CROPPING STRUCTURE PROPOSAL FOR BAGHDAD GOVERNORATE UNDER WATER DEFICIT

Ithmar. M. Hamza and Eskander. H. Ali

Department of Agricultural Economics, College of Agricultural Engineering Sciences, University of Baghdad, Iraq
*Email: Eskanderhali81@gmail.com

ABSTRACT

The research was aimed to prepare an optimal cropping plan in Baghdad governorate that minimize the cost and maximize the net return of the water unit. This research was carried out using the goal programming method, which is a technology applied to solve the problems related to multiple goals, within the general framework of linear programming. The requirements of one donum were collected by a questionnaire from 100 farmers in Baghdad governorate during 2020, and the available resources were collected from the Ministry of Agriculture. The annual water ration rate per donum for all crops was about 18,954.15 m^3 $dunum^{-1}$, while the total water requirements of the cultivated winter crops amounted to 115828443.3 m^3 $million^{-1}$, while the water requirements of the cultivated summer crops amounted to 147646203 m^3 $million^{-1}$, and by calculating the net yield of water unit 6, it was revealed that the highest net return was achieved in the production of beans, as it reached 360 d. m3, followed by the okra crop, which achieved a return of 235 d. m^3, this is due to the high economic yield of these crops. While the wheat crop as a cash crop, the net water yield was 130 d. m^3. The total cost of the current cropping structure amounted to 63.4 billion dinars, while the proposed optimal structure amounted to 8.5 billion dinars. As it provides about 55 billion dinars, the net revenue of the actual unit of water in Baghdad Governorate was 31.4 billion dinars and the optimal plan produced 160.8 billion dinars, which returned to a net return of 362.9 thousand dinars per water donum. The optimal crop structure revealed eight crops, three of which were winter crops, and suggested an increase in wheat area by 73.3%. The research recommended the application of the proposed optimal crop structure using economic tools, and work on using modern irrigation methods to improve water use efficiency, as well as supporting protected agricultural projects.

Keywords: programming goals, net water revenue, total deviations, resource management, decision problems.

INTRODUCTION

The scarcity water is one of the main issues facing the agricultural sector in Iraq. The main problem is about how to rationalize the use of water in this sector considering the water availability, as the water resource from the Tigris and Euphrates rivers has decreased in recent years, and on the other hand, the demand for the revenue of the water unit has increased. Also, the wasteful use leads to reduce the available water required for new areas of reclaimed lands. Accordingly, it is necessary to find the best alternatives for the current cropping structure (2), as the agricultural sector depends on the water availability more than any other productive sector in the national economy.

The water availability required to irrigate various agricultural crops is the most important determinant of expansion in this sector, and the amount of available water is the important issue for agricultural crops expansion. Where the water requirements vary among the crop and regions, that shall be managed to ensure the maximum extent possible and with high efficiency.

In light of the increased pressure on the limited agricultural resources and population needs; the privation of an entity to determine the crop structure and the prices of production requirements under the import pressure, the development of these resources has become one of the main priorities to minimize the economic risk and ensure the stability of farm income and maximize economic efficiency of the water unit, which require to take water into consideration within the agricultural planning models, is important to study the water deficit during the determination and selection of agricultural activities and considering cost and return. The cropping structure will guide the decision maker in enhance policies, decrease obstacles to agricultural production, rationalizing the use of resources, and develop a clear policy based on scientific foundations for resource development.

The agricultural sector is one of the largest sectors exposed to many risky factors, the agriculture is generally characterized as a biological industry, as it linked to many factors and variables and the associated biological repercussions, which means that agricultural production and the achieved return are linked to many economic variables and fluctuations. This means that agricultural production is exposed to significant risks at a time when agricultural policies seek to achieve stability for agricultural returns. Therefore, it became necessary to clarify the points of risk (10).

Therefore, taking decisions related to the crop structure takes a certain risk, which requires reconsidering the crop structure among time in order to achieve relative stability in farmers' incomes and maintain an acceptable level of risk because the crop structure reflects the reality of food production and the extent of society's dependence on its local resources.

And then to identify the reality of the crop structure, which is the result of the interaction of economic, natural, technological, and legislative factors, which leads to the production of agricultural crops that make up the crop structure, may be mixed in its concept with the agricultural cycle. However, it can be defined as a list of different agricultural crops that will be produced, coupled with the areas allocated to each of them in different seasons. The agricultural cycle is the system whereby certain crops are successively planted in a specific area of land during a specified period of time, and the cycle is named after the main crop. As for the expression of the crop structure, it is one of the synonyms of the crop structure, but for basic crops only, while the expression of the agricultural mode expresses both together in addition to other overlapping variables.

The optimal cropping structure is also defined as reconsidering the area of agricultural land resources that are currently available among their alternative uses while minimizing the investment expenses with the aim of maximizing net agricultural income in light of balanced agricultural development with other components of economic, social, organizational, and political development. The optimal cropping structure is the method that achieves the largest possible profit margin, and this depends on input and output cost and productivity. It is a dynamic process and varies among years according to the farmer needs and two of the different crop's profits during the previous year.

It also differs based on the economic or national individual point of view and given the existence of a competitive relationship on limited agricultural land between different crops in one agricultural season. The increase in the area of one crop is always at the expense of the other crops, especially if the total demand of agricultural land is fixed and limited. The crop structure aims to achieve food security that targets the interest of all members of society, especially the poor one, which can be satisfied through the available commodities, whether from local production or from foreign trade. The overall food security can be improved by allocating resources between food commodities and cash commodities. The greater the degree of unwillingness to risk, the greater the expansion in the substitution of food crops for cash crops, which affects the reduction of the agricultural sector's contribution to attracting foreign exchange earnings. Therefore, it is necessary to develop a clear plan for the advancement of the agricultural sector and food industries by reconsidering the crop structure that achieves food security and apply the linear programming and operations research in planning to build a model that takes into account the desired goals, which has attracted the attention of many researchers such as (11), (3) (9), (5), (12), and (8)

The research problem relayed on Baghdad governorate that has the elements of agricultural development and possesses a measure of economic resources, and these resources have not been exploited in an economic manner. Also, a decrease in the efficiency of resource use for most agricultural crops occurred with a decrease and instability in the amount of productivity of the cultivated crops, , the issue of employment, and the decrease in the levels of the Tigris River. Accordingly, the research was aimed to develop a clear plan for the agricultural sector in the governorate of Baghdad by reconsidering the current crop structure and reaching an optimal crop structure that achieves food security, considering the potential risk factor in water shortage and directing the use of available resources with the maximum efficiency possible to maximize the income.

MATERIALS AND METHODS

The methodology relied on two types of data in order to achieve the research objectives: The first is cross-sectional data collected from 100 farmers in the governorate of Baghdad to determine the costs and revenues of all crops grown in the governorate to calculate the total cost per dunum and the profit margin for each dunum and its needs of economic resources as well as the net return achieved of the water unit. The second type of data is secondary data obtained from the Ministry of Agriculture and the Ministry of Planning.

The research method represented the application of programming goals, which is a more common model for addressing multi-objective problems, and in addition, it is possible to deal with multiple goals, which are measured by different units of measurement. The model provides a large amount of data for decision makers to reach the right decision and provides more understanding of the problem nature. The goal programming method is one of the most important methods of mathematical programs aimed at reaching optimization, as it is an extension of the traditional linear programming methods with a single goal.

This model has invented by Cooper and Ferguson, who were relied on by the Generac Electric Corporation to prepare a wage schedule for workers in one of the production divisions in the company. Then, several attempts were made to develop this software and its definitions were varied. Aouni, (1998) defined it as a technique used to solve multi-objective decision problems, it also can be defined as a mathematical model that aims to find the best solutions and the closest to the values of a number of predetermined goals. In another definition, goal programming is a technology used to solve problems with multiple goals, within the general framework of linear programming. (7). It is important to note in linear programming that the goal is optimization, while here in programming the goals, the goal is saturation, and the changes are linear and non-linear, and in programming goals, the goal function is deviation variables, unlike in linear programming, which were decision variables. It should also be arranged according to importance and unequal importance as in linear programming, where it is possible by managing problems with multiple or conflicting goals, whether instantaneous or in stages, where the multiple goals programming model was formulated by defining the goals to be achieved and the corresponding values for each goal. Then each goal is expressed by the goal constraint in the form of an equation that contains two variables, one of which is the quantity in excess of the target value, and the second variable is the missing quantity,

These two variables are called deviating variables, and the goal function is formulated in the form of minimizing the sum of the deviations variables, and it is possible to estimate a coefficient corresponding to each goal known as "priority coefficient" which reflects the degree of preference of the decision maker for the goal (14), and the formulation of the goals programming model is according to The following equation (18):

Min Z=∑pi$(D_i^+ + D_i^-)(D_i^+ + D_i^-)$
Subject to
$\sum aijXi + Di -_{Di} += bi$
Xi,Di-,Di+≥0

RESULTS AND DISCUSSION

1- The reality and needs of the cropping structure in Baghdad governorate: Agriculture is one of the main economic activities that contribute to the national economy. Food security is in line national security, and achieving food security depends primarily on providing food from local agricultural production. The advancement of the agricultural sector also contributes to vary the economy, alleviate the poverty, improve the trade balance, and achieve the progress of all related sectors. In addition to the fact that the local product is safer and healthier to the consumer compared to the importation, since most of the diseases of the era are related to food and food consumption, and the development of the agricultural sector is reflected positively on improving the environmental reality.

Therefore, the agricultural sector is the mainstay of the economy in the least developed countries, as it represents the most of total domestic product (ranging between 30-60% in two thirds of these countries), and a large proportion of the labor which may reach 40%, and may even reach 90% in other countries, as it represents a major source of currency (up to 25%, and may even reach 95% in three quarters of the least developed countries). The strong links (pre-and post-production) that linking agriculture to the rural sector and other sectors of the economy provide an additional paying capability for growth and income .

Hence, it is unable to achieve tangible progress in enhance the economic growth, alleviate poverty and raise the level of food security in most of these countries without upgrading the human and productive capacities of the agricultural sector and increasing its contribution to economic and social development in general. As a strong food and agricultural system is one of the main pillars of any comprehensive strategy for economic growth and development. This is the view of the document prepared by the Department of Economic and Social Policies of the FAO .It is also possible to note the extent of the problem from the horrific decline in the productivity of the lands and the lack of production conditions in the reclaimed or mainly cultivated areas.

As the quantity of food demand is directly affected by the available and cultivated lands in terms of area, type, or production capacity, as the total area of Iraq is 173 million dunums, and the arable lands are estimated to be 30 million donums, which constitutes 17.3% of the total area of Iraq and that the arable area is still not fully exploited. As the exploited area is less than 23 million dunums, or one third of the arable lands outside agricultural activity (1).

• Total and cultivated area of Baghdad Governorate

Table (1) revealed the total area in Baghdad, which amounted to (1822000) dunams for the period (2018-2020), and it represents the administrative area of Baghdad governorate distributed over (10) districts and (32) sub-districts, and this area is fixed for the years of study and it is not subject to change, followed by Diyala, Anbar, Babylon, and Salah al-Din. Baghdad population reached (9,400,000), and it ranks first in terms of population, and that this area constitutes (1.2%) of the area of agricultural area in Iraq. As this area in 2018 was 41,920 dunams, or 17.2% of the area of Baghdad governorate, and this area decreased in comparison to previous years, due to population growth, urban expansion, and desertification. The cultivated area reached (242,497 dunums) in 2018, which forms 13.3% of the arable area of Baghdad that associated with agricultural production.

Table 1. Total, arable, and cultivated area (dunums) in Baghdad Governorate during the period of (2018-2020)

year	Total area	Cultivated area (Donum)	Non-cultivated area (Donum)	Percent (%)
2018	**1822000**	242497	**41920**	**14.7**
2019	**1822000**	241670	**41920**	**14.7**
2020	**1822000**	401193	**41920**	**14.7**

reference: Organized and calculated by the researcher based on the Ministry of Agriculture and Planning data.

- **Crop structure in the exploited agricultural lands in Baghdad Governorate (summer crops)**

The crop structure is determined to some extent by the relative importance of agricultural production on the one hand, and the availability of agricultural and natural productive resources on the other hand, which shows the nature of resource use to a large extent. As the crop structure in the governorate shows the size of economic activity in how agricultural resources are used which allows to evaluate the crop specialization and its direction in that governorate and the extent of its stability and dependence on the comparative advantage that distinguishes the crop from the rest of the crops as well as the relative benefit in its cultivation compared to other crops. In order to identify the nature of the cropping structure prevailing in the governorate, Table 5 revealed that there is a discrepancy in the agricultural area of most of the crops for the summer season (2017-2018, 2018-2019, 2019-2020), respectively,

As we note in the light of this table that the crops structure that were planted in the three seasons (29) crops at the level of Baghdad governorate and in general are cereal field crops (yellow and white corn, Lucerne seeds, millet seeds), vegetable crops and fodder crops, as well as oil crops such as sesame Some observations can be summarized from Table 2:

1- The fluctuation in the areas of crops planted in the seasons (2018, 2019 and 2020), where there is an expansion in the cultivation of some crops (yellow corn, green beans, paper, watermelon, okra, eggplant, cucumber, tomato, onion, sweet pepper, Lucerne, fodder mixtures) and a decrease in some areas of other cultivated crops (millet, Lucerne, and sorghum seeds, sesame, onions, green peas, green beans, mung, pine trees, hot peppers, radishes, parsnip, alfalfa, sorghum fodder, millet fodder).

2- The limited cultivation of some crops in the season (2018, 2019) and their absence in 2020 season, and the crops that are restricted to cultivation are (millet seeds, Lucerne seeds, green peas, onions, pine trees, hot peppers, chard, and sorghum.

3- There is also a limited cultivation of some crops in the season (2019,2020) and their absence in the year 2018. The crops are (sesame, green peas, radish).

4- The total cultivated area for the three seasons is characterized by instability, as it changes among years. The total cultivated area for the 2018 agricultural season amounted to 53,955 dunums, while the total cultivated area for 2019 amounted to 80,168 dunums. While the total cultivated area for the 2020 season amounted to 152,166 dunums, meaning there is a continuous increase for each season.

reference: Organized and calculated by the researcher based on the Ministry of Agriculture and Planning data.

• Crop structure in the exploited agricultural lands in Baghdad Governorate (winter crops)

In order to identify the nature of the cropping structure prevailing in the governorate and the crops of the winter season, Table 3 revealed that there is a discrepancy in the agricultural area of most of the crops, as well as an increase in the agricultural area of grains from the year 2018 to the year 2020, and we also note that the largest area planted with grain was in 2020, reaching 172880 dunums, and the lowest area was in 2019. This fluctuation is due to several things, including the security conditions that the governorate witnessed, as well as the scarcity of water and the environmental conditions, considering that the grain group included wheat and barley crops during the three seasons (2018, 2019, and 2020). As for legumes, which included peas, beans, cowpeas they witnessed fluctuations in the cultivated area as well. The highest area was in 2020 and the lowest in 2018 due to the high prices of these crops and the increase in their economic returns, which prompted producers to plant these crops.

As for the group of onions and tubers that contained all species of onions and garlic, as they increased throughout this period, while the winter vegetable crops that contained the crops of eggplant, tomato, water cucumber, okra and other crops reached the highest area in 2020 as it reached 7330 dunums, which fell to the lowest level. The year 2019 is due to fluctuations in the prices of these crops. Data in this table revealed that the cereals ranked first in terms of area, as the cultivated area during that period was estimated at 424,718 dunums, followed by the summer crops with about 286,289 dunums, then Winter vegetable crops, followed by oil crops and leguminous crops.

Table 2. Crop structure in the exploited agricultural lands in Baghdad governorate during the period of (2018-2020) (summer crops).

T	The crop	Area(d)			Produce (t)		
		2018	2019	2020	2018	2019	2020
1	Corn	3306	32562	39887	2135	27040	31375
2	Millet	20	120	0	3	45	0
3	Alfalfa	5	0	0	2	0	0
4	Sorghum	48	0		56	0	
5	Sesame	0	599	400	0	165	80
6	Onion	1563	2072	4111	3490	4404	12333
7	Scallions	1032	18	0	1754	23	0
8	Pea	0	19	0	0	25	
9	Green bean	722	531	1320	910	647	1445
10	Vigna	2979	2536	8422	7062	6427	12633
11	Mung bean	68	1091	1000	74	1074	500
12	Watermelon	5042	2590	6377	17716	8003	20853
13	Melon	4041	2399	7939	11145	5625	20959
14	Okra	4358	3797	11358	8362	7324	17037
15	Eggplant	5818	5239	10500	24339	28714	45885
16	Cucumber	4580	5063	9147	9621	9571	22410
17	Armenian cucumber	2759	1888	6465	8471	5733	15839
18	crookneck squash	171	187	0	296	328	0
19	Squash	2642	2112	6215	10718	8078	16470
20	Tomatoes	7909	5006	9027	33581	18987	30240
21	Bell pepper	2742	2744	5860	7889	6753	12892
22	Chili pepper	322	457	0	915	357	0
23	Radish	0	8	20	0	20	47
24	Chard	128	23	0	153	40	0
25	Clover	498	265	7726	910	1985	25110
26	Alfalfa	1336	2639	9845	2065	14854	55920
27	Fodder mixture	1296	2302	6045	2312	8402	23005
28	White corn fodder	188	2878	0	387	5180	0
29	Millet fodder	382	1023	502	1185	1631	744
Total		53955	80168	152166	155551	171435	365777

Table 3: Crop structure in the exploited agricultural lands in Baghdad governorate during the period of (2018-2020) (winter crops):

T	The crop	Area			Produce		
		2018	2019	2020	2018	2019	2020
1	Wheat	128390	102101	155683	91141	86416	133831
2	Barley	12845	8502	17197	5466	4772	8816
3	Onion	123	361	515	324	757	901
4	Scallions	107	68	14	181	129	49
5	Pea	40	19	39	38	25	38
6	Green bean	332	116	287	436	173	287
7	Vigna	93	0	0	320	0	0
8	fava bean	1932	3196	4202	3483	5616	9980
9	Okra	873	286	563	2103	729	619
10	Eggplant	1711	760	1416	108	4889	8269
11	Cucumber	5014	1187	2299	18220	4528	8047
12	crookneck squash	14	14	19	35	44	60
13	Squash	1057	479	861	3145	1853	2669
14	Tomatoes	925	682	1238	3459	2701	4271
15	Bell pepper	2220	529	953	7148	1481	2287
16	Chili pepper	154	72	0	379	226	0
17	Garlic	250	425	645	340	854	1290
18	Dry Garlic	5	0	15	15	0	19
19	Carrot	429	88	285	1201	179	784
20	Beta vulgaris	495	717	1241	1119	1577	3258
21	Turnip	930	1094	1092	2845	2784	2730
22	Onion	1187	1013	1832	5530	4209	7605
23	Radish	211	174	275	725	553	825
24	Chard	488	364	606	954	741	1151
25	Cabbage	1018	725	957	3203	1846	3110
26	Cauliflower	1036	795	879	2848	2263	2923
27	Lettuce	2704	2682	2171	5538	4666	5601
28	Spinach	307	415	651	707	1006	977
29	Clover	2154	1845	2084	17666	9345	8680
30	Alfalfa	1492	4336	2977	11872	29595	20785
31	Fodder mixture	1117	2562	6570	2827	12927	38566

reference: Organized and calculated by the researcher based on the Ministry of Agriculture and Planning data.

• Water Resources

Agricultural development in general depends on two main factors, namely water and land, and with the development and scientific progress in the agricultural field and the use of modern methods in agriculture, as the availability of water has become the main determinant of agricultural development, and Baghdad governorate suffers from water scarcity, as it is an issue of shrinking The volumes of water entering the governorate have become one of the most important and influential issues because of their close association with humans, agriculture, and biodiversity. Water resources also suffer from many physical, chemical, or biological changes, and these changes lead to water pollution.

Table 4 revealed the cultivated area, the water ration rate, and the total water required of the cultivated summer crops. The water ration can also be defined as the amount of cubic meters required to irrigate a dunum of a crop, i.e. the theoretical water ration is the amount of water that is required to irrigate an area to produce the best crop without water loss. The data presented in Table 4 indicates the total rates of cultivated areas of various field and vegetable crops at the level of Baghdad governorate, estimated in the year 2020 to be about 146,121 dunums, the total area planted for summer crops,

While the annual water rationing rate for the total dunum per m^3 of all crops was estimated at 15,334.8 dunum per m^3, while the total water requirement of the cultivated summer crops amounted to 147646203 million per m^3.

Table 4: Cultivated area, water ration rate, and total water requirement of summer crops planted during 2020.

T	The crop	Cultivated area	Annual water ration rate	Total water needs
1	Corn	39887	1286.2	51302659.4
2	Sesame	400	662.8	2648000
3	Onion	4111	784.2	3223846.2
4	Green bean	1320	412.4	544368
5	Vigna	8422	342.1	2881166.2
6	Mung bean	1000	815.2	815200
7	Watermelon	6377	790.4	5040380.8
8	Melon	7939	790.4	6274985.6
9	Okra	11358	1456.8	16546334.4
10	Eggplant	10500	582.2	6113100
11	Cucumber	9147	730.8	6684627.6
12	Armenian cucumber	6465	730.8	4724622
13	Squash	6215	609.6	3788664
14	Tomatoes	9027	846.4	7640452.8
15	Bell pepper	5860	904.4	5299784
16	Radish	20	464.7	9294
17	Clover	7726	662.8	5120792.8
18	Alfalfa	9845	1900	18705500
19	Millet fodder	502	562.6	282425.2
Total		146121	15334.8	147646203

reference: Organized and calculated by the researcher based on the Ministry of Agriculture and Planning data.

• results of Table 5 refer to the total rates of areas planted with various field and vegetable crops at Baghdad Governorate during the year 2020 which amounted about 200996 dunums, the total area planted for winter crops, while the annual water rationing rate for dunams per m^3 was estimated for all crops amounted to 18954.15 per dunam per m^3. While the total water requirement of the cultivated winter crops amounted to 115828443.3 million m^3.

Table 5. Cultivated area, water ration rate, and total water needs of winter crops planted for the year (2020)

T	The crop	Cultivated area	Annual water ration rate	Total water needs
1	wheat	155683	562.6	87587255.8
2	barley	17197	437.2	7518528.4
3	Onion	515	784.2	403863
4	Scallions	14	784.2	10978.8
5	Pea	39	342.1	13341.9
6	Green bean	287	412.4	118358.8
7	fava bean	4202	271.8	1142103.6
8	crookneck squash	19	609.6	11582.4
9	Squash	861	609.6	524865.6
10	Dry Garlic	645	784.2	505809
11	Carrot	15	784.2	11763
12	Beta vulgaris	285	464.7	132439.5
13	Turnip	1241	540.15	670326.15
14	Dry Garlic	1092	563.3	615123.6
15	Onion	1832	784.2	1436654.4
16	Radish	275	464.7	127792.5
17	Chard	606	540.15	327330.9
18	Cabbage	957	609.6	583387.2
19	Cauliflower	879	517	454443
20	Lettuce	2171	464.7	1008863.7
21	Spinach	651	540.15	351637.65
22	Clover	2084	662.8	1381275.2
23	Alfalfa	2977	1900	5656300
total		200996	18954.15	115828443.3

reference: Organized and calculated by the researcher based on the Ministry of Agriculture and Planning data.

• Water uses in Baghdad Governorate

Table 6 revealed that there were several areas of water use, which were consumptive and non-consumptive use. The first is the agricultural use of irrigation water, daily domestic use, and industrial use.

While the second one is represented in water budgets and the use of water resources in generating electricity. The water uses in the agricultural sector represent about 1.53 billion m^3 per year, which is about 43.1% of the total water uses at Baghdad governorate, according to the estimation of the Iraqi Ministry of Planning. The amount of water for humans and domestic uses is about 2.07 billion m^3 per year, representing about 56.4% of the total water uses of the governorate. The amount of water used in industry is about 0.19 billion m^3 per year, which is about 5.2% of the total water use in Baghdad governorate during 2019-2020.

Table 6. Percentages and quantities of water demand for different uses during the water year (2019-2020)

Type of use in Baghdad province	processing rate (%)	Quantity (billion m^3/year)
Agricultural	43.1	1.58
Household	56.4	2.07
Industrial	5.2	0.19
Environmental	0	0
Total	100	3.67

reference: Organized and calculated by the researcher based on the Ministry of Agriculture and Planning / Environment Statistics Department data.

• Capital Resources:

Capital resources are of great importance in agricultural sector, especially in the contribution of agricultural production development by providing the necessary agricultural services to accelerate agricultural development, and that capital can express two concepts; the first is capital formation, which reflects a large part of fixed capital, such as agricultural machinery and equipment. The second expresses the variable capital expressed in the requirements of production. The total fixed capital formation is defined as the value of the acquired fixed assets, and fixed assets, excluding land, are intended as productive assets that are used frequently in production over accounting periods, such as machinery, equipment, means of transportation etc.

Capital formation is also defined as that part of the immediate productive capacity directed to the production of capital goods in order to increase the country's production capacity. Data in Table 5 revealed the relative distribution of the number of drawers and harvesters by administrative units, it was found that Baghdad Governorate owns 6103 agricultural drawers for the period 2018-2020, operating drawers reached 5819 and the rest is non-operating out of its total at the governorate.

While the total number of harvesters for the period 2018-2020 at the governorate level, reached 142, the operation is only 127 of them, while the remaining 15 harvesters were considered non-operating, indicating a severe shortage in their numbers despite the governorate's have large areas planted with grain crops.

Table 7: Number of drawers and harvesters in Baghdad governorate

Year	Tractor		The total	Reapers		The total
	Working	Not working (damaged)		working	Not working (damaged)	
2018	5758	283	6041	119	15	134
2019	5833	288	6121	129	15	144
2020	5866	281	6147	131	15	146
2021	4772	220	4992	85	14	99

reference: Organized and calculated by the researcher based on the Ministry of Agriculture and Planning data.

• Net Revenue of Water Unit.

Can be defined as the ratio between the net return in dinars to the water ration (m^3), as some researchers use this criterion to express the efficiency of water use, and that the economically efficient amount of water depends on the prices of water, other resources, output prices, economic, technical, and environmental factors (6). The efficiency of irrigation water use is defined as the ratio between the amount of water required to produce a certain level of output and the amount of water actually used on the farm. Therefore, the efficiency of water use is achieved. By producing a greater amount of the product with the same available amount of water resources or using less water to produce the same production levels achieved (16). When calculating the net return per unit of water as in Table 6, it was found that the highest net return was achieved in the production of beans, as it reached 360 d per m^3. Followed by the okra crop, which achieved a yield of 235 d per m^3, due to the high economic return of these crops. As for the wheat crop, being a cash crop, the net water yield was 130 d per m^3. The more efficient the use of water and its management lead to an increase in the net water return (18).

Table 8. Net water yield per donum for cropping structure in Baghdad governorate.

T	the crop	Total Cost 1000 d	Total Revenue	Profit Realized	Net Water Revenue
1	Wheat	254	485	231	130
2	Barley	200	474	274	120
3	Tomatoes	298	375	77	65
4	Watermelon	287	379	92	73
5	Okra	222	383	161	235
6	Squash	278	557	279	170
7	Pepper	266	443	177	160
8	Potato	256	378	122	80
9	Onion	272	451	179	140
10	Garlic	463	731	268	210
11	Green bean	271	1144	873	360
12	Cucumber	343	455	112	82

13	**fava bean**	**261**	**537**	**276**	**75**
14	**Eggplant**	**300**	**434**	**134**	**78**
15	**Lettuce**	**187**	**381**	**194**	**90**

2- Target programming models to develop optimal plans for crop installation

In the objective function, the target is to minimize undesirable deviations from the desired goals as possible, and the objective function for programming goals tries to reduce the set of positive and negative deviations. The formulation of the linear programming model requires defining the target function and defining the constraints and determinants of the technical coefficients that are required to produce one dunum of each crop. The objective function can be formulated and the technical parameters and constraints of the linear programming model can be defined as follows (4) (11)

1. Objective Function

The research aims to develop a plan for agricultural production in Baghdad considering the issue of water deficit and the decrease in the water share, so the objective function in the model programming objectives represents maximizing the net return from the water unit with a minimization as follows:

2. Productive activities

The productive activities included 15 crops, which are prevalent in the governorate, and which constitute most of the crop structure, divided between the summer and winter seasons. It also contained strategic grain crops such as wheat and barley, and important vegetable crops such as tomatoes, cucumbers, and eggplant.

3. Limitations and obstacles

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 restrictions included:

A - Land resource constraints per dunums: It includes three restrictions, the first of which is related to the total arable areas at 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.

B - Water resource constraints per m3: 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 restrictions were formulated representing the total monthly water needs of the cropping activities included in the model, as the amount of water resources was calculated. Water available per month for agricultural crops.

C - Manual work restrictions per hours: 12 manual labor restrictions were formulated representing the manual labor hours required by the cropping activities included in the model, which were divided into three months to be more accurate and thus were four restrictions.

D - Mechanical work constraint per hour: The mechanized work constraint has been formulated because mechanization is an important determinant for the expansion of production activities and also depends on it in technical development, so a constraint was added to the model.

• Regulatory or legislative restrictions, including:

A - The area of crops that the farmer grows.

B - The area of crops that were recently banned from being imported by the Ministry of Agriculture.

C- Crops that were prevented due to water shortage.

5- Non-negative restrictions

All the variables in the model mean that the crops are greater or equal to zero, meaning positive. Accordingly, the mathematical formulation matrix was built for the target programming model for the crop composition as shown in Table 7.

Table 9. Matrix programming objectives for the prevailing cropping structure in the province of Baghdad.

W	V	U	T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
		Wheat	Barley	Tomatoes	Watermelon	Okra	Squash	Pepper	Potato	Onion	Garlic	Green bean	Cucumber	fava bean	Eggplant	Lettuce					signal	amounts of resources available
		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	D1	D2	D3	D4		
	MIN.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1		
	total area	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0		443059
	winter crops	1	1	0	0	0	0	0	0	1	1	1	0	1	0	1	0	0	0	0	≥	274697
	summer crops	0	0	1	1	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	≥	168362
January	m3	93.77	72.87	0	0	0	0	0	67.04	0	98.03	0	0	45.3	0	0	0	0	0	0	≥	387847886
Febraury	m3	93.77	72.87	0	0	0	0	0	67.04	98.03	98.03	0	0	45.3	0	0	0	0	0	0	≥	378741257
March	m3	93.77	72.87	169.28	131.73	208.1	203.2	113.05	67.04	98.03	98.03	77.45	146.16	45.3	83.17	116.18	0	0	0	0	≥	371226240
April	m3	93.77	72.87	169.28	131.73	208.1	203.2	113.05	67.04	98.03	98.03	77.45	146.16	45.3	83.17	116.18	0	0	0	0	≥	346982400
May	m3	0	0	169.28	131.73	0	203.2	0	0	98.03	0	77.45	0	0	83.17	0	0	0	0	0	≥	415993783
June	m3	0	0	169.28	0	208.1	0	113.05	0	98.03	0	0	0	0	0	0	0	0	0	0	≥	426791314
July	m3	0	0	169.28	0	208.1	0	113.05	0	0	0	0	0	0	83.17	0	0	0	0	0	≥	401913051
August	m3	0	0	0	131.73	208.1	0	113.05	67.04	0	0	77.45	146.16	0	83.17	116.18	0	0	0	0	≥	469892571
September	m3	0	0	0	131.73	208.1	0	113.05	67.04	98.03	98.03	77.45	146.16	0	83.17	116.18	0	0	0	0	≥	517466880
October	m3	0	0	0	131.73	208.1	0	113.05	67.04	98.03	98.03	77.45	0	45.3	83.17	0	0	0	0	0	≥	804380983
November	m3	93.77	72.87	0	0	0	0	113.05	67.04	98.03	98.03	0	146.16	45.3	83.17	0	0	0	0	0	≥	467152457
December	m3	93.77	72.87	0	0	0	0	0	67.04	98.03	98.03	0	0	45.3	0	92.94	0	0	0	0	≥	488189481
Manual labor monthes jan.-mar.	hour	5	6	22	10	32	59	26	30	78	48	20	17	20	24	60	0	0	0	0	≥	136524480
Manual labor monthes apr.-jun.	hour	3	2	65	25	74	90	73	66	0	0	24	143	21	78	0	0	0	0	0	≥	136524480
Manual labor monthes jul.-sept.	hour	0	0	170	75	105	0	140	155	0	0	0	0	0	132	0	0	0	0	0	≥	136524480
Manual labor monthes octo.-dece	hour	7	7	112	0	37	28	60	110	60	62	42	0	39	69	42	0	0	0	0	≥	136524480
labor robotic	hour	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	0	0	0	0	≥	18327600
	MAX.	231000	3E+05	77000	92000	2E+05	279000	177000	122000	179000	3E+05	873000	112000	276000	134000	194000	0	0	0	0	≥	160,818,600,000
	MIN	284000	2E+05	298000	287000	2E+05	278000	266000	286000	272000	5E+05	271000	343000	261000	300000	187000	0	0	0	0	≥	8838070000

Reference: by researchers based on the questionnaire and the Ministry of Agriculture.

After completing the formulation of the matrix of the mathematical model for programming objectives, which includes maximizing the net water unit and minimizing the cost. The data were entered into the calculator and using the QSB program and by applying the programming of goals, the first scene was obtained as in Table 8, which shows the alternative plan for cropping in Baghdad to ensure the achievement of the level of the required goals without an increase or decrease in its level from the projected target function. whether in the case of maximizing the net revenue of the water unit or minimizing the cost of one dunum. The results in Table 8 revealed that the level of the required goals was achieved because the total target function reached zero. The analytical results according to the optimal cropping plan, showed 8 crops, including three winter crops, namely wheat, onions, and garlic, and five summer crops, namely, tomato, rosemary, pepper, potatoes, and eggplant.

This scenario suggested increasing the areas of some crops, for example, it suggested increasing the area of the wheat crop to 269,683 dunums, which is an increase from the current plan by 114,258 dunams, and this increase is the largest proposed increase over winter crops, estimated at 73.3%. While the largest increase in summer crops was in the tomato crop, as the optimal plan proposed an increase in its area from 9,027 dunums to 142544 dunums.

By comparing the actual plan with the proposed plan, it reveals that the total cost of the current cropping structure amounted to 63.4 billion dinars, while in the proposed optimal amounted to 8.5 billion dinars, which saves about 55 billion dinars. The actual net revenue of the water unit in Baghdad was 31.4 billion dinars, and the optimal plan resulted in 160.8 billion, which is to achieve a net return of about 362.9 thousand dinars per dunum in water. In terms of profit, one dunam achieved a rate of 119.6 thousand dinars, which increased to 200.4 thousand dinars, meaning that the proposed optimal plan increased profits from 53 billion dinars to 88.8 billion dinars, which confirms the achievement of the required goals by applying a scientific method in planning and developing an agricultural plan for Baghdad that contribute to achieve a set of goals together (Table 8).

Table 10. The analytical results of linear programming model, that maximizes the net water unit revenue and minimizes costs for the year 2020 with the imposition of legislative restrictions

No.	Decision Variable	Solution Value	Unit Cost c(j)	Total Contribution	Constraint	Left Hand Side	Right Hand Side	Slack or Surplus
X1	Wheat	269941000	0	0	Total area	443059000	443059000	0
X2	Barley	0	0	0	Winter area	274697000	274697000	0
X3	Tomatoes	142544000	0	0	Summer area	168362000	168362000	0
X4	Watermelon	6377000	0	0	Water Jan.	25591670000	357547900	25234120000
X5	Okra	0	0	0	Water Feb.	25994670000	375741200	25618930000
X6	Squash	0	0	0	Water Mar.	52488500000	371226200	52117280000
X7	pepper	5860000	0	0	Water Apr.	52488500000	346982400	52141530000
X8	Potato	3223000	0	0	Water May	26234370000	415993800	25818370000
X9	Onion	4111000	0	0	Water Jun.	25195320000	426791300	24768530000
X10	Garlic	645000	0	0	Water Jul	25653790000	401913100	25251890000

X11	**Green bean**	**0**	**0**	**0**	**Water Aug.**	**2580060000**	**469892600**	**2110167000**
X12	**Cucumber**	**0**	**0**	**0**	**Water Sep.**	**3046291000**	**517466900**	**2528824000**
X13	**fava bean**	**0**	**0**	**0**	**Water Oct.**	**3046291000**	**504381000**	**2541910000**
X14	**Eggplant**	**10358000**	**0**	**0**	**Water Nov.**	**27518620000**	**467152400**	**27051460000**
X15	**Lettuce**	**0**	**0**	**0**	**Water Dec.**	**25994670000**	**458159500**	**25536510000**
X16	**D1**	**0**	**1.0000**	**0**	**Labor 1**	**53658150000**	**136524500**	**5229290000**
X17	**D2**	**0**	**0**	**0**	**Labor 2**	**11648730000**	**136524500**	**11512210000**
X18	**D3**	**0**	**0**	**0**	**Labor 3**	**27397980000**	**136524500**	**27261450000**
X19	**D4**	**0**	**1.0000**	**0**	**Labor 4**	**19562000000**	**136524500**	**19425470000**
					Labor 5	**1515747000**	**18327600**	**1497420000**
					MAX	**77646060000000**	**16081860000**	**77629990000**
					MIN	**47537560000000**	**8535057000000**	**39002510000**
					Objective Function (MIN.) = 0			

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

The research came out with a set of conclusions, including that the cropping structure of Baghdad governorate does not achieve optimization and does not follow the optimal allocation of resources and fluctuates among years, and that there is an expansion of crops that do not decrease in cost and the rate of water consumption is more. There is a shortage in the cultivation of crops with the highest net water return, such as beans and okra, and that there are legislative and regulatory restrictions that must be included in the proposed crop composition matrix as it related to food security such as the necessity of producing wheat crop as it is an important strategic crop. Despite the problem of water scarcity, it is possible to achieve an optimal plan with the amount of water available if a scientific method is adopted in planning to draw up optimal agricultural plans that consider all economic and climatic changes.

The research recommended to work on the application of the proposed cropping structure, which contributes to minimizing the cost and maximizing the net return of the water unit using the economic tools represented in the support concept. projecting a time and financial program for the transition to modern agriculture through the adoption of modern irrigation technologies, protected agriculture, and hydroponics, activating the role of cooperatives Agricultural leaders and rural leaders to contribute to persuading and satisfying farmers to adopt these technologies and the optimal plan.

Reference:

1-Abdullah, Salem Abdullah, 2007.The effect of climate on estimating the water needs of wheat and barley crops in the governorates of Basra, Maysan and Dhi Qar, Basra lit. JO.No.44.

2-Abdullah, Asaad Abdul Amir. 2021. An analytical study of the optimal plans for the use of irrigation water in Iraqi agriculture for the period (2017-2020). Master Thesis, College of Agriculture, University of Baghdad.

3-Salt, Mohamed Mustafa (2017) Sustainable agricultural development and the food security bet in Algeria, through the Wheat Division.

4-Alnassr, R. Sh. (2019). The Optimal Crop Rotation of AL-Rasheed District Farms Using Linear Programming Technique. The Iraqi Journal of Agricultural Sciences, 50 (Special Issue): 113 – 127

5-AL-Nassr,2019,Using Sensitivity Analysis in Determining Optimal production plans in AL-Kadhimiyia District Farms (Sinaa Farm Case Study (2016-2017) Plant Archires,Vol.19, Supplement 2,pp-263-269

6-Ashfaq, Muhammad, Salma Jabeen and Irfan Ahmad Baig (2005) " Estimation of The Economic Value of Irrigation Water", J. Agri. Soc.,Vol. (1), No. (3).

Belaid Aouni ,Le modèle de Programation mathématique avec buts dans un environnement imprecis, sa formulation et une Application, Thèse présentée pour l'obtention du grade de Philosophiae doctor (ph.D Faculté des Sciences de l'administration, université LAVAL, Québec (CANADA), 1998, p 15.

7-Benli,B and S.Kodal (2003).”A non linear model for farm optimization with adequate and limited water supplies: application to the south-east Anatolioan project (GAP)region “.Agriculture Water M anagement ,62:187-203.

8-Bijan, G. and S. AL-Reza.2004.Linear and non-linear optimization models for allocation of a limited water supply. Irrig. and Drain. 53(1): 39–54.

9-Chahraman,B.andA.Sepaskhah(2004).” Linear and non linear optimization models for allocation of a limited water supply” Irrigation and Drainage,53(1):39-54.

10-Debertin ,D. L. 2012 . Agricultural Production Economics . University of Kentucky second Edition. Pp:412.

11-Gorantiwar, S.Dand I.K.Smout(2005).”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.

12- Hao Aimin , Uncertainty , Risk Aversion and Risk Management in Agriculture , 2010 , china .

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

15-Koundour, PH. And Nauges,C.2005. Production Function Estimation with Selectivity and Risk Considerations. Journal of Agricutural and Resource Economics . vol.30(3): 597-608.

16-Shajari, S., M. Bakhshoodeh and G. R. Soltani (2008) " Enhancing Irrigation Water Use Efficiency Under Production Risk: Evidence From Wheat Farms in Iran", American-Eurasian J. Agric. & Environ. Sci., 2(Supple 1).

17-Shideed, Kamial H. (2000) " Economic Assessment of On-Farm Water Use Efficiency in Rainfed Agriculture", IPA J. of Agric. Res. Vol. (10), No.(1).

18-Stacho, J. (2014). Introduction to Operations Research: Deterministic Models. 1st edn. Columbia University, New York, USA, pp: 121.