JPB REVIEW
INTERNATIONAL JOURNAL OF PROFESSIONAL BUSINESS REVIEW
ISSN: 2525-3654
OPEN ACCESS

ANALYTICAL STUDY OF THE OPTIMUM PLAN FOR CROPPING PATTERN IN BAGHDAD GOVERNORATE

Ithmar Mansour Hamza[A], Eskander H. Ali[B]

ARTICLE INFO

Article history:

Received 31 January 2023

Accepted 06 April 2023

Keywords:

Cropping Pattern;
Water Revenue;
Non-Negative Constraints;
Linear Programming.

ABSTRACT

Purpose: The research aimed to reallocate the available economic resources and develop optimal economic plans that maximize net income, reduce costs, and maximize the net revenue of the water unit in Baghdad Governorate.

Theoretical framework: Using the linear programming model as the underpinning theoretical framework, this study discovered that the profit margin exceeds the current reality by approximately 67.5%. proposed plans reduced the total annual needs of water with the proposed plans compared to the actual plan, as the actual cropping pattern needs 463474646 m3. However, with the addition of legislative constraints, the proposed cropping pattern requires 262867570 m3, resulting in a 43.2% reduction in water use.

Design/methodology/approach: The method of linear programming in achieving the objective function. The research required two types of data: cross-sectional data collected from 104 farmers from the Baghdad governorate for the year 2020. Besides, the secondary data that collected from the Ministry of Agriculture and the Ministry of Water Resources. Then, three optimal plans were estimated whose objective function was maximizing net income, minimizing costs, and maximizing net water unit, respectively. The study included 15 productive activities, 12 water constraints, four constraints for human work, and one for mechanized work during the year, where legislative and organizational constraints were also added.

Findings: The results of the optimal plan for the proposed cropping pattern indicated that the gross profit margin of the prevailing cropping pattern is 52.9 billion and in the plan without legislative constraints 138.2 billion. In comparison, it amounted to 88.8 billion with the presence of legislative constraints, which exceeds the profit margin in the current reality by about 67.5%. Besides that, one dunam will achieve a profit of 198.6, that is, an addition of 144.7 to the profit of a dunum in the current pattern. The actual cropping pattern needs 71412355 human labor hours, which is an average of 178 hours per acre, while drawing a plan for the proposed cropping pattern with the addition of legislative constraints, it needs 53473612 hours at a rate of 120.6 hours. As for the results of the proposed cropping pattern according to the function of maximizing the net revenue of the water unit, it indicated that the proposed cropping pattern, with the inclusion of these constraints, amounted to a net water revenue of about 362.9 thousand dinars. It is also rewarding and high and exceeds about 363% of the actual net revenue or about 284.6 thousand dinars. The proposed plans likewise reduced the total annual needs of water with the proposed plans compared to the actual plan, as the actual cropping pattern needs 463474646 m^3. However, the proposed cropping pattern with the addition of legislative constraints needs 262867570 m^3 meaning that it reduced water use by 43.2%.

Research, Practical & Social implications: This is very important due to the problem of water scarcity and its impact on the cropping pattern, that is, with this surplus quantity, it is possible to grow other crops and not be affected by the scarcity

[A]*Assistant Professor, Department of Agricultural Economics, College of Agricultural Engineering Sciences, University of Baghdad, Iraq. E-mail: Eskanderhali81@gmail.com Orcid: https://orcid.org/0000-0002-5035-962*
[B] *Researcher in The Ministry of Electricity, Iraq. E-mail: athmar.manssour1108a@coagri.uobaghdad.edu.iq Orcid: https://orcid.org/0000-0002-5744-322X*

of water. Instead, the economic efficiency of water use amounted to 19.5%, and the inefficiency in the cropping pattern in terms of water revenue amounted to 80.5%.

Originality/value: This a rticle applied a scientific method applied for the first time in Baghdad Governorate / Iraq. Two types of data were used. and three programmatic goals.

Doi: https://doi.org/10.26668/businessreview/2023.v8i4.892

ESTUDO ANALÍTICO DO PLANO ÓTIMO PARA O PADRÃO DE CULTIVO NO GOVERNO DE BAGDÁ

RESUMO

Objetivo: A pesquisa teve como objetivo realocar os recursos econômicos disponíveis e desenvolver planos econômicos ideais que maximizem a receita líquida, reduzam custos e maximizem a receita líquida da unidade de água na província de Bagdá.

Referencial teórico: Utilizando o modelo de programação linear como referencial teórico de sustentação, este estudo constatou que a margem de lucro supera a realidade atual em aproximadamente 67,5%. os planos propostos reduziram as necessidades anuais totais de água com os planos propostos em comparação com o plano real, pois o padrão de cultivo real precisa de 463474646 m3. No entanto, com a adição de restrições legislativas, o padrão de cultivo proposto requer 262867570 m3, resultando em uma redução de 43,2% no uso de água.

Desenho/metodologia/abordagem: O método de programação linear para atingir a função objetivo. A pesquisa exigiu dois tipos de dados: dados transversais coletados de 104 agricultores da província de Bagdá para o ano de 2020. Além disso, os dados secundários coletados de o Ministério da Agricultura e o Ministério dos Recursos Hídricos. Em seguida, foram estimados três planos ótimos cuja função objetivo era maximizar o lucro líquido, minimizar os custos e maximizar a unidade líquida de água, respectivamente. O estudo incluiu 15 atividades produtivas, 12 constrangimentos hídricos, quatro constrangimentos de trabalho humano e um de trabalho mecanizado durante o ano, onde foram também adicionados constrangimentos legislativos e organizacionais.

Resultados: Os resultados do plano ótimo para o padrão de cultivo proposto indicaram que a margem de lucro bruto do padrão de cultivo predominante é de 52,9 bilhões e no plano sem restrições legislativas é de 138,2 bilhões. Comparativamente, ascendeu a 88,8 mil milhões com a presença de constrangimentos legislativos, o que supera a margem de lucro na realidade atual em cerca de 67,5%. Além disso, um dunam alcançará um lucro de 198,6, ou seja, um acréscimo de 144,7 ao lucro de um dunum no padrão atual. O padrão de cultivo real precisa de 71412355 horas de trabalho humano, o que é uma média de 178 horas por acre, enquanto traçando um plano para o padrão de cultivo proposto com a adição de restrições legislativas, ele precisa de 53473612 horas a uma taxa de 120,6 horas. Quanto aos resultados do padrão de cultivo proposto de acordo com a função de maximizar a receita líquida da unidade de água, indicou que o padrão de cultivo proposto, com a inclusão dessas restrições, totalizou uma receita líquida de água de cerca de 362,9 mil dinares. Também é gratificante e alto e ultrapassa cerca de 363% da receita líquida real ou cerca de 284,6 mil dinares. Os planos propostos também reduziram as necessidades anuais totais de água com os planos propostos em comparação com o plano real, pois o padrão de cultivo real precisa de 463474646 m3. No entanto, o padrão de cultivo proposto com a adição de restrições legislativas precisa de 262867570 m3, o que significa que reduziu o uso de água em 43,2%.

Implicações de pesquisa, práticas e sociais: Isso é muito importante devido ao problema da escassez de água e seu impacto no padrão de cultivo, ou seja, com essa quantidade excedente, é possível cultivar outras culturas e não ser afetado pela escassez de água . Em vez disso, a eficiência econômica do uso da água foi de 19,5% e a ineficiência no padrão de cultivo em termos de receita de água foi de 80,5%.

Originalidade/valor: Este artigo aplicou um método científico aplicado pela primeira vez na província de Bagdá / Iraque. Dois tipos de dados foram usados. e três metas programáticas.

Palavras-chave: Padrão de Cultivo, Receita hídrica, Restrições não Negativas, Programação Linear.

ESTUDIO ANALÍTICO DEL PLAN ÓPTIMO PARA EL PATRÓN DE CULTIVO EN LA GOBERNACIÓN DE BAGDAD

RESUMEN

Propósito: la investigación tuvo como objetivo reasignar los recursos económicos disponibles y desarrollar planes económicos óptimos que maximicen los ingresos netos, reduzcan los costos y maximicen los ingresos netos de la unidad de agua en la gobernación de Bagdad.

Marco teórico: Utilizando el modelo de programación lineal como marco teórico de apoyo, este estudio descubrió que el margen de beneficio supera la realidad actual en aproximadamente un 67,5%. Los planes propuestos redujeron las necesidades anuales totales de agua con los planes propuestos en comparación con el plan real, ya que el patrón de cultivo real necesita 463474646 m3. Sin embargo, con la adición de restricciones legislativas, el patrón de cultivo propuesto requiere 262867570 m3, lo que resulta en una reducción del 43,2 % en el uso de agua.
Diseño/metodología/enfoque: el método de programación lineal para lograr la función objetivo. La investigación requirió dos tipos de datos: datos transversales recopilados de 104 agricultores de la gobernación de Bagdad para el año 2020. Además, los datos secundarios recopilados de el Ministerio de Agricultura y el Ministerio de Recursos Hídricos. Luego, se estimaron tres planes óptimos cuya función objetivo era maximizar la utilidad neta, minimizar los costos y maximizar la unidad neta de agua, respectivamente. El estudio incluyó 15 actividades productivas, 12 restricciones hídricas, cuatro restricciones por trabajo humano y una por trabajo mecanizado durante el año, donde también se agregaron restricciones legislativas y organizacionales.
Hallazgos: Los resultados del plan óptimo para el patrón de cultivo propuesto indicaron que el margen de beneficio bruto del patrón de cultivo prevaleciente es de 52,9 mil millones y en el plan sin restricciones legislativas de 138,2 mil millones. En comparación, ascendió a 88,8 mil millones con la presencia de restricciones legislativas, lo que supera el margen de beneficio en la realidad actual en aproximadamente un 67,5%. Además de eso, un dunum logrará una ganancia de 198,6, es decir, una adición de 144,7 a la ganancia de un dunum en el patrón actual. El patrón de cultivo real necesita 71412355 horas de trabajo humano, que es un promedio de 178 horas por acre, mientras que dibujar un plan para el patrón de cultivo propuesto con la adición de restricciones legislativas necesita 53473612 horas a una tasa de 120,6 horas. En cuanto a los resultados del patrón de cultivo propuesto según la función de maximizar los ingresos netos de la unidad de agua, indicó que el patrón de cultivo propuesto, con la inclusión de estas restricciones, ascendió a un ingreso neto de agua de alrededor de 362,9 mil dinares. También es gratificante y alto y supera alrededor del 363% de los ingresos netos reales o alrededor de 284,6 mil dinares. Los planes propuestos también redujeron las necesidades anuales totales de agua con los planes propuestos en comparación con el plan real, ya que el patrón de cultivo real necesita 463474646 m3. Sin embargo, el patrón de cultivo propuesto con la adición de restricciones legislativas necesita 262867570 m3, lo que significa que redujo el uso de agua en un 43,2 %.
Implicaciones de investigación, prácticas y sociales: esto es muy importante debido al problema de la escasez de agua y su impacto en el patrón de cultivo, es decir, con esta cantidad excedente, es posible sembrar otros cultivos y no verse afectado por la escasez de agua. . En cambio, la eficiencia económica del uso del agua ascendió al 19,5 %, y la ineficiencia en el patrón de cultivo en términos de ingresos por agua ascendió al 80,5 %.
Originalidad/valor: Este artículo aplicó un método científico aplicado por primera vez en la Gobernación de Bagdad/Irak. Se utilizaron dos tipos de datos. y tres metas programáticas.

Palabras clave: Patrón de Cultivo, Ingresos por Agua, Restricciones no Negativas, Programación Lineal.

INTRODUCTION

The cropping pattern is a relative concept because it is not easy to know what is optimal specifically. After all, there are a large number of goals assigned to agriculture. In addition to the limited cultivated area, any expansion in the cultivation of one crop will be at the expense of another crop. Thus, there is a severe conflict between the goals and each other. As a result of this competition, it is difficult to elect a cropping pattern that achieves all of these goals, so some studies show the importance of cropping patterns and contribute to defining research methods and analytical tools. It is one of the main tools for the use of agricultural economic resources in general and agricultural land and water in particular. The cropping pattern is meant to determine the areas that are grown of crops and their cultivation areas and the varieties that are grown from each crop according to specific agricultural dates and at the appropriate time and weather conditions, with the succession of cultivation of these crops in organized and arranged agricultural cycles. Studies of the optimal allocation of agricultural resources are one of the most important goals of economic development, especially in light of the scarcity and limitedness of such resources, which necessitates the need for efficient and optimal use of those resources.

These studies in the agricultural sector in Iraq represent one of the main economic issues of concern to decision-makers and those responsible for developing policies related to the organization and methods of exploiting the available resources in Iraq. The study also derives its scientific importance from the fact that it is based on a quantitative mathematical method, which is the linear programming technique, as a planning method that contributes to analyzing and solving the problems of the optimal distribution of resources. This technique faces the makers of productive decisions who work under certain constraints and controls that limit their abilities to choose the most appropriate decisions. Plus, the benefits from the final results that will be reached in addressing the problems of the optimal distribution of scarce productive resources, and the ability to measure, compare and predict to evaluate the available alternatives to choose the best one (Abdullah, 2021). Since the nature of the relationship between inputs and outputs is often not a linear relationship and bearing to each other a fixed revenue on capacity, as is the case in the first-order homogeneous Cobb- Douglas production function to reflect the constant revenues to scale. The concept of non-linearity does not entail the necessity of the existence of linear relationships between inputs and outputs. Therefore, it reflects a revenue to scale that may be constant, increasing, or decreasing, this is consistent with the practical reality, and in this case, the NLP non-linear programming method aimed to provide a solution to this problem (Al-Hassan, 2016). Linear and non-linear programming methods can be used to obtain a proposed cropping pattern that maximizes the total profit margin, and thus it is possible to derive the demand for production factors. As well as, the possibility of obtaining the shadow price, which expresses the real price of the production element quantity if this resource is exhausted and fully utilized. But it does not represent the market price and has nothing to do with the supplier's specifications (Ismail, 1981). Agriculture in general, and in Baghdad in particular, are exposed to many price and production risks that affect the imbalance in the structure of the cropping pattern, Then, neglecting the introduction of risk in planning models led to biased estimates of the volume of outputs and overestimation of the input volume, as well as an error in estimating the required technology and thus affecting decisions. (Dat, 2023) This is, of course, reflected in the efficiency of use, the instability of income, and, finally, the low level of economic efficiency. The failure to use the scientific method in planning and the discouragement of agriculture made the farmer not adopt a cropping pattern that does not maximize his net income, and the decrease in levels and water quotas under traditional irrigation patterns will deepen the water problem and will take on more dangerous dimensions that prevent agricultural expansion and achieve self-sufficiency, which requires a shorter achievement water resource efficiency. Accordingly, the cropping pattern applied in the governorate departs from the combination that gives the highest farm income and did not take into account the achievement of food security. There is an expansion of cash commodities at the expense of food commodities.

The research aims to reallocate the available economic resources and develop optimal economic plans that maximize net income, minimize costs, and maximize the net revenue of the water unit. The use of linear programming as a quantitative method in constructing an optimal cropping pattern has attracted the attention of many researchers, including (Mohammed and Basil, 2003) who researched farm planning under conditions of risk and uncertainty in a rural area in Bangladesh. Similarly, (Al-Shazly et al., 2009) targeted the Egyptian cropping pattern under risk and local and international variables. Then, (Mahmoud, 2013) presented a study on the planning of the Egyptian cropping pattern under low risk, as it is considered the large size of risk and the exacerbation of water scarcity to which the Egyptian agricultural sector in general and the cropping pattern in particular(Sarjiman et al., 2023). Plus, the consequent instability of agricultural production is exposed. Whereas, (Al-Husseini et al., 2014) conducted an economic analysis of the uses of land and water resources in Iraq, studying the current situation of irrigation systems in the Iraqi agricultural sector, estimating the productive and economic indicators of those systems, and trying to reach the optimal use of those resources. Moreover, (Raphael, 2017) studied the production risks of the system of growing varieties of maize crops in the Republic of Tanzania, where the above research focused on improving the maize production system for smallholders.

MATERIAL AND METHODOLOGY

To achieve the research objectives, the research relied on two types of data: The first is cross-sectional data collected from 104 farmers in the governorate of Baghdad to determine the costs and revenues of all crops grown in the governorate. The profit margin for each dunum to calculate the total cost per dunum, and it's needs of economic resources, as well as the net revenue achieved from the water unit. The second type of data is secondary data obtained from the relevant authorities such as the Ministry of Agriculture and the Ministry of Planning. The research method is the quantitative mathematical method (using the linear programming method) in analyzing the data and extracting the required results using the statistical program Win QSB, which depends on the analysis of the Simplex Method.

RESULTS AND DISCUSSION

The results of the linear programming models for three scenarios were formulated and analyzed as follows:

First Scenario

The linear programming model maximizes the net income of one dunum of the prevailing cropping pattern for the year (2020). The first scenario divides into two parts: the first is the formulation of the linear programming model that maximizes the net income of the prevailing cropping pattern without legislative constraints. The second is the formulation of the linear programming model that maximizes the net income of the prevailing cropping pattern for the year (2020), with the inclusion of legislative constraints, as follows:

The First Plan is the Linear Programming Model that Maximizes the net Income of the Prevailing Cropping Pattern for the year (2020) Without Legislative Constraints

Linear programming aims at maximizing or minimizing a specific linear objective function, and this objective function has a set of constraints that define the problem of linear programming. The formulation of the model is intended to express the real relationships with a proposed mathematical relationship based on the study and analysis of reality, or according to the problem formulation and the model can be evaluated either graphically or mathematically (Gorantiwar, and Smout, 2005).

- **Determining the data used in the linear programming model**

1. Objective Function

The objective function of this model was to maximize the net income per dunum realized from various activities as they were cultivated during the agricultural season (2019-2020). The aim of this is to draw a plan for agricultural production in the governorate of Baghdad. The formulation of the model is the most important stage of linear programming, and the basic model consists of:

$$\text{Max } \Sigma \; C_jX_j = C_1X_1 + C_2X_2 + C_3X_3 \ldots\ldots\ldots\ldots C_{15}X_{15}$$

Since:
ΣC_jX_j= represents the total value of the objective function to be maximized (total net income)
C_j = net income from the crop j
X = the cultivated area of crop (j) where (j = 1,2,…,15) the crops grown.

Formulating the model aim to determine the optimal mix of crops that achieve the greatest possible net income according to the available possibilities (Huang and Loucks, 2010).

2. Determining the matrix data of technical coefficients of the constraints that represent the needs of crops from the various production requirements per dunum, which represent (LHS). Left-Hand -Side
3. Determining the available quantities of agricultural production requirements, which represent the Right Hand Side (RHS).

After the important basic constraints are identified, as well as the non-negative constraints, the stage of formulating linear programming models will discuss.

- **Formulating a Linear Programming Model that Maximizes the net Income of the Prevailing Cropping Pattern for the year (2020) Without Legislative Constraints**

1. Objective Function Data

This model aimed to maximize the total net income per dunum of the optimal cropping pattern. This means that a group of crops must be selected that can maximize the total net income, taking into account the constraints of land, water, and human resources. The first plan for this model includes (15) crops.

$$MaxZ=231000X1+274000X2+77000X3+92000X4+161000X5+279000X6+ 177000X7+122000X8+179000X9+268000X10+873000X11+112000X12+ 276000X13+134000X14+194000X15$$

Since: X1: wheat, X2: barley, X3: tomato, X4: watermelon, X5: okra X6: zucchini, X7: pepper X8: potato X9: onion X10: garlic X11: beans X12: cucumber X13: beans X14: eggplant X15: lettuce.

Set of Constraints

The objective function has been achieved according to many constraints and determinants divided into two parts: some of them are resource constraints and others are legislative and organizational.

- Resource constraints included

i. Land resource constraints/dunum: It includes three constraints, the first of which is related to the total arable areas at the level of Baghdad. The second constraint is related to the total area of winter crops, while the third constraint is related to the total area of summer crops.

ii. Water resource constraints/m^3: It was assumed that the amount of irrigation water for the crops of the model under study does not exceed the total amount of available irrigation water, as (12) water constraints were formulated representing the total monthly water needs of the cropping activities included in the model, as the amount of water available per month for crops was calculated.

iii. Manual work/hour constraints: 12 manual labor constraints have been formulated representing the manual labor hours needed by the cropping activities included in the model, divided over three months to be more accurate, and consequently there were four constraints.

iv. Mechanized work constraint/hour: The mechanized work constraint was formulated because mechanization is an important determinant for the expansion of production activities and also depends on it in technical development.

- Organizational or legislative constraints, including:

- The area of crops that farmers have to grow.
- The area of crops that have been prevented from being imported by the Ministry of Agriculture.
- Crops that were prevented due to water shortage.

Non-negative constraints:

It means all the variables in the model, which crops are greater or equal to zero, meaning positive. So the matrix is shown in Table 1.

Table (1) Matrix of the mathematical formulation of the linear programming model (first scenario, first model), which maximizes the net income of the prevailing cropping pattern for the year (2020)

		حنطة	شعير	طماطة	رقي	باميا	شجر	فلفل	بطاطا	بصل	ثوم	فاصوليا	خيار	باقلاء	باذنجان	خس	الاشارة	الكميات المتاحة من الموارد
		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15		
	MAX	130000	120000	65000	73000	235000	170000	160000	80000	140000	210000	360000	82000	75000	78000	90000		
	اجمالي المساحة الكلية	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		443059
	اجمالي المحاصيل الشتوية	1	1	0	0	0	0	0	0	1	1	1	0	1	0	1	≤	274697
	اجمالي المحاصل الصيفية	0	0	1	1	1	1	1	1	0	0	0	1	0	1	0	≤	168362
كانون ٢	م٣	93.77	72.87	0	0	0	0	0	67.04	0	98.03	0	0	45.3	0	0	≤	357547886
شباط	م٣	93.77	72.87	0	0	0	0	0	67.04	98.03	98.03	0	0	45.3	0	0	≤	375741257
اذار	م٣	93.77	72.87	169.28	131.73	208.11	203.2	113.05	67.04	98.03	98.03	77.45	146.16	45.3	83.17	116.2	≤	371226240
نيسان	م٣	93.77	72.87	169.28	131.73	208.11	203.2	113.05	67.04	98.03	98.03	77.45	146.16	45.3	83.17	116.2	≤	346982400
مايس	م٣	0	0	169.28	131.73	0	203.2	0	0	98.03	0	77.45	0	0	83.17	0	≤	415993783
حزيران	م٣	0	0	169.28	0	208.11	0	113.05	0	98.03	0	0	0	0	0	0	≤	426791314
تموز	م٣	0	0	169.28	0	208.11	0	113.05	0	0	0	0	0	0	83.17	0	≤	401913051
اب	م٣	0	0	0	131.73	208.11	0	113.05	67.04	0	0	77.45	146.16	0	83.17	116.2	≤	469892571
ايلول	م٣	0	0	0	131.73	208.11	0	113.05	67.04	98.03	98.03	77.45	146.16	0	83.17	116.2	≤	517466880
تشرين ١	م٣	0	0	0	131.73	208.11	0	113.05	67.04	98.03	98.03	77.45	0	45.3	83.17	0	≤	504380983
تشرين ٢	م٣	93.77	72.87	0	0	0	0	113.05	67.04	98.03	98.03	0	146.16	45.3	83.17	0	≤	467152457
كانون ١	م٣	93.77	72.87	0	0	0	0	0	67.04	98.03	98.03	0	0	45.3	0	92.94	≤	458159451
العمل اليدوي للشهور ك٢ ـ اذار	ساعة	5	6	22	10	32	59	26	30	70	48	20	17	20	24	60	≤	136524480
العمل اليدوي للشهور نيسان ـ حزيران	ساعة	3	2	65	25	74	90	73	65	0	0	24	143	21	75	0	≤	136524480
العمل اليدوي للشهور تموز ـ ايلول	ساعة	0	0	170	75	105	0	140	155	0	0	0	0	0	132	0	≤	136524480
العمل اليدوي للشهور ت١ ـ ك١	ساعة	7	7	112	0	37	28	60	110	60	62	42	0	39	69	42	≤	136524480
العمل الالي	ساعة	4	3	2.5	3	2.5	2.5	2.5	2.5	2.5	2.5	3	3	2.5	2.5	2.5	≤	18327600

Reference / Prepared by the researcher based on the reports and publications of the original data sources, namely: the Iraqi Ministry of Agriculture and the Iraqi Ministry of Water Resources. As for the data on the needs of one dunum of resources, it was based on the questionnaire form

- **The Results of the First Scenario Analysis**

The results of the first scenario analysis: the results of the analysis of the linear programming model that maximizes the net income of the prevailing cropping pattern for the year (2020) without including legislative constraints:

After formulating the mathematical form of the objective function and the determinants of the first model of the linear programming model. the data was entered into the electronic machine (computer) for analysis and using the (QSB) program (for solving linear programming problems) in the light of the model (1) data., where legislative constraints were not included.

Table (2) The analysis results of the linear programming model that maximizes the net income of the prevailing cropping pattern for the year (2020) without including legislative constraints

No.	Decision Variable	Solution Value	Unit Cost c(j)	Total Contribution	Constraint	Left Hand Side	Right Hand Side	Slack or Surplus
X1	Wheat	0	130000.0000	0	Total area	443059.0000	443059.0000	0
X2	Barley	0	120000.0000	0	Winter area	274697.0000	274697.0000	0
X3	Tomatoes	0	65000.0000	0	Summer area	168362.0000	168362.0000	0
X4	Watermelon		73000.0000	0	Water Jan.	0	357547900.0000	357547900.0000
X5	Okra	168362.0000	235000.0000	39565070000.0000	Water Feb.	0	375741200.0000	375741200.0000
X6	Zucchini	0	170000.0000	0	Water Mar.	56313100.0000	371226200.0000	314913200.0000
X7	Pepper	0	160000.0000	0	Water Apr.	56313100.0000	346982400.0000	290669300.0000

X8	Potato	0	80000.0000	0	Water May	21275280.0000	415993800.0000	394718500.0000
X9	Onions	0	140000.0000	0	Water Jun.	35037820.0000	4267913000000	391753500.0000
X10	Garlic	0	210000.0000	0	Water Jul	35037820.0000	401913100.0000	366875200.0000
X11	Beans	274697.0000	360000.0000	98890920000.0000	Water Aug.	56313100.0000	469892600.0000	413579500.0000
X12	Cucumber	0	82000.0000	0	Water Sep.	56313100.0000	517466900.0000	461153800.0000
X13	Beans	0	75000.0000	0	Water Oct.	56313100.0000	504381000.0000	448067900.0000
X14	Eggplant	0	78000.0000	0	Water Nov.	0	467152400.0000	467152400.0000
X15	Lettuce	0	90000.0000	0	Water Dec.	0	458159500.0000	458159500.0000
	Objective	Function	(MAX.) =	138456000000	Labor 1	10881520.0000	136524500.0000	125643000.0000
					Labor 2	19051520.0000	136524500.0000	117473000.0000
					Labor 3	17678010.0000	136524500.0000	118846500.0000
					Labor 4	17766670.0000	136524500.0000	118757800.0000
					Labor 5	1244996.0000	18327600.0000	17082600.0000

Reference: Organized by the researcher based on the results obtained using the WIN QSB statistical program

The proven results in Table (2) showed that all available agricultural lands amounting to (443059) dunums have been fully exploited. Furthermore, the value of the net income for the Baghdad Governorate amounted to (138456000000) dinars, with an increase of (161.2%) over the net agricultural income achieved at field prices, which amounted to (53004014000) dinars. Although some crops did not appear, as only two crops appeared, okra and beans. The productive resources that have been fully exploited, which represent limited resources, are represented by the agricultural land of Baghdad (C_1), the area of winter crops (C_2), and the area of summer crops (C_3). Adding one unit of (C_1), that is, one dunum, will add to the value of the objective function (235000) dinars and up to (443059) dunums as a maximum, Likewise, adding one unit of (C_2) will add to the value of the objective function (125,000) dinars, and up to (274697) dunums as a maximum. In the same role, adding one unit of (C_3), that is, one dunum, will add to the value of the objective function (0) dinars and up to (168362) dunums as a maximum, this is what the shadow prices of these resources reflect. The below Table also shows the analysis results of the linear programming model, which maximizes the total net income achieved in light of the proposed areas in the plan.

Table (3) The analysis results of the linear programming model that maximizes the net income of the prevailing cropping pattern in the average period (2018 - 2020) with the inclusion of legislative constraints

No.	Decision Variable	Solution Value	Unit Cost c(j)	Total Contribution	Constraint	Left Hand Side	Right Hand Side	Slack or Surplus
X1	Wheat	155683.0000	130000.0000	20238790000.0000	Total area	443059.0000	443059.0000	0
X2	Barley	17197.0000	120000.0000	2063640000.0000	Winter area	274697.0000	274697.0000	0
X3	Tomatoes	9027.0000	65000.0000	586755000.0000	Summer area	168362.0000	168362.0000	0

X4	Watermelon	6377.0000	73000.0000	465521000.0000	Water Jan.	16321190.0000	357547900.0000	341226700.0000
X5	Okra	118155.0000	235000.0000	27766430000.0000	Water Feb.	16724190.0000	375741200.0000	359017100.0000
X6	Zucchini	6215.0000	170000.0000	1056550000.0000	Water Mar.	55081330.0000	371226200.0000	316144900.0000
X7	Pepper	5860.0000	160000.0000	937600000.0000	Water Apr.	55081330.0000	346982400.0000	291901100.0000
X8	Potato	3223.0000	80000.0000	257840000.0000	Water May	11919280.0000	415993800.0000	404074500.0000
X9	Onions	4111.0000	140000.0000	575540000.0000	Water Jun.	27182800.0000	4267913000000	399608500.0000
X10	Garlic	645.0000	210000.0000	135450000.0000	Water Jul	27641280.0000	401913100.0000	374271800.0000
X11	Beans	90688.0000	360000.0000	32647680000.0000	Water Aug.	35782240.0000	469892600.0000	434110400.0000
X12	Cucumber	9147.0000	82000.0000	750054000.0000	Water Sep.	36248470.0000	517466900.0000	481218400.0000
X13	Beans	4202.0000	75000.0000	315150000.0000	Water Oct.	34849670.0000	504381000.0000	469531400.0000
X14	Eggplant	10358.0000	78000.0000	807924000.0000	Water Nov.	19585060.0000	467152400.0000	447567400.0000
X15	Lettuce	2171.0000	90000.0000	195390000.0000	Water Dec.	16925960.0000	458159500.0000	441233500.0000
					Labor 1	8291537.0000	136524500.0000	128232900.0000
					Labor 2	15537340.0000	136524500.0000	120987100.0000
	Objective	Function	(MAX.) =	88800310000	Labor 3	17106360.0000	136524500.0000	119418100.0000
					Labor 4	12538380.0000	136524500.0000	123986100.0000
					Labor 5	1402877.0000	18327600.0000	16924720.0000

Reference: Organized by the researcher based on the results obtained using the WIN QSB statistical program

Considering that the total objective function amounted to about 138,456,000,000 Iraqi dinars, with two crops within the winter crops group. The model proposes allocating the areas of the green bean crop to about 274697 dunums, and within the summer crops, the model proposes to allocate the areas of the okra crop to about 168,362 dunums. The analysis results also indicated that there is a large surplus of economic resources included in the simplex schedule (water, manual work, automated work), especially water resources. It can also note that the proposed cropping pattern in this scenario achieved the goal of maximizing net income and gave a profit of more than 161% of the profit in the current plan. But this plan did not show most of the crops, especially the important strategic crops, such as wheat, which is related to the issue of food security, as well as barley from the important grain fodder crops. In addition to the most important vegetable crops, especially the crops that the Ministry of Agriculture prevented from importing and which must be available from local products such as tomatoes, eggplant, cucumbers, zucchini, onions, etc., and at the same time, this plan is illogical and does not fit with the actual demand. That is why it was neglected and not relied upon, although the objective function is of a higher and more important value, it is not more important because of the need for other important crops.

- **The results of the analysis of the linear programming model, which maximizes the net income of the prevailing cropping pattern with the addition of legislative constraints:**

To improve the results of solving the first plan within the first scenario, a set of legislative constraints related to the allocation of certain agricultural areas to some field and vegetable crops that did not appear in the first plan were included and added. As the linear programming model was formulated, which maximizes the net income of a dunum of the prevailing cropping pattern for the year (2020) with the imposition of legislative constraints. This model consists of the function of the objective of the first plan and the same constraints with the addition of a set of legislative constraints that represent the areas of a group of crops that farmers must cultivate. As well as, the areas of a group of crops that were recently banned from being imported by the Iraqi Ministry of Agriculture (if they did not appear in the first plan of the model), which starts from C_{22} to C_{34} and as follows:

C22=X1≤155683

C23=X2≤17197

C24=X3≤9027

C25=X4≤11358

C26=X6≤ 6215

C27=X7≤5860

C28=X8≤ 3223

C29=X9≤4111

C30=X10≤645

C31=X12≤9147

C32=X13≤4202

C33=X14 ≤10358

C34=X15 ≤2171

After completing the formulation of the mathematical form of the objective function and the determinants of the second plan within the first scenario. These data were inputted into the computer for analysis and after applying the program (QSB) (for solving linear programming problems) in the light of the model data with the inclusion of legislative constraints. The results showed that all available agricultural lands amounting to (443059) dunums have been fully exploited, and the value of the net income in the cropping pattern of the province of Baghdad has reached (88800310000) dinars, with an increase of (67.5%) over the net agricultural income achieved in the current cropping pattern at current prices, which amounted to (53004014000) dinars. The plan showed the following crops: wheat, barley, lettuce, onions, beans, garlic, peppers, tomatoes, cucumbers, eggplants, zucchini, potatoes, watermelon, beans, and okra. The productive resources that have been fully exploited, which represent limited resources, are represented by the agricultural land of Baghdad governorate (C_1), the area of winter crops (C_2), and the area of summer crops (C_3). Besides that adding one unit of (C_1), this is, one dunum will add to the value of the objective function (235,000) dinars and up to (443059) as a maximum. Similarly, adding one unit of (C_2) will add to the value of the objective function (125,000) dinars and up to (274697) as a maximum, and adding one unit of (C_3) will add to the value of the objective function (0) dinars and up to (168362) dunums as a maximum. This is what shadow prices reflect for these resources. Table (3) shows the analysis results of the linear programming model, which maximizes the total net income achieved with the presence of legislative constraints. In light of the areas proposed in the plan, the cultivation of basic and required crops and vegetables has been expanded, and the total objective function reached about 88800310 thousand Iraqi dinars and by fifteen crops, which is planted during the summer and winter seasons, as the group of winter crops included wheat (X1), barley (X2), onions (X9), garlic (X10), beans (X11) and lettuce (X15). Whereas, the group of summer crops included tomatoes (X3), watermelon (X4), okra (X5), zucchini (X6), peppers (X7), potatoes (X8), cucumbers (X12), beans (X13), and eggplant (X14). The total exploited summer areas amounted to about 168,362 dunums, while the total exploited winter areas amounted to about 274,697 dunums. Despite the economic merit of the results presented in the Table, the estimated model suggests an increase in the areas allocated to each of the bean and okra crops than those cultivated for the year (2020). Moreover, the proposed cropping pattern showed that there is a surplus in the amount of water for all months of the year and that there is also, a surplus in the suppliers of manual labor and mechanized work. The surplus in these resources can contribute to the cultivation of other crops.

- **Comparison between the results of the first Scenario and the results of the actual cropping pattern**

For each cropping pattern, whether prevalent or proposed, a set of economic indicators is important and is relied upon in determining this pattern. Here the plans for the cropping pattern are clear and summarized in Table 4 which shows a comparison of these indicators between the actual cropping pattern and the proposed cropping pattern, whether with or without legislative constraints. It is noted that the total arable area in the province of Baghdad has been completely exhausted in reality and in the proposed plans. Even though the crops that were included in the actual plan were 15 winter and summer crops and became two crops in the proposed plan without constraints and this is illogical and therefore constrained and then appeared in the plan with constraints. The total profit margin of the prevailing cropping pattern is 52.9 billion, and in the plan without legislative constraints, 138.2 billion, and with the presence of legislative constraints, it amounted to 88.8 billion, which exceeds the profit margin in the current reality by about 67.5%. This gives us an indication of the importance of proposed plans and the extent to which they achieve the goal on the one hand and the misuse of resources and lack of planning in the current pattern on the other hand. That is, if quantitative methods are followed in developing and drawing a cropping plan aimed at maximizing profits, then one dunum will achieve a profit of 198.6, that is, by adding 144.7 of the dunum profit in the current pattern. Thus, it consumes 463474646 m^3 of water for the current cropping pattern, which is more than the required and planned water needs of about 126171661 m^3, and therefore there will be a greater surplus of water in the case of applying the proposed plans. The actual cropping pattern needs 71412355 human labor hours, which is an average of 178 hours per dunum while drawing up a plan for the proposed cropping pattern with the addition of legislative constraints, needs 53473612 hours at an average of 120.6 hours. This will certainly reduce the cost and thus increase profits and there will be a surplus of work that can be exploited in other sectors and reduces disguised unemployment. One dunum in the actual cropping pattern needs 2-6 working hours, while in the case of the proposed cropping pattern using the linear programming method, the dunum needs 1-3 working hours, which is a total of 1402877, which is the reason for the expansion of vegetable crops that need more work, especially in plowing and soil preparation. it was found when measuring the economic efficiency of the cropping pattern applied in the province of Baghdad that it reached 59.6%. Accordingly, the province of Baghdad does not achieve full economic efficiency in its cropping pattern followed, and the level of inefficiency for it was 40.4%, and this indicates inefficiency in resource management and not following a scientific method in its exploitation. There was no quantitative planning in building the current cropping pattern.

Table (4) Economic indicators of the actual and proposed cropping pattern

Model indicators	Actual cropping pattern plan	Results of the optimal cropping pattern without legislative constraints	Optimal cropping pattern results with legislative constraints
Suggested number of crops	15	2	15

Total cultivated area (dunum)	443059	443059	443059
Gross profit margin (billion Iraqi dinars)	53	138.4	88.8
Dunum profit margin (thousand Iraqi dinars)	52.9	313.2	198.6
Total annual need of water (m^3)	463474646	372916420	337302458
Excess quantities of water (m^3)	4649733654	4740331900	4318672200
Annual need of human labor (hours)	71412355	65377720	53473612
Annual need of mechanized work (hours)	1083221	1244996	1402877

Reference / Organized and calculated by the researcher based on the results of analyzing the study data and also on the questionnaire

- **Second Scenario**

The Linear Programming Model That Minimizes Costs per Dunum of the Prevailing Cropping Pattern for the Year (2020) in the Baghdad Governorate

The second scenario is divided into two parts, the first of which is the formulation of the linear programming model, which minimizes the costs of the prevailing cropping pattern during the year (2020) without legislative constraints, Then, the second is the linear programming model, which minimizes the costs of the prevailing cropping pattern for the year (2020) with legislative constraints and according to the following:

The Second plan is the Linear Programming Model that Minimizes the Costs of the Prevailing Cropping Pattern for the year (2020) Without Legislative Constraints

Linear programming aims at maximizing or minimizing a specific linear objective function, and this objective function has a set of constraints that define the problem of linear programming. Considering that the model formulation is intended to express the real relationships with a proposed mathematical relationship based on the study and analysis of reality, or according to the formula of the problem and the model can be evaluated either graphically or mathematically.

- Determining the data used in the linear programming model

1. Objective Function

This model aims to minimize the costs of one dunum of the optimal cropping pattern, which means that a group of crops that can be minimized the costs must be chosen, taking into account the constraints of land, water, and human resources. The first plan for this model includes (15) crops.

MinZ=254000X1+200000X2+298000X3+287000X4+222000X5+278000X6+266000X7+256000X8+272000X9+463000X10+271000X11+343000X12+ 261000X13+300000X14+187000X15

Since: X1: wheat, X2: barley, X3: tomato, X4: watermelon, X5: okra X6: zucchini, X7: pepper X8: potato X9: onion X10: garlic X11: beans X12: cucumber X13: beans X14: eggplant X15: lettuce.

Set of constraints:

There is a set of constraints that assume in formulating the programming model, the same constraints that were used in the first model (first scenario) and as shown in the aforementioned model (1), which included area constraints, water constraints, human labor constraints, and labor constraints. Accordingly, the linear programming matrix was formulated as in Table 5.

Table (5) Mathematical Formulation Matrix for the Linear Programming Model, Second Scenario, The first model that minimized costs for the prevailing cropping pattern for the year (2020)

		حنطة	شعير	طماطة	رقي	باميا	شجر	فلفل	بطاطا	بصل	ثوم	فاصوليا	خيار	باقلاء	باذنجان	خس	الاشارة	الكميات المتاحة من الموارد
		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15		
	MIN	254000	200000	298000	287000	222000	278000	266000	256000	272000	463000	271000	343000	261000	300000	187000		
	اجمالي المساحة الكلية	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		443059
	اجمالي المحاصيل الشتوية	1	1	0	0	0	0	0	0	1	1	1	0	1	0	1	≥	274697
	اجمالي المحاصل الصيفية	0	0	1	1	1	1	1	1	0	0	0	1	0	1	0	≥	168362
كانون ٢	م٣	93.77	72.87	0	0	0	0	0	67.04	0	98.03	0	0	45.3	0	0	≥	357547886
شباط	م٣	93.77	72.87	0	0	0	0	0	67.04	98.03	98.03	0	0	45.3	0	0	≥	375741257
اذار	م٣	93.77	72.87	169.28	131.73	208.11	203.2	113.05	67.04	98.03	98.03	77.45	146.16	45.3	83.17	116.18	≥	371226240
نيسان	م٣	93.77	72.87	169.28	131.73	208.11	203.2	113.05	67.04	98.03	98.03	77.45	146.16	45.3	83.17	116.18	≥	346982400
مايس	م٣	0	0	169.28	131.73	0	203.2	0	0	98.03	0	77.45	0	0	83.17	0	≥	415993783
حزيران	م٣	0	0	169.28	0	208.11	0	113.05	0	98.03	0	0	0	0	0	0	≥	426791314
تموز	م٣	0	0	169.28	0	208.11	0	113.05	0	0	0	0	0	0	83.17	0	≥	401913051
اب	م٣	0	0	0	131.73	208.11	0	113.05	67.04	0	0	77.45	146.16	0	83.17	116.18	≥	469892571
ايلول	م٣	0	0	0	131.73	208.11	0	113.05	67.04	98.03	98.03	77.45	146.16	0	83.17	116.18	≥	517466880
تشرين ١	م٣	0	0	0	131.73	208.11	0	113.05	67.04	98.03	98.03	77.45	0	45.3	83.17	0	≥	504380983
تشرين ٢	م٣	93.77	72.87	0	0	0	0	113.05	67.04	98.03	98.03	0	146.16	45.3	83.17	0	≥	467152457
كانون ١	م٣	93.77	72.87	0	0	0	0	0	67.04	98.03	98.03	0	0	45.3	0	92.94	≥	458159451
العمل اليدوي للشهور ك٢ -اذار	ساعة	5	6	22	10	32	59	26	30	70	48	20	17	20	24	60	≥	136524480
العمل اليدوي للشهور نيسان - حزيران	ساعة	3	2	65	25	74	90	73	65	0	0	24	143	21	75	0	≥	136524480
العمل اليدوي للشهور تموز - ايلول	ساعة	0	0	170	75	105	0	140	155	0	0	0	0	0	132	0	≥	136524480
العمل اليدوي للشهور ت١ - ك١	ساعة	7	7	112	0	37	28	60	110	60	62	42	0	39	69	42	≥	136524480
العمل الالي	ساعة	4	3	2.5	3	2.5	2.5	2.5	2.5	2.5	2.5	3	3	2.5	2.5	2.5	≥	18327600

Reference / Prepared by the researcher based on the data of the Iraqi Ministry of Agriculture and the Iraqi Ministry of Water Resources, as well as on the questionnaire

- The analysis results of the linear programming model that minimizing costs for the prevailing cropping pattern for the year (2020) without including legislative constraints:

After completing the formulation of the mathematical form of the objective function and the determinants of the first model of the linear programming model. These data were inputted into the computer for analysis and after applying the program (QSB) in the light of the data of model (1) without including legislative constraints. The analysis results of this model showed, as in Table (6) that the total target function amounted to about 8.8 billion. Despite the fact, that the total costs for the cropping pattern were 63.4, and this is also considered exaggerated, the plan chose the least expensive crops, which means that this plan achieved the goal of minimizing the costs necessary for the prevailing cropping pattern. It is noted that four crops appeared in this plan: barley, okra, zucchini, and lettuce, as this model suggests expanding the areas planted for crops. The analysis results also indicated that there is a large surplus of economic resources included in the simple Table (water, manual work, mechanized work), especially the water resource. The proposed cropping pattern in this scenario achieved the goal of minimizing cost, costs, but this plan did not show most of the crops, especially strategically important crops such as wheat, which is related to the issue of food security. As well as the most important vegetable crops, especially crops that the Ministry of Agriculture has banned from importing and which must be available for local products such as tomatoes, eggplants, cucumbers, onions, etc. Therefore, this plan is considered illogical and does not fit with the actual demand, and therefore it has been neglected and not relied upon. Although the objective function is of high value and importance, it is no more important given the need for other important crops, as the plan showed that all arable land introduced as a constraint has been fully exploited. This was accompanied by a decrease in the water needs of the governorate as well as the emergence of a surplus in most economic resources, especially human labor and water, and these surplus resources can be used for other economic activities.

Table (6) The analysis results of the linear programming model that reduces costs for the prevailing cropping pattern for the year (2020) without including legislative constraints

No.	Decision Variable	Solution Value	Unit Cost c(j)	Total Contribution	Constraint	Left Hand Side	Right Hand Side	Slack or Surplus
X1	Wheat	6410765.0000	254000.0000	0	Total area	443059000.0000	443059000.0000	0
X2	Barley	0	200000.0000	1282153000.0000	Winter area	274697000.0000	274697000.0000	16.0000
X3	Tomatoes	0	298000.0000	0	Summer area	168362000.0000	168362000.0000	0
X4	Watermelon	166314800.0000	287000.0000	0	Water Jan.	467152400.0000	357547900.0000	109604600.0000

X5	Okra	2047214.0000	222000.0000	36921880000.0000	Water Feb.	467152400.0000	375741200.0000	91411200.0000
X6	Zucchini	0	278000.0000	569125400.0000	Water Mar.	66664410000.0000	371226200.0000	66293190000.0000
X7	Pepper	0	266000.0000	0	Water Apr.	66664410000.0000	346982400.0000	66317430000.0000
X8	Potato	0	256000.0000	0	Water May	415993800.0000	415993800.0000	0
X9	Onions	0	272000.0000	0	Water Jun.	34611770000.0000	4267913000000	34184980000.0000
X10	Garlic	0	463000.0000	0	Water Jul	34611770000.0000	401913100.0000	34209860000.0000
X11	Beans	0	271000.0000	0	Water Aug.	65781260.0000	469892600.0000	65311380000.0000
X12	Cucumber	0	343000.0000	0	Water Sep.	65781260.0000	517466900.0000	65263800000.0000
X13	Beans	0	261000.0000	0	Water Oct.	34611770.0000	504381000.0000	34107390000.0000
X14	Eggplant	0	300000.0000	0	Water Nov.	46715240.0000	467152400.0000	0
X15	Lettuce	268286200.0000	187000.0000	50169530000.0000	Water Dec.	25401680000.0000	458159500.0000	24943520.0000
	Objective	Function	(MIN.) =	88942690.0000	Labor 1	21578500.0000	136524500.0000	21441970.0000
					Labor 2	12504370.0000	136524500.0000	12367840.0000
					Labor 3	17463050.0000	136524500.0000	17326530.0000
					Labor 4	17523870.0000	136524500.0000	17387340.0000
					Labor 5	1110853.0000	18327600.0000	1092525.0000

Reference: Organized by the researcher based on the results obtained using the WIN QSB statistical program

- The analysis results of the linear programming model that reduces costs for the prevailing cropping pattern for the year (2020), with the addition of legislative constraints:

To improve the results of solving the plan, a set of legislative or organizational constraints were included for the components of the previous plan. These constraints relate to the allocation of certain agricultural areas for some field and vegetable crops that did not appear in the results of the first plan, and they are the same ones that were used in the second plan for the first scenario. After completing the formulation of the mathematical form of the objective function and the determinants of the first model of the linear programming model. These data were inputted into (a computer) for analysis and after applying for the program (QSB) (for solving linear programming problems) with the inclusion of legislative constraints. The results of this plan are logical from the economic aspect of the decrease in costs in the cropping pattern of the governorate of Baghdad to about 85350570000 billion. In addition to the presence of most of the basic crops and vegetables for consumption, the results in Table (7) indicated that all available agricultural lands amounting to (443059) have been fully exploited. The proposed cropping pattern, with the addition of legislative constraints approved by the Ministry of Agriculture within its annual plans, or which the researcher deems important, indicated that five crops will appear during the winter season, which are wheat, barley, onions, beans, and lettuce. Besides, ten summer crops, namely, tomatoes, watermelon, okra, zucchini, peppers, potatoes, garlic, beans, cucumbers, and eggplants. This plan meets the demand needs on the one hand and minimizes cost, on the other hand, that is, it achieves the objective function. It was also evident from the results of the second plan of the second scenario that there is a surplus of water during the months of the productive year. There is also a surplus in human labor during the four seasons, and there is a surplus in mechanized work during the year, and this means that the needs for crops are much less than the available resources and that it can be used in other economic activities.

Table (7) The analysis results of the linear programming model that reduces costs for the prevailing cropping pattern for the year (2020) with the imposition of legislative constraints

No.	Decision Variable	Solution Value	Unit Cost c(j)	Total Contribution	Constraint	Left Hand Side	Right Hand Side	Slack or Surplus
X1	Wheat	155683000.0000	254000.0000	39543480000000.0000	Total area	443059.0000	443059000.0000	0
X2	Barley	108736000.0000	200000.0000	2174720000000.0000	Winter area	274697.0000	274697000.0000	0
X3	Tomatoes	9027000.0000	298000.0000	2690046000000.0000	Summer area	168362.0000	168362000.0000	0
X4	Watermelon	6377000.0000	287000.0000	1830199000000.0000	Water Jan.	22995660000.0000	357547900.0000	22638110.0000
X5	Okra	124310000.0000	222000.0000	27596820000000.0000	Water Feb.	23398660000.0000	375741200.0000	23022920.0000
X6	Zucchini	0	278000.0000	0	Water Mar.	54600050000.0000	371226200.0000	54228830.0000
X7	Pepper	5860000.0000	266000.0000	1558760000000.0000	Water Apr.	54600050000.0000	346982400.0000	54253080.0000
X8	Potato	3283000.0000	256000.0000	840448000000.0000	Water May	3734843000.0000	415993800.0000	3318849.0000
X9	Onions	4111000.0000	272000.0000	1118192000000.0000	Water Jun.	28463720000.0000	4267913000000	28036930.0000
X10	Garlic	645000.0000	463000.0000	298635000000.0000	Water Jul	28922190000.0000	401913100.0000	28520280.0000
X11	Beans	1320000.0000	271000.0000	357720000000.0000	Water Aug.	2989400000.0000	469892600.0000	29423500.0000
X12	Cucumber	9147000.0000	343000.0000	3137421000000.0000	Water Sep.	30359630000.0000	517466900.0000	29842160.0000
X13	Beans	4202000.0000	261000.0000	1096722000000.0000	Water Oct.	29213050000.0000	504381000.0000	28708670.0000
X14	Eggplant	10358000.0000	300000.0000	3107400000000.0000	Water Nov.	26259540000.0000	467152400.0000	25792380.0000
X15	Lettuce	0	187000.0000	0	Water Dec.	23398660000.0000	458159500.0000	22940500.0000
					Labor 1	6755226000.0000	136524500.0000	6618701.0000
	Objective	Function	(MIN.) =	85350570	Labor 2	13475610000.0000	136524500.0000	13339080.0000
					Labor 3	17761940000.0000	136524500.0000	17625410.0000
					Labor 4	9394826000.0000	136524500.0000	9258302.0000
					Labor 5	1403962000.0000	18327600.0000	1385634.0000

Reference: Organized by the researcher based on the results obtained using the WIN QSB statistical program

- **Comparison between the results of the first scenario and the results of the actual cropping pattern**

For each cropping pattern, whether prevalent or proposed, a set of economic indicators is important and is relied upon in determining this pattern. Here the plans for the cropping pattern are clear and summarized in Table 8 which shows a comparison of these indicators between the actual cropping pattern and the proposed cropping pattern, whether with or without legislative constraints. It is noted that the total arable area in the province of Baghdad has been completely exhausted in reality and the proposed plans, while the crops that were included in the actual plan were 15 winter and summer crops and became two crops in the proposed plan without restrictions and this is illogical and therefore constrained and then appeared in the plan with constraints. The total costs of the prevailing cropping pattern were 63.4 billion and in the plan without legislative constraints 8.8 billion, and with the presence of legislative constraints amounted to 8.5. This indicates the importance of the proposed plans and the extent to which they achieve the goal on the one hand and the misuse of resources and lack of planning in the current pattern on the other hand. That is if quantitative methods were followed in developing and drawing a cropping plan aimed at minimizing costs per dunum. The actual cropping pattern needs 71412355 human work hours, this is, an average of 178 hours per dunum, while it needs 47387602 hours by drawing a plan for the proposed cropping pattern with the addition of legislative constraints. This pattern certainly reduces the cost and thus increase profits and there is a surplus of work that can be exploited in other sectors and it reduces disguised unemployment. One dunum in the actual cropping pattern needs 2-6 working hours, while in the case of the proposed cropping pattern using the linear programming method, the dunum needs 1-3 working hours, which is a total of 1403962, which is the reason for the expansion of vegetable crops that need more work, especially in plowing and preparing the soil.

Table (8) Economic indicators of the actual and proposed cropping pattern

Model indicators	Actual cropping pattern plan	Results of the optimal cropping pattern without legislative constraints	Optimal cropping pattern results with legislative constraints
Suggested number of crops	15	2	15
Total cultivated area (dunum)	443059	443059	443059
Total costs billion dinars	63.4	8.8	8.5
Total annual need of water (m^3)	463474646	395945781	328935453
Excess quantities of water (m^3)	4649733654	4717302519	3943664004
Annual need of human labor (hours)	71412354	69069790	47387602
Annual need of mechanized work (hours)	1083221	1110853	1403962

Reference / Organized and calculated by the researcher based on the results of analyzing the study data and also on the questionnaire.
Source: Prepared by the authors (2022).

Third Scenario

The linear programming model that maximizes the net income of the water unit for the prevailing cropping pattern for the year (2020)

The third scenario is also divided into two parts: the first is the formulation of the linear programming model that maximizes the net income of the water unit for the prevailing cropping pattern without legislative constraints. Moreover, the second is the linear programming model that maximizes the profit margin of the water unit for the prevailing cropping pattern with legislative constraints, according to the following:

- Formulation of a linear programming model that maximizes the net income of a water unit for the prevailing cropping pattern without legislative constraints:

1. Objective Function Data: Believing in the magnitude and aggravation of the water problem in the recent period and because of its implications on the cropping pattern and production activities. The objective function was determined by maximizing the net water revenue for the cropping pattern in Baghdad Governorate, as well as identifying the surplus from the water resource. Therefore, it is necessary to choose a group of crops that can maximize the net revenue of the water unit, taking into account all of the land and water resources, manual work, and mechanized work, as this plan includes 15 crops.

MaxZ=231000X1+274000+77000X3+92000X4+161000X5+279000X6+177000X7+122000 X8+179000X9+268000X10+873000X11+112000X12+276000X13+134000X14+194000X15

2. The set of constraints: The same constraints were used in the first scenario, which included the area constraint within three constraints, summer, winter, and total area, the water constraints within 12 constraints according to the months, and the human work constraints with four constraints and the mechanized work constraints per year as mentioned previously, where the linear programming matrix is described in Table 9.

Table (9) Matrix of the mathematical formulation of linear programming model (the third scenario) The first model that maximizes the net revenue of the water unit for the prevailing cropping pattern for the year 2020

		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	الاشارة	الكميات المتاحة من الموارد
	MAX	231000	274000	77000	92000	161000	279000	177000	122000	179000	268000	873000	112000	276000	134000	194000		
	اجمالي المساحة الكلية	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		443059
	اجمالي المحاصيل الشتوية	1	1	0	0	0	0	0	0	1	1	1	0	1	0	1	≤	274697
	اجمالي المحاصل الصيفية	0	0	1	1	1	1	1	1	0	0	0	1	0	1	0	≤	168362
كانون ٢	م٣	93.77	72.87	0	0	0	0	0	67.04	0	98.03	0	0	45.3	0	0	≤	357547886
شباط	م٣	93.77	72.87	0	0	0	0	0	67.04	98.03	98.03	0	0	45.3	0	0	≤	375741257
اذار	م٣	93.77	72.87	169.28	131.73	208.11	203.2	113.05	67.04	98.03	98.03	77.45	146.16	45.3	83.17	116.18	≤	371226240
نيسان	م٣	93.77	72.87	169.28	131.73	208.11	203.2	113.05	67.04	98.03	98.03	77.45	146.16	45.3	83.17	116.18	≤	346982400
مايس	م٣	0	0	169.28	131.73	0	203.2	0	0	98.03	0	77.45	0	0	83.17	0	≤	415993783
حزيران	م٣	0	0	169.28	0	208.11	0	113.05	0	98.03	0	0	0	0	0	0	≤	426791314
تموز	م٣	0	0	169.28	0	208.11	0	113.05	0	0	0	0	0	0	83.17	0	≤	401913051
اب	م٣	0	0	0	131.73	208.11	0	113.05	67.04	0	0	77.45	146.16	0	83.17	116.18	≤	469892571
ايلول	م٣	0	0	0	131.73	208.11	0	113.05	67.04	98.03	98.03	77.45	146.16	0	83.17	116.18	≤	517466880
تشرين ١	م٣	0	0	0	131.73	208.11	0	113.05	67.04	98.03	98.03	77.45	0	45.3	83.17	0	≤	504380983
تشرين ٢	م٣	93.77	72.87	0	0	0	0	113.05	67.04	98.03	98.03	0	146.16	45.3	83.17	0	≤	467152457
كانون ١	م٣	93.77	72.87	0	0	0	0	0	67.04	98.03	98.03	0	0	45.3	0	92.94	≤	458159451
العمل اليدوي للشهور ك٢ ـ اذار	ساعة	5	6	22	10	32	59	26	30	70	48	20	17	20	24	60	≤	136524480
العمل اليدوي للشهور نيسان ـ حزيران	ساعة	3	2	65	25	74	90	73	65	0	0	24	143	21	75	0	≤	136524480
العمل اليدوي للشهور تموز ـ ايلول	ساعة	0	0	170	75	105	0	140	155	0	0	0	0	0	132	0	≤	136524480
العمل اليدوي للشهور ت١ ـ ك١	ساعة	7	7	112	0	37	28	60	110	60	62	42	0	39	69	42	≤	136524480
العمل الالي	ساعة	4	3	2.5	3	2.5	2.5	2.5	2.5	2.5	2.5	3	3	2.5	2.5	2.5	≤	18327600

Reference / Prepared by the researcher based on the data of the Iraqi Ministry of Agriculture and the Iraqi Ministry of Water Resources, as well as the questionnaire form.

Table (10) The analysis results of the linear programming model that maximizes the net revenue of a water unit for the prevailing cropping pattern for the year (2020) without including legislative constraints

No.	Decision Variable	Solution Value	Unit Cost c(j)	Total Contribution	Constraint	Left Hand Side	Right Hand Side	Slack or Surplus
X1	Wheat	0	231000.0000	0	Total area	443059.0000	443059.0000	0
X2	Barley	0	274000.0000	0	Winter area	274697.0000	274697.0000	0
X3	Tomatoes	0	77000.0000	0	Summer area	168362.0000	168362.0000	0
X4	Watermelon	0	92000.0000	0	Water Jan.	0	357547900.0000	357547900.0000
X5	Okra	0	161000.0000	46973000000.0000	Water Feb.	0	375741200.0000	375741200.0000
X6	Zucchini	168362.0000	279000.0000	0	Water Mar.	55486440.0000	371226200.0000	315739800.0000
X7	Pepper	0	177000.0000	0	Water Apr.	55486440.0000	346982400.0000	291496000.0000
X8	Potato	0	122000.0000	0	Water May	55486440.0000	415993800.0000	360507400.0000
X9	Onions	0	179000.0000	0	Water Jun.	0	4267913000000	426791300.0000
X10	Garlic	0	268000.0000	0	Water Jul	0	401913100.0000	401913100.0000
X11	Beans	274697.0000	873000.0000	239810500000.0000	Water Aug.	21275280.0000	469892600.0000	448617300.0000
X12	Cucumber	0	112000.0000	0	Water Sep.	21275280.0000	517466900.0000	496191600.0000
X13	Beans	0	276000.0000	0	Water Oct.	21275280.0000	504381000.0000	483105700.0000
X14	Eggplant	0	134000.0000	0	Water Nov.	0	467152400.0000	467152400.0000
X15	Lettuce	0	194000.0000	0	Water Dec.	0	458159500.0000	458159500.0000
					Labor 1	15427300.0000	136524500.0000	1210972000.0000

Objective	Function	(MAX.) =	286783500000.0000	Labor 2	21745310.0000	136524500.0000	1147792000.0000
				Labor 3	0	136524500.0000	136524500.0000
				Labor 4	16251410.0000	136524500.0000	120273100.0000
				Labor 5	1244996.0000	18327600.0000	17082600.0000

Source: Prepared by the authors (2022).

- The analysis results of the linear programming model, which maximizes the net income of a water unit for the prevailing cropping pattern without including legislative constraints:

The mathematical form of the objective function and its determinants was formulated for the linear programming model, the aim of which is to maximize the net water revenue for the cropping pattern of the province of Baghdad. Then, the data was entered to analyze with a program to solve the problem of linear programming (QSB) without legislative constraints by the Ministry of Agriculture, which means developing an alternative plan for the current cropping pattern. Table 10 also shows the results of the analysis of the linear programming model which maximizes the total net return of the water unit in the light of the areas proposed in the plan. The total objective function reached 286.7 billion Iraqi dinars by two crops, zucchini, and beans. However, it was noted that the proposed crop pattern in the third Scenario achieved the goal of maximizing the net return of the water unit and gave us a profit exceeding the profit in the current plan of Baghdad Governorate. The proposed cropping pattern in this scenario achieved the goal of minimizing cost, costs, but this plan did not show most of the crops, especially strategically important crops such as wheat, which is related to the issue of food security. As well as most important vegetable crops, especially crops that the Ministry of Agriculture has banned from importing and which must be available for local products such as tomatoes, eggplants, cucumbers, onions, etc. Therefore, this plan is considered illogical and does not fit with the actual demand, and therefore it has been neglected and not relied upon

- Formulating a linear programming model that maximizes the net income of a water unit for the prevailing cropping pattern with the imposition of legislative constraints:

To improve the results of solving the plan, a set of legislative or organizational constraints for the components of the previous plan (the third scenario) were included. These constraints are related to the allocation of certain agricultural areas to some field and vegetable crops that did not appear within the results of the first plan, which were used in the second plan of the first scenario, that are constraints imposed by the Ministry of Agriculture and imposed within the framework of improving the model to suit the economic logic. After formulating the mathematical form of the objective function and the determinants of the first model of the linear programming model. The data was inputted into the electronic machine (computer) for analysis and using the (QSB) program (for solving linear programming problems) in the light of the model (1) data, where legislative constraints were not included. The proven results in Table (11) showed that all available agricultural lands amounting to (443059) dunums have been fully exploited. Furthermore, the results of this plan are economically logical to maximize the net return of the water unit for the proposed crop composition of Baghdad Governorate, which amounted to about 160818600000 m^3. The proposed cropping pattern proposed a return per unit of water that is 411.5% higher than the water yield achieved by the prevailing cropping pattern of 31434534000 dinars, thus achieving the plan's goal of maximizing the net water yield The plan showed 15 crops distributed between two seasons: the winter season appeared in the crops which are wheat, barley, onions, beans, lettuce. Besides, ten summer crops, namely, tomatoes, watermelon, okra, zucchini, peppers, potatoes, garlic, beans, cucumbers, and eggplants. The plan reduced some of the areas of crops, such as barley, and expanded the area of some crops such as beans and zucchini based on the yield of water. The results of the proposed cropping pattern are according to the goal of maximizing the water yield and minimizing the cost that there is a surplus in water during the months of the year, that is, the proposed need is less than the available need per acre. There is also a surplus of human labor during the planting seasons as well as a surplus of mechanical labor during the year.

Table (11) The analysis results of the linear programming model, which maximizes the net revenue of a water unit for the prevailing cropping pattern for the year (2020) without including legislative constraints

No.	Decision Variable	Solution Value	Unit Cost c(j)	Total Contribution	Constraint	Left Hand Side	Right Hand Side	Slack or Surplus
X1	Wheat	155683.0000	231000.0000	35962770000.0000	Total area	443059.0000	443059.0000	0
X2	Barley	17197.0000	274000.0000	4711978000.0000	Winter area	274697.0000	274697.0000	0
X3	Tomatoes	9027.0000	77000.0000	695079000.0000	Summer area	168362.0000	168362.0000	0
X4	Watermelon	6377.0000	92000.0000	586684000.0000	Water Jan.	16321190.0000	357547900.0000	341226700.0000
X5	Okra	11358.0000	161000.0000	1828638000.0000	Water Feb.	16724190.0000	375741200.0000	359017100.0000
X6	Zucchini	113012.0000	279000.0000	31530350000.0000	Water Mar.	54556960.0000	371226200.0000	316669300.0000
X7	Pepper	5860.0000	177000.0000	1037220000.0000	Water Apr.	54556960.0000	346982400.0000	292425500.0000
X8	Potato	3223.0000	122000.0000	393206000.0000	Water May	33620430.0000	415993800.0000	382373400.0000
X9	Onions	4111.0000	179000.0000	735869000.0000	Water Jun.	4957279.0000	4267913000000	421834000.0000
X10	Garlic	645.0000	268000.0000	1728600000.0000	Water Jul	5415752.0000	401913100.0000	396497300.0000
X11	Beans	90688.0000	873000.0000	79170630000.0000	Water Aug.	13556710.0000	469892600.0000	456335900.0000

X12	Cucumber	9147.0000	112000.0000	1024464000.0000	Water Sep.	14022940.0000	517466900.0000	503444000.0000
X13	Beans	4202.0000	276000.0000	1159752000.0000	Water Oct.	12624140.0000	504381000.0000	491756900.0000
X14	Eggplant	10358.0000	134000.0000	1387972000.0000	Water Nov.	19585060.0000	467152400.0000	447567400.0000
X15	Lettuce	2171.0000	194000.0000	421174000.0000	Water Dec.	16925960.0000	458159500.0000	441233500.0000
	Objective	Function	(MAX.) =	160818600000.0000	Labor 1	11175060.0000	136524500.0000	125349400.0000
					Labor 2	17246100.0000	136524500.0000	119278400.0000
					Labor 3	5892676.0000	136524500.0000	130631800.0000
					Labor 4	11577200.0000	136524500.0000	124947300.0000
					Labor 5	1402877.0000	18327600.0000	16924720.0000

Source: Prepared by the authors (2022).

Comparison between the results of the third scenario and the results of the actual cropping pattern

The comparison of economic indicators between the prevalent cropping pattern in Baghdad governorate and the proposed cropping pattern is important and is relied upon in determining this pattern, whether with or without legislative constraints. It is noted that one dunam in the actual plan achieves a net water return of 78.3 thousand dinars, which is low for two reasons, the first is the decrease in productivity and the second is the decrease in the profit of one dunam. But, the net water return recorded 63.4 billion in the plan without legislative constraints, which is the highest value, and with the presence of legislative constraints amounted to 8.5. However, it came within the framework of an illogical plan that emphasized the concept of return and excluded other issues related to food and others indicators. In the proposed cropping pattern, including these constraints, the net water yield was about 362.9 thousand dinars, which is also rewarding and high and exceeds by about 363% of the actual net return, i.e. about 284.6 thousand dinars. The proposed plans also reduced the total annual water needs with the proposed plans compared to the actual plan, as the actual cropping pattern needs 463474646 m3. Though the proposed cropping pattern with the addition of legislative constraints needs 262867570 m3, that is, it reduced water use by 43.2%, which is very important due to the problem of water scarcity and its impact on the crop composition, i.e. with this excess amount, other crops can be grown and not affected by water scarcity. Finally, the economic efficiency of water use reached 19.5% and the inefficiency in cropping pattern in terms of water yield amounted to 80.5%, and this gives us an indication of the inefficiency of water use and the adoption of traditional methods of irrigation, which affected the efficiency goal.

Table (12) Economic indicators of the actual and proposed cropping pattern

Model indicators	Actual cropping pattern plan	Results of the optimal cropping pattern without legislative constraints	The optimal cropping pattern results in legislative constraints
Suggested number of crops	15	2	15
Total cultivated area (dunum)	443059	443059	443059
The total profit margin for water unit (dinars)	31434534000	286783500000	160818600000
Dunum profit of water unit (dinars/dunum)	78352.6	647280.6	362973.3
Total annual need for water (m^3)	463474646	230258160	26286752
Excess quantities of water (m^3)	4649733654	4892963200	4850381000
Annual need of human labor (hours)	71412354	53424020	45891036

Reference / Organized and calculated by the researcher based on the results of analyzing the study data and also on the questionnaire

CONCLUSION

The cropping pattern prevailing in the province of Baghdad was not based on scientific bases and did not follow sound scientific planning, but was made according to the desires and needs of farmers, and part of it was based on a social heritage and certain habits. With the policy of subsidizing grains (wheat, barley) it was found that there is an expansion in the areas of grain crops, and there are crops, although they achieve high profits, but did not expand their cultivation due to the difficulty of farmers adopting new crops such as beans. Besides, the absence of important crops in some years of study and the decrease in the areas of others crops, especially vegetables such as green peppers, green peas, and zucchini. Also, the agricultural areas in the province of Baghdad decreased and were affected by the process of population and urban sprawl, as well as climate and water factors, as the agricultural plan was reduced based on the decreasing quantities of water. Plus, the small size of areas in general in Baghdad governorate and their dwarfing for many reasons made them unable to absorb advanced technology and benefit from the advantages of large production, but remained within the scope of the family farm. The high costs of producing some crops, which weakened farmers' funding, led to the lack of expansion in their cultivation and had a significant impact on the cropping pattern. It was also concluded that there were no accurate statistics available on water needs and water rations, but even in some data related to the areas of some crops in the Ministry of State, there was a contradiction in some of them. Furthermore, the instability of prices and their decline in some cases due to the dumping of the market and the failure to protect the local product made the cropping pattern achieve a low total profit compared to the optimal plans. The proposed cropping pattern aims at maximizing agricultural profit. It achieved a profit that exceeds the actual profit by 67.5% indicating the importance of the proposed plan and the misuse of resources in the current plan. The proposed plans in general showed that there is a surplus of human labor, mechanized work, and water in most months of the year. It can conclude from it that the actual plan uses more resources than the needs that achieve the objective function, and thus reflected in the decrease in profits and the increase in costs. The study recommended the necessity of working on the application of the proposed cropping pattern, which contributes to minimizing the cost and maximizing the net revenue of the water unit by using the economic tools represented in the concepts of subsidy. The ministries with an impact on the agricultural aspect should be involved, such as the Ministry of Electricity, the Ministry of Industry, and the Ministry of Trade. Improving water use efficiency by applying modern irrigation methods in every Baghdad governorate, whether center pivot sprinkler irrigation for large areas or solid set sprinkler irrigation for small areas that are planted with grain or drip irrigation systems for vegetable crops. This is done by providing concessional loans to purchase these technologies and the imposition of a tax on the use of water and it is not free. Develop alternative plans to benefit from surplus economic resources when implementing optimal plans and exploit them in other economic activities. For example, establishing manufacturing industries within rural areas that absorb surplus labor on the one hand and help in price stability on the other. Moreover, activating risk management strategies (adjustment to risk, risk mitigation, risk prevention), through institutional diversification, vertical integration, insurance, and adjusting the level of input use. Otherwise, the state guarantees this through the presence of factories and companies, and the importance of legislating and activating laws to protect agricultural lands from being overrun by urban or industrial encroachment, which affects the area of arable lands, and thus the cropping pattern in the governorate.

REFERENCES

Abdullah, Asaad Abdul-Amir, 2021, Analytical study of optimal plans for the use of irrigation water in Iraqi agriculture for the period (2017-2020), Master's thesis, College of Agriculture, University of Baghdad.

Al-Hassan, Saad Aziz, 2015, an economic analysis of wheat crop productivity in reclaimed and non-reclaimed lands in light of risk and uncertainty in Iraq, Ph.D. thesis, University of Baghdad, College of Agriculture, Department of Agricultural Economics.

Al-Husseini et al., Muhammad Al-Husseini Muhammad, Muhammad Ibrahim Muhammad Al-Shahawi, Samerah Nima Kamel Al-Thamer, 2014, An economic analysis of the uses of land and water resources in Iraq, Department of Agricultural Economics, University of Alexandria.

Dat , P. M. (2023). Export of some key Agricultural products of Vietnam. International Journal of Professional Business Review, 8(1), e0417. https://doi.org/10.26668/businessreview/2023.v8i1.417

El-Shazly et al., Fawzi Abdel Aziz, Mahmoud El-Sayed Issa Mansour, Musa Abdel-Azim Ahmed, Imad Abdel-Masih Shehata, 2009, a study on the Egyptian cropping pattern in light of risk and the local and international variables, Center for Economic and Financial Research and Studies, Faculty of Economics and Political Science, University of Cairo.

Gorantiwar, S.Dand I.K.Smout(2005).”A multilevel approach for optimizing land and water resources and irrigation deliveries for tertiary under irrigation schemes ll: Application “ Journal of the Irrigation and Drainage Division, ASCE,131(3):264-272.

Huang G., Loucks D.2010. "An Inexact Two-Stage Stochastic Programming Model for Water Resources Management Under Uncertainty" Civil Engineering Environmental Systems, vol. 17,2000:95-18,

Ismail, Imad Ammar, 1981, Determining the optimal cropping pattern for the state farm in Hawija - an analytical study using linear programming, Master's thesis, College of Agriculture, University of Baghdad.

Mohamed, Heba. F. and Haji, M.A.M. 2015. The Impact of Risk on Decision Making in the Cropping Structure.J.Agri. Econom and Socialsci. Mansoura Univ. Vol.6(12) : 2007-2020

Sarjiman, Y., Lazim, H. M., & Lamsali, H. (2023). A Lean Management Approach of Rice Subsidy Distribution: Some Findings from a Study in Selangor. International Journal of Professional Business Review, 8(1), e01257. https://doi.org/10.26668/businessreview/2023.v8i1.1257