached in the case of crop compositions that reduce water needs to two models. Where to put the first model on based on the minimization of the water needs of agricultural crops with a commitment to producing the actual crop composition for 2012, While the second model focused on the minimization of water needs with a commitment to using the entire of cropped area, Which was used in the actual installation of the 2012. Models proposed an alternative to installation of crop applied in Iraq's agricultural sector during 2012 to the increase in both net return per unit of water and the net return to dunum. Which in turn leads to increase the overall yield. And reduce the required water needs of the crop in the proposed structures, which can take advantage of the surplus in the planting of additional spaces. It found that for these proposed models the effects of on each of the self-sufficiency of the crops and the value of imports and the GDP*and per capita GDP compared to 2012.

Key words : Economic Analysis, Linear Programming, Crop Composition, Water Needs.

Introduction

Compositions crop is considered one of the most important of data sources to agriculture at the present time, because of its role in increasing agricultural production on the one hand, and on the other hand, they are important in terms of actions aimed at rationalizing the use of water in the agricultural sector. Crop installation is defined as spaces that are planted with agricultural crops during time period often be year So that this crop installation achieves maximum productive efficiency, and it helps in the planting new crop varieties that the community wishes to benefit from in aspects of the food or manufacturing or export (Mashhoor, 2010). The crop installation depends on the general grounds group together constitute the basic props which it builds on it The structure of crop composition and its features and that meets the different needs of the state, It takes into account all delimiters and factors affecting on it (Saqr, 2007), These foundations are as follows:

- Increase agricultural production including corresponds with increasing population growth.
- providing the maximum amount of food crops such as grain¡ pulses and oil crops¡ because the production this crop does not meet the basic needs of the population¡ so it should include crop installation the expansion of the space those crops to increase the rates the self-sufficiency from them.
- Reduce the imports of agricultural crops, and increase agricultural exports of the strategic crops.
- Provide a minimum level of production of some crops

necessary for the industrial sector as a raw material.

- Provide for the needs of animal production from the fodder crops to sustain the livestock.
- Taking into account the economic and marketing dimension and the Price Relations for the Agricultural products.
- Selection of the quality of crops to be cultivated In each region according to the type of soil¡ and the extent of the availability of irrigation water¡ in addition to natural weather conditions and environmental conditions that affect the success of the cultivation of different crops.

Studies have shown deviation present crop structure in Iraq's agricultural sector for economic and efficient use of resources and agricultural productivity (The Ministry of Finance-Economic Department, 2011).

Clearly, the variation in the net return per unit of land and water and a decrease of both productivity, Moreover economic efficiency of some crops, In addition to the cultivation of crops with high consumption of water in amidst the challenges facing the Iraqi agricultural sector it related to the lack of water resources and the need to rationalize their use. These things requiring the need to reconsider composition current crop. So that access to the crop composition achieves the rationalization the use of irrigation water, and it possibility of achieving horizontal expansion of agriculture, as one of the factors economic and social development at the national level in the light of that is available to Iraq of a massive agricultural potential (Al-Badri, 2010).

Research aims propose the crop compositions models, which lower the water needs as an alternative to the installation of crop applied in Iraq's agricultural sector during 2012, and to identify the economic indicators for these models and compare it with economic indicators for installation applied in Iraq's agricultural sector for the year 2012, In addition To identify the effects of these models on each of the self-sufficiency of the crop and the value of imports and the GDP and per capita GDP in Iraq in 2012, and to reach a set of recommendations stemming from the results obtained, which can be useful for economic policy makers in this area.

Imposes the search that not to follow compositions cropping obligated to has led to difficulty in adjust and tighten the control on the use of water resources, which become constitutes danger to it, that lack of commitment by the farmers in irrigation in time and the quantities specified it led to a lack the availability of water at all times, which led to the asylum many farmers to individual solutions through overtaking on irrigation quotas schedules set by concerned authorities, these abuses have led to the creating a situation of inequality of opportunities between farmers, in addition to that this Individual orientation leads to the waste of more water, so the efficiency in water use requires the need to change the current cropping pattern and the selection of compositions cropping consume less water.

Materials and Methods

For identifying the optimum planning for the installation of crop, the study relied on the use of linear programming methods through the application program WINQSB, where considered from mathematical methods used in economic planning, and one of the most commonly used quantitative methods In solving the problem optimization relating to at optimal distribution of available resources, and limited between alternative uses view to achieving the maximum profit possible, at the lowest costs possible, and within the constraints, and the possibilities available.

The Data Sources

Adopted Search on sources of secondary data published and unpublished from Iraqi governmental bodies and of the Central Agency for Statistics, and the use of previous references that are relevant to the subject of study.

Results and Discussion

First: Characterization of model linear programming used in the analysis

This part of the study aims to characterization of linear programming models used and by which they can the trade- off between numbers of substitute's installation of crop the proposed according, to the desired goal of all of them. This descriptions Includes display for the assumptions model objective function and constraints that they been imposed by the when applying these models.

The objective function

In the case of the minimization of water needs, the objective function represented as follows:

$$\text{Min W} = \sum_{i=1}^{n} N_i X_i$$

Such that:

$$\sum_{i=1}^{m} a_i X_i \geq X_i \qquad \text{(for all } i\text{, } i = 1 \text{ to m)}$$

$$X_i \geq 0 \qquad \text{(for all } i\text{, } i = 1 \text{ to m)}$$

Where:

W = the objective function model.

N_i = crop water requirements.

X_i = activity area or crop.

a_i = technical transactions for the activity or crop (the number of irrigations water(.

b_i = available constraint size (the amount of water available to grow crops included in the plan).

$X_i \geq 0$ = not the negative.

Second: agricultural activities in the linear programming model

The number of activities included in the linear programming method is 20 cropping activities, and its total areas are estimated to be about 8.395 million dunums as indicated in table 1, representing about 93.3% of the total agricultural area of about 9.00 million dunums in 2012 (The Ministry of Planning, the Central Bureau of Statistics, 2013).

Third: - Linear programming constraints

1. The physical limitations:

(a): Under the agricultural area available

Includes constraint crop area for 2012, this constraint has been put based on not exceed spaces the proposed models for available spaces during 2012.

(b): Restrictions water resources available

Estimated total size for water resources available for model linear programming early 26.039 cubic meters, were mathematical drafting for constraint on the basis put 12 monthly constraint for irrigation water provided that does not exceeds multiplying water requirements of agricultural crops in the area. Which will determine the internally in the model for water available per month. In addition, drafted constraint the water resources as follows:

$E_i X_i$ = W

Where:

E_i = the amount of the monthly water estimated for crop.

X_i = the area planted with the crop.

W = the amount of irrigation water available per month.

2. Regulatory restrictions

Includes a set of restrictions and as follows:

- Constraint especially to achieve saucepan suitable of food security they requires that not less area planted with wheat about the average area which planted wheat crop during the period (2000-2012), with the aim of bridging the gap between production and consumption from this crop.

- Special constraints to rationalizing the use of irrigation water:

This means no commitment to reducing top and the minimum of area cultivated of Rice crop during the period (2000-2012).

3. The marketing constraints

This constraint includes the non-compliance to reducing top and minimum areas under crops; this is because Iraq Imports large quantities of crops per year to fill the local need of them, so was converted imported quantities of crops that have higher yielding to areas for the cultivation these crops.

Fourth: Linear programming model for crop installation

(Table 1) shows the crop installation actual for most important crops planted in Iraq in 2012. Where it indicates that, the net return per unit of water about 91.45 dinars per cubic meter. Net return on dunam is amounted about 283 950 dinars, and amounted to crop water requirements of about 26.04 billion cubic meters of water, while reached the area from crops planted this space about 8395000 dunam.

Models have been developed to minimize the water requirements, in order to reduce the water used to irrigate crops in order to reach the optimal use of water in Iraq's agricultural sector, was used upper limit and minimum from areas agricultural activities inward in the model during the study period to reach the crop structure that reduce water needs and at the same time it increases the rest of the other economic indicators and compare the results of these models with the crop structure actual 2012 in Iraq.

It has been reached in the case of crop compositions that reduce water needs for two models, which can be explained as follows:

The first model: The minimization of water requirements with a commitment to the production of all crops actual structure

This model has developed based on the minimization of the water needs of agricultural crops with the obligation produce the actual crop installation for 2012. and indicate the data of table 2 that the results the first model to minimize water needs led to the fulfillment of the actual production and increase of all economic indicators, although that model led to a decline in crop area, and can clarification the results of this model as follows:

- Net return per unit of water amounted about 160.79

Table 1: Present Crop Structure from the Most Important Crops Cultivated in Iraq in 2012.

Totals of the crops	Crops	Area in dunam	Net overall return (million iq. Dir)	Water needs (billion m^3)
Grains Groups	Wheat	4706645	457849.25	11.993
	Barley	1315310	71008.06	3.351
	Rice	318767	111557.49	2.744
	Maize	603598	100189.78	2.145
Lequmes Groups	broad beans	18982	5537.73	0.044
	Mung Beans	59581	7091.39	0.162
Industry and oil crops	Cotton	65461	31521.61	0.356
	Sun flower	8701	1091.76	0.034
	Sesame	89029	74453.14	0.400
	Ground-nut	48183	20309.65	0.139
Fooder Groups	Alfalfa	229876	364273.46	1.998
	Lucerne	7794	134461.62	0.271
Buber and bulbs	Potato spring	77692	40239.95	0.173
	Potatoes autumn	98874	18224.46	0.181
	Onions	69861	33023.99	0.279
	Garlic	6769	7514.57	0.011
Vegetables Group	Tomatoes	245794	411602.65	0.747
	Cucumbers	224130	194816.15	0.668
	Egg-plant	89850	225521.7	0.238
	Green pepper	39828	73434.87	0.106

Total Grope Area : 8394875 dunum Net Total Return : 2383723.28 million iq. Dir

Water Needs : 26.039 billion m^3 Net return for dunum : 283949.82 iq. Dir

Net return per unit of water : 91.45 iq. Dir / m^3

Reference:

- Al-Thamir, S.N.K. (2014). Economics of water resources in Iraq and the efficiency of their use in Iraq's agriculture sector, PhD Thesis, Faculty of Agriculture, Alexandria University**.**
- The Ministry of Planning, the Central Bureau of Statistics (2013). Crops and Vegetables Assemblage Report, Baghdad, Iraq.

dinars per cubic meter for the installation of the proposed crop, an increase of 69.34 dinars and increased by 75.82% bout his counterpart for the installation of the applicable crop in 2012 in Iraq.

- Crop area was Decreased for the proposed crop installation where amounted to about 6.357 million dunums increased by 24.28% from the crop area for 2012, amounting to about 8.395 million dunams.

- Decreased the required amount of water for the irrigation of crops in the proposed crop structure in this model to about 15.559 billion cubic meters, a decrease of about 10.48 billion cubic meters, rate 40.25% of The amount of water required for the crop installation in 2012 and estimated at 26.039 billion cubic meters.

- An increase in net return of dunum at about 395.55 thousand dinars, an increase of 111.60 thousand dinars, and an increase of 39.30% from the net return of dunum in crop Installation in 2012 amounting to about of 283.95 thousand dinars.

It is evident from the results of the first model to decrease water needs that agricultural crops in the proposed composition has retained the same agricultural area that was in the 2012 plan, except decrease in the area of each of the wheat crop by 36.3% compared to an area of wheat in 2012, terms that model linear programming to minimize water needs turned use to full wheat area modern to irrigation cultivated and exit wheat area cultivated by irrigation traditional terms covered this area wheat production in 2012, So this model shows the impact of the use of modern irrigation methods to provide the land and the irrigation water in addition to the increase in production, it is proposed to reduce the maize crop area increased by 37.7%, and reduce the eggplant crop area by 2.1% from its counterpart In crop structure applied in 2012.

As it is proposed the first model to minimize water needs to increase the area of each of the cotton crop and

Table 2 : Installation crop the proposed to minimize water needs with commitment to actual production for the year 2012.

Totals of the crops	Crops	Area in dunam	Ration of change the crop area %	Net overall return (million iq. Dir)	Water needs (billion m^3)
Grains Groups	Wheat	0	-36.3	0.00	0
	Wheat (Sprinkler irrigation)	3000000		572100.00	3.948
	Barley	1315310	0.00	572100.00	3.351
	Rice	318767	0.00	111557.48	2.744
	Maize	85462	-37.7	14185.63	0.304
	Maize (Sprinkler irrigation)	290432		98834.01	0.648
Lequmes Groups	Broad beans	18982	0.00	5537.73	0.044
	Mung Beans	59581	0.00	7091.39	0.044
Industry and oil crops	Cotton	21134	78.6	10176.71	0.115
	Cotton (Drip irrigation)	30345		19096.11	0.090
	Sun flower	8701	0.00	1091.76	0.034
	Sesame	89029	0.00	74453.14	0.400
	Ground-nut	48183	0.00	20309.670	0.139
Fooder Groups	Alfalfa	55360	61.8	87726.34	0.481
	(Sprinkler irrigation)	86734		271087.12	0.434
	Lucerne	77944	0.00	134461.62	0.271
Buber and bulbs	Potato spring	77692	0.00	40239.95	0.173
	Potatoes autumn	98874	0.00	18224.46	0.181
	Onions	69861	0.00	33023.99	0.279
	Garlic	6769	0.00	7514.57	0.011
Vegetables Group	Tomatoes	245794	0.00	411602.65	0
	Cucumbers	224130	0.00	194816.15	3.948
	Egg-plant	83485.12	-2.1	209545.98	3.351
	Egg-plant (Sprinkler irrigation)	4475		14618.48	2.744
	Green pepper	39828	0.00	73434.87	0.304

Total Grope Area : 6356872.12 dunum — Net Total Return: 2501737.85 million iq. Dir

Water Needs : 15.559 billion m^3 — Net return for dunum : 393548.56 Iq. Dir

Net return per unit of water: 160.79 Iq. Dir / m^3

Source: The results of the analysis using a program Win QSB .

alfalfa to 78.6%, 61.8% in the same order, compared with its counterpart in crop installation the applicable in 2012.

The second model : minimize water needs with commitment using a full crop area used for the actual installation for 2012

Put this model based on minimization of the water needs of agricultural crops, with a commitment to the use of all each crop area for 2012. Which amounts to about 8.395 million dunam, indicate table 3 that the results of the second linear programming model to minimize water needs, led to reduce the required water needs of agricultural crops for those water needs for crops in the crop structure for 2012 despite the use of the same crop area in two models. In addition, the proposed structure of the crop led to the increase of all economic indicators for those economic indicators of the structure of the crop actual 2012. In addition, can spell the results of this model are as follows:

- totaled net return per unit of water about 135.72 dinars per cubic meter for the installation of the proposed crop an increase of 44.27 dinars, and increased by 48.41% for crop structure for 2012 in Iraq. Although that the crop area for the installation of the proposed crop equal with crop area for 2012 which amounts to about 8.395 million dunam.
- Decreased the amount of water required for the irrigation of crops in the cropping installation proposed in this model to about 20.343 billion cubic meters. A decrease of approximately 5.7 billion cubic meters, by a rate 21.88% of the amount of water needed for the installation of the crop in 2012, and which it is estimated at about 26.039 billion cubic meters.
- Increase the net of return of dunam¡ where reached

Table 3: Installation crop the proposed to minimize water needs with a commitment to the use of agricultural land in 2012.

Totals of the crops	Crops	Area in dunam	Ration of change the crop area %	Net overall return (million iq. Dir)	Water needs (billion m^3)
Cereal crops	Wheat	1706645	7.10	166017.65	4.349
	Wheat (Sprinkler irrigation)	3331358		635289.97	4.384
	Barley	1315310	0.00	71008.06	3.351
	Rice	318767	0.00	111557.48	2.744
	Maize	85462	-37.70	14185.63	0.304
	Maize (Sprinkler irrigation)	290432		98834.01	0.648
Legume Crops	Broad beans	18982	0.00	5537.73	0.044
	Mung Beans	59581	0.00	7091.39	0.162
Industrial and oily crops	Cotton	21134	-21.40	10176.71	0.115
	Cotton (Drip irrigation)	30345		19096.11	0.090
	Sun flower	8701	0.00	1,091.76	0.034
	Sesame	89029	0.00	74453.14	0.400
	Ground-nut	48183	0.00	20309.67	0.139
Forage Crops	Alfalfa	55360	-0.40	87726.34	0.481
	Alfalfa (Sprinkler irrigation)	86734		271087.12	0.434
	Clover (Berseem)	77944	0.00	134461.62	0.271
Crops tubers and Onions	Potato spring	77692	0.00	40239.95	0.173
	Potatoes autumn	98874	0.00	18224.46	0.181
	Onions	69861	0.00	33023.99	0.279
	Garlic	6769	0.00	7514.57	0.011
Vegetable Crops	Tomatoes	245794	0.00	411602.65	0.747
	Cucumbers	224130	0.00	194816.15	0.668
	Egg-plant	83485	-2.10	209545.68	0.222
	Egg-plant (Sprinkler irrigation)	4475		14618.48	0.009
	Green pepper	39828	0.00	73434.87	0.106

Total Grope Area : 8394875 dunum	Net Total Return: 2761067.95 million iq. Dir
Water Needs : 20.343 billion m^3	Net return for dunum : 328899.23 Iq. Dir
Net return per unit of water: 135.72 Iq. Dir / m^3
Source: The results of the analysis using a program Win QSB .

about 328.90 thousand dinars¡ with an increase of 44.95 thousand dinars¡ and a rate an increase of 15.83% more than the net return of dunum in crop composition in 2012, which reached about 283.95 thousand dinars.

Since the model is designed to minimize, water needs with a commitment using a full crop area in 2012. So the results of the second model from linear programming to minimize, water needs, as described in table 3 which indicate that agricultural crops in the proposed installation of the crop, has maintained on the same agricultural area in the 2012 plan.

Except for increase the area of wheat crop (traditional + modern) increased by 7.01% on an area of the wheat crop in 2012, and so for being a strategically important crop, so the increase in area of that crop is obligatory for the achievement of self-sufficiency of it and for Reduce imports.

The data in table 3 indicate that the second model for the minimization of water needs proposes reducing the area of each of maize, cotton, alfalfa and eggplant at a rate of 37.70%, 21.40, 0.40%, 2.10%, respectively, and so to the fact that these crops used modern irrigation methods in planting.

Assess the effects of the proposed linear programming models to minimize water needs in Iraq's agricultural sector

The economic indicators was differed between the models proposed as an alternative to the installation of crop applied in the Iraq's agricultural sector during 2012. In addition to the increase in both net return per unit of water and the net return dunum. Which in turn leads to increase, the overall yield and reduce the required water needs in the proposed crop installation which can be used to implant additional spaces,

Found that for these proposed models the effects of on each of the self-sufficiency of the crop and the value of imports and the GDP and the average per capita GDP compared to 2012.

The following is a review of the effects of these models:

1. The effects on the sufficiency ratios of agricultural crops

Results show for the proposed crop composition to reduce water needs with a commitment to produce all the crops in the actual crop structure for 2012, that the crops has retained the same proportions of production and in the same proportions of the sufficiency, which it was in the actual crop structure for the year 2012.

Except for the wheat crop, Where it sufficiency ratio increased in this model to 21.51% compared with sufficiency ratio of the crop in 2012 and amounting to 18.87%, an increase of 2.64%, However, in this model was reduce acreage and reduce water needs and increase the proportions of the rest of the target economic indicators from the model.

Therefore, we can take advantage of the spaces and surplus water to cultivate additional quantities of agricultural crops and increase sufficiency ratios from it, and it explained the results of cropping structure proposed for the second model for minimizing water requirements with the use of the entire space used in the actual structure for 2012.

So that the model worked on commitment cultivating the same cultivated area in the actual structure of the 2012 with a reduction of its water needs by showing the influence of modern methods of irrigation for some crops planted and increase the rest of the other indicators.

For this has retained the crops in this model on the same proportions of the sufficiency which it was in the actual crop structure, except for the wheat crop. Where it sufficiency ratio increased in this model to 30.73% compared with sufficiency ratio of the crop in 2012 amounting to 18.87 % an increase of 11.86 %.

Because the amount of space used in modern irrigation, and did not show the increase in the sufficiency ratio for the rest of crops that go into Replanted Modern irrigation methods, because the small size of the area used modern irrigation, and The monopoly of the wheat crop in increase in area and thus increase the sufficiency ratios.

2. The impact on GDP

Statistics indicate of Iraq's Central Bureau of Statistics that the GDP of Iraq in 2012 amounted to about 251 667 billion Iraqi dinars.

The contribution of the agricultural sector in which for the same year amounted to about 10194 billion Iraqi dinars, and a rate of approximately 4.05% of GDP, And the average per capita GDP reached about 74326 thousand Iraqi dinars, according to market prices in 2012 (The Ministry of Planning-Central Bureau of Statistics (2013).

The following clarification for the impact of models the proposed composition of the crop on the value of gross domestic product and per capita:

- led the first model proposed for minimizing water requirements to increase the contribution of agricultural output in the GDP increased by 1.16%, This led to an increase in GDP to about 251785 billion Iraqi dinar by 0.04%, While the average per capita GDP according to the first sample reached about 7361 thousand Iraqi dinars.
- led the first model proposed for minimizing water requirements to increase the contribution of agricultural output in the GDP increased by 3.70%, This led to an increase in GDP to about 252044 billion Iraqi dinar by 0.15%, While the average per capita GDP according to the first sample reached about 7368 thousand Iraqi dinars.

3. The impact on the value of imports

It was the focus of the proposed structure of the crop models to increase areas and production of crops with high revenue from water unit for reducing the value of imported crops involved in the models comparison with the value of imports for the year 2012.

Where the value of imports of the most important agricultural crops for the year 2012 about 6.32562 trillion Iraqi dinars (The Ministry of Planning, the Central Bureau of Statistics, 2013), Import value was calculated from the crops in to the proposed compositions after deducting the value of annual consumption in Iraq from the proposed production models.

The proposed models have focused on minimizing water requirements to reduce the cultivated areas and the provision in the water needs, In order to utilize them in increasing quantities produced from crops and thus reduce the quantities imported ones, Therefore, production rates have were similar in these models with the actual composition of the crop for 2012.

Except wheat crop it has been devaluing its imports in the first model for minimize the water needs to 800 billion Iraqi dinars and increased by 10.72% compared to

2012. Which amounted to approximately 896.44 billion Iraqi dinars. While, the value of imports has fell for the wheat crop in the second model to minimize water needs to 465.25 billion Iraqi dinars, a rate 48.1% compared to the value of imports of wheat crop for 2012.

Recommendations

From the results that have been reached, we can recommend as following:

1. Focus on increase dunum productivity of agricultural crops, and modify the current crop composition and expansion in the cultivation of crops the most efficient in water consumption that lead to increase each of the return of unit water and net return for dunum and reduce the required water needs.
2. Work on reducing water wastage during transport and distribution, and raise the efficiency of water use in the agricultural sector through the maintenance and improvement of canals and irrigation systems and the use of techniques and methods of modern irrigation, such as irrigation systems (sprinkler and drip).
3. The need for the state role the guideline indirectly through the use of motivational and organizational means, Such as carrying the State for part of the cost of some agricultural operations for some of the important strategic crops, and provide high productivity varieties and do not lead to increased production costs to achieve an increase in net revenue, which is the main engine of the resolutions of agricultural production.
4. Supporting and activating extension activities in the field of use of water resources in Iraq's agricultural sector in collaboration with the Irrigation management in the Ministry of Water Resources, and through the expansion of the extension programs for farmers to make them aware of the importance of water and rationalizing the use of irrigation water and use it optimally.
5. Encourage the cultivation of crops the alternative less water and resistance to salinity and drought, and the use of genetic engineering techniques to find varieties and breeds of crops more withstand to salinity and more resistant to drought and needs less water.

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