ISSN: 2754-477X

Journal of Food Technology & Nutrition Sciences

Review Article

Open Access

Economic Feasibility Study for Implementing a Maize Cultivation Project in Iraq Using a Drip Irrigation System (2030–2040)

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ABSTRACT

Iraq has vast agricultural areas, compared to the limited water. to solve this problem, the idea of using a drip irrigation system to grow corn was proposed.

This method is used in a number of countries around the world, but its use in Iraq is for growing vegetables, fruit trees, and windbreaks. Some experiments are currently being conducted (the results have not yet been proved.)

The project aims to achieve 90% irrigation efficiency and save more than 25% of water by adopting drip irrigation instead of surface irrigation to confront water shortages.

The proposed project area and productivity were determined at 285,500 dunums and 1,245.7 kg / dunum, respectively, based on previously achieved areas and productivity for the period 2016-2023. The productivity of the drip irrigation project was determined at 2,000 kg / dunum, based on previously conducted research and experiments.

The project duration was set at 10 years, starting from the base year 2030. Annually, 10% of the proposed area (285,500 dunums) of corn will be converted from surface irrigation to drip irrigation

The statistical criteria used were net present value, cost-benefit ratio and (ROI) Return on investment, and for each criterion, special coefficients of 8% and 10% were used.

Statistical results showed that drip irrigation was superior in terms of net present value and return on investment at a discount rate of 10%, while other statistical criteria showed similar results between surface irrigation and drip irrigation. Although the total cost of cultivating a dunam of corn with drip irrigation is 25% higher than the cost of surface irrigation, drip irrigation will still be the preferred option, as it saves more than 25% of water compared to surface irrigation, which is the primary goal.

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Received: March 19, 2026; **Accepted:** March 25, 2026; **Published:** April 03, 2026

Keywords: Surface Irrigation, Drip Irrigation, Net Present Value, Benefit –Cost Ratio, IRR

Introduction

The production of maize (Zea mays L) has a significant place in world agriculture with a production potential of approximately1162 M t harvested and197 M ha planted area with an average yield of 5.8 t ha 1 making it the second most widely grown crop in the world after wheat [1].

Maize (Zea mays L.) is the major irrigated summer cereal crop in Iraq it's very higher consumer to the amount of irrigation water applied, the seasonal water use about 750- 900 mm therefore accurately irrigation methods and practices seem to be very important with this crop under irrigation water rarity conditions.

Drip irrigation system is traditionally the application of a constant steady flow of water to soil at low pressure. In this system, water is applied directly to the root zone of plants by means of applicators (drippers) operated under low pressure with the applicators being placed either on or below the surface of the ground. Water loss is minimized through these measures, as there is very little splash owing to the low pressure and short distance to the ground [2]

Drip irrigation is an efficient method to save water, enhance yield, and yield quality, compared with sprinkle and surface irrigation methods [3]

Unfortunately, its high initial costs represent one of the biggest constraints to the widespread adoption of drip irrigation Precision irrigation systems require good management and accumulated experience to control more than one common factor affecting the homogeneity of irrigation water distribution, such as drip lines, the distance between them, depth of drip line rate, irrigation frequency and irrigation time position, the distance between emitters operational pressure, emitters discharge globally approved system for its high [4].

irrigation water to the base or root zone of plants". It is an efficient method for Drip irrigation is defined as the slow, frequent application of small volumes of minimizing the water used in agricultural and horticultural crop production. These systems commonly use designed to only wet the root zone and maintain this zone at or near an optimum moisture level.

Hence, there is a potential to conserve water losses by not irrigating the whole field [5]

The drip irrigation system is a irrigation efficiency and efficiency of use It is an effective method for rationing water and fertilizers.

It facilitates the addition of chemical fertilizers in the form of a solution mixed with irrigation water and pumped directly into the area of the spread of the root group [6].

In several experiments with drip irrigation on corn crop, it was shown that In corn crop, 3 treatments of drip irrigation produced about 9.57, 9.38 and 9.07 ton / ha. (tons/ha) [4]

The maximum maize grain yield (8753 and 8860 kg/ha) was achieved in both the seasons (2019-20) respectively [7]

Grain production reached 6.16-5.75-6.36 tons/ha for drip, sprinkler, and surface irrigation, respectively.

In maize cultivation, drip irrigation efficiency was 1.51 kg/m3, followed by sprinkler irrigation at 1.06 kg/m^3, and surface irrigation at 0.81 kg/m^3.

Drip irrigation saves 48% of water compared to surface irrigation and 25% compared to sprinkler irrigation. Maize water requirements from germination to harvest were 4,074 m3|ha for drip irrigation, 5,390 m^3|ha for sprinkler irrigation, and 7,880 m3|ha for surface irrigation [8].

Search has shown that the drip irrigation method saved 25% of irrigation water while maintaining a high productivity of the yellow corn crop, amounting to 11.9-12.5 tons per hectare, reported also that the highest average maize grain [9].

Drip irrigation is the most effective way to convey directly water and nutrients to plants and not only save water but also increases yields of crops [10].

In a dry grain production experiment for maize, drip irrigation treatment yielded an average grain yield of **6.090** kg ha^{-1} [11].

Drip irrigation saved 37.7% and 40.6% irrigation water in both seasons 2019 and 2020, respectively as related with gravity irrigation (furrow-ridge planting) and similar outcomes reported by [12].

Compared to 50–60 % water use efficiency (WUE) in surface irrigation, drip has 90 % WUE that reduces water consumption by 30–70% [13].

The use efficiency of N, P and K in drip fertigation has been found to be 90%, 45% and 80% compared to 30–50%, 20% and 50% in case of soil application [14]

These results suggest that alternating fresh and saline water could reduce freshwater usage by 50% while maintaining acceptable crop yields, making it a cost-effective solution for water-scarce regions [15]

In maize cultivation, the total water requirements were 4392.87 m3/ha, followed by drip irrigation (5565 m3/ha) and furrow irrigation (9011.92 m3/ha) [16]

Materials and Methods

Area and Productivity of Maize with Surface & Drip Irrigation

According to statistical data from the Ministry of Agriculture regarding the areas planted with maize, the achieved production, and the productivity throughout Iraq for the period 2016-2023, the area average was **285,500** dunums, the average production was 351,000 tons, and the productivity was **1,245.7** kg / dunum. See Table 1

Table 1: Showing the Cultivated Area, Production, and Yield of Maize in Iraq 2016-2023

Agricultural Season	Total Area 1000 dunums*	Total Production 1000 tons	Yield kg | dunum
2016	267	260	972
2017	208	185	890
2018	47	63	1360
2019	402	473	1175
2020	362	419	1158
2021	312	374	1299
2022	331	496	1497
2023	355	538	1515
Average	285.5	351	1245.7

*One dunum is equivalent to 1/4 hectare

The value of the above **285,500** dunums in the proposed project will be based on the fact that 10% of it will be implemented annually under drip irrigation until 2039, see Table 2 and the productivity of surface irrigation will remain 1,245.7 tons/dunum , while the productivity of drip irrigation will be 2 tons | dunum based on the studies and research that we explained in the introduction to the research.

In light of the arithmetic mean of the yield achieved in previous years, which was 1,245.7 dinars per dunum, and the arithmetic mean of the area, which was 285,500 dunums, both figures were calculated in the estimates of agriculture and future production.

Table 2: Showing the Proposed Area for Cultivation Under Drip Irrigation at a Rate of 10% Annually for Maize Cultivation Starting from the Base Year 2030

Agricultural Season	The area to be cultivated is 1000 dunams	
	Surface Irrigation	Drip Irrigation
2030	258.5	-
2031	257.0	28.5
2032	228.5	57.0
2033	200.0	85.5
2034	171.5	114.0
2035	143.0	142.5
2036	114.5	171.0
2037	86.0	199.5
2038	57.5	228.0
2039	29.0	256.5
2040	-	285.5

Maize Under Drip Irrigation Maize Under Surface Irrigation

Calculating Project Costs

One of the problems we face in estimating costs is the annual increase in project input prices, as demonstrated by the following research and studies:

The costs went upward with an increase approximately (140,000 - 238,000) Iraqi dinars (2017 - 2021) for wheat and maize [17]

They showed in an economic study that the cost of a dunum also rose to 255,886 Iraqi dinars | dunum.

Then, the total cost of growing corn increased to 411,121 Iraqi dinars [18]

In light of this research, we can adopt the estimate of 300,000 Iraqi dinars as the total cost of planting a dunum of maize under surface irrigation.

As for the cost under the drip irrigation system.

Add to this the annual depreciation cost of the drip irrigation system, based on its price of 4 million Iraqi dinars and its productive lifespan of 10 years.

Therefore, the total cost of planting a dunum of corn under drip irrigation will be 400 thousand Iraqi dinars.

Total cost of maize cultivation - Surface irrigation =**300.000** Iraqi dinars Cost per dunum

Cultivated area | dunu × Cultivated area | dunum

Total cost of maize cultivation - Drip irrigation = **400.000** Cost per dunum

Iraqi dinars×Cultivated area | dunum

Table 3: Total Cost of One Billion Iraqi Dinars for the Surface and Drip Irrigation Project for Maize

Agricultural Season	Total cost one billion	
	Surface Irrigation	Drip Irrigation
2030	77.5	-
2031	77.1	11.4
2032	68.5	22.8
2033	60.0	34.2
2034	51.4	45.6
2035	42.9	57.0
2036	34.3	68.4
2037	25.8	79.8
2038	17.2	91.2
2039	8.7	102.9
2040	-	114.4
Total	463.4	627.2

Table 4: Showing Production | 1000 tons for Surface and Drip Irrigation 2030-2039

Agricultural Season	Production |1000 tons	
	Surface Irrigation	Drip Irrigation
2030	322.2	-
2031	320.1	57.0
2032	284.6	114.0
2033	249.1	171.0
2034	213.6	228.0
2035	178.1	285.0
2036	142.6	342..0
2037	107.1	399.0
2038	71.6	456.0
2039	36.1	513.0
2040	-	571.0
Average	192.5	313.1

Return Calculation

After we have determined the areas implemented by surface irrigation and their production of 1245.7 kg | dunums and the area that will be implemented annually is 28850 dunums and with an assumed production of **2000 kg | dunums** and in light of the following law we will obtain the production as follows.

Table 5: Total Yield of Maize Under Surface Irrigation and Drip Irrigation Systems 2030-2040

Agricultural Season	Revenue | billion Iraqi dinars	
	Surface Irrigation	Drip Irrigation
2030	122.4	-
2031	121.6	21.6
2032	108.1	43.3
2033	94.6	64.9
2034	81.1	86.6
2035	67.6	108.3
2036	54.1	129.9
2037	40.6	151.6

2038	27.2	173.2
2039	13.7	194.9
2040	-	216.9
Average	73.1	119.1

Production | tons = Productivity (kg) | dunum × area dunum

The price of maize for the 2023-2024 season, set by the Iraqi government, was approved at (380.000) Iraqi dinars | ton

Discount Rates

After calculating the total costs of growing yellow corn under surface or drip irrigation over the project's 10-year lifespan, as shown in the Tables (3&5) we encountered a problem: the costs varied in value from year to year. Future returns also varied in value from year to year over the project's lifetime.

To address this problem, we resorted to using discount rates, which eliminate the effect of time on the value. Discount rates of 8% and 10% were chosen in this study, the following table reflects the estimated costs and returns.

Time preference criteria give weight to time, favoring returns received early over returns realized later. The same applies to costs, which give a degree of preference to what is spent later over what is spent early, i.e., preferring a dinar spent tomorrow over a dinar spent today. This is achieved through what is known as the discount factor. As a general rule, we can adopt the following formula

Future value of an amount = Present value × 1/(1 + the chosen interest rate)^{n}

n denotes the number of years.

Table 6: Showing the Total Costs Treated with 8% and 10% Discounts for the Maize Project

Agricultural Season	Discount factor 8%	Total cost one billion Iraqi dinar at discount factor8%		Discount factor 10%	Total cost one billion Iraqi dinar at discount factor10%	
		Surface Irrigation	Drip Irrigation		Surface Irrigation	Drip Irrigation
2030	0.926	71.7	-	0.909	70.4	-
2031	0.857	66.0	9.7	0.826	63.6	9.4
2032	0.794	54.3	18.1	0.751	51.4	17.1
2033	0.735	44.0	25.1	0.683	40.9	23.3
2034	0.681	35.0	30.6	0.621	31.9	28.3
2035	0.630	27.0	35.9	0.564	24.1	32.1
2036	0.583	19.9	39.8	0.513	17.5	35.0
2037	0.540	13.8	43.0	0.467	12.0	37.2
49.2	0.500	8.6	45.6	0.424	7.2	38.6
51.4	0.463	-4.0	47.6	0.386	3.3	39.7
52.9	0.429	-	48.8	0.350	-	40.0
Total		280.4	344.2		322.3	300.7

Table 7: Showing the Total Return Treated With 8% and 10% Discounts for the Maize

Agricultural Season	Discount factor 8%	Total return one billion Iraqi dinar at discount factor8%		Discount factor 10%	Total return one billion Iraqi dinar at discount factor10%	
		Surface Irrigation	Drip Irrigation		Surface Irrigation	Drip Irrigation
2030	0.926	111.2	-	0.909	`111.2	-
2031	0.857	104.2	18.5	0.826	100.8	17.9
2032	0.794	85.8	34.3	0.751	81.1	32.5
2033	0.735	69.5	47.7	0.683	64.6	44.3
2034	0.681	55.2	58.8	0.621	51.0	54.4
2035	0.630	42.5	64.4	0.564	38.1	61.0
2036	0.583	31.5	75.7	0.513	27.7	66.6
2037	0.540	21.9	81.8	0.467	18.9	70.7
2038	0.500	13.6	86.6	0.424	11.5	73.4
2039	0.463	6.3	90.2	0.386	5.2	75.2

2040	0.429	-	93.0	0.350	-	75.9
Total		541.7	651.0		510.1	571.9

Statistical Analysis
Three criteria were used in the statistical analysis: net present value, benefit -cost ratio, and internal rate of return.

Results and Discussion
Projects are typically ranked according to this criterion based on the result of subtracting negative discounted cash flows from positive discounted cash flows, with preference given to the project with the highest value.

A project achieving a net present value of zero does not necessarily mean that it will not generate a return on its investment. Note that the net present value is positive at the specified discount rate, indicating that the project is commercially viable [19]

Net Present Value at a Discount Factor of 8%
Surface Irrigation = Total Revenue - Total Cost
541.7 -280.4 = 261.3
Drip Irrigation = Total Revenue - Total Cost
651.0 – 344.2 = 306.8

Net Present Value at a Discount Factor of 10%
Surface Irrigation = Total Revenue - Total Cost
510.1 – 322.3 =187.8
Drip Irrigation = Total Revenue - Total Cost
571.9 – 300.7 = 271.2

The Benefit-Cost Ratio (BCR) is a financial metric that helps evaluate the economic efficiency of an investment [20].

This criterion complements the previous criterion, whereby projects are weighted based on the realized return on invested capital.

The World Bank adopted this criterion by dividing the total returns by the total costs.

This criterion is based on the achieved ratio, giving priority to the project with the highest ratio, while projects with a ratio greater than one are accepted. In other words, projects with a ratio of benefits to costs greater than one an integer.

According to this criterion, the result was as follows, at a discount rate of 8%,
Benefit-Cost Ratio at a Discount Factor of 8%
Surface Irrigation = Total Revenue | Total Cost P
541.7 | 280.4 = 1.93
Drip Irrigation = Total Revenue | Total Cost
651 | 344.2 = 1.89

Benefit-Cost Ratio at a Discount Factor of 10%
For surface irrigation 510.1 | 322.3 =1.58
For drip irrigation 571.9 | 399.7 =1.43

Internal Rate of Return (IRR)
The internal rate of return (IRR) represents the amount of returns a project generates per unit of allocated resources [21]

It is calculated through trial and error, selecting multiple discount rates until the discount rate that reduces the present value to zero is reached. It represents the project's earning potential, i.e., the interest rate. If the IRR is 10%, this means that the funds will be invested at a 10% interest rate. This criterion is one of the most efficient.

Finally, this criterion represents the weighting of the project's eligibility for projects that achieve the highest economic and social returns.

The mathematical formula for this standard is as follows
Internal rate of return = S1 + Q1(S1- S2) | Q2- Q1
- Q1: The higher discount price
- Q2: The discount price means the lowest
- S1: Means the net present value at the highest discount price
- S2: Means the net present value at the lowest discount price

By applying the law to the net present value at the discount rates of 8% and 10%

For Surface Irrigation
10+ 2×510.1 | 541.7 - 510.1 = 32.6 %
For drip irrigation
10+ 2× 571.9 | 651- 571.9 = 14.5 %

The Internal Rate of Return
Since the net present value achieved is positive because the investments are distributed over the life of the project and are not concentrated in the first years, which makes it impossible to determine a realistic internal rate of return, even though we perform the mechanical calculations automatically.

A lower internal rate of return may be acceptable from a less risky or less water-intensive project, compared to a higher internal rate of return, because other factors common to the two projects differ. so accepting the higher internal rate of return requires that all factors are equal between the two projects.

The statistical analysis and the criteria used in it, including the benefit-to-cost ratio, the internal rate of return, and the return on investment, did not give a preference to drip irrigation.

The reason may be that the cost of the drip irrigation system was added to the total cost of agriculture, with an increase of more than 25% over the cost of growing corn under surface irrigation. However, the desired goal is achieved by increasing productivity and quality and rationalizing water consumption by between 25-50% in the case of switching to the drip irrigation system.

The solution requires that the government increase its support for farmers producing corn by raising its price from 380 thousand dinars to 500 thousand dinars or more.

(ROI) Return on investment is a financial ratio used to compare the profitability of an investment with its cost. It is calculated by dividing the profit by the investment cost and multiplying the result by 100 to obtain a percentage.

It is used to measure investment efficiency and evaluate the profitability of a project, and can be applied to various investments such as stocks, real estate, or digital marketing campaigns.

(ROI) for Maize at Discount factor 8%
Surface Irrigation 541.7 – 280.4 = 261.3

261.3 | 280.4 ×100 = 93.1
Drip Irrigation 651.0 – 344.2 = 306.8
306.8 | 344.2 ×100 = 89.1

(ROI) for Maize at Discount Factor 10 %
Surface Irrigation510.1 – 322.3 = 178.8
178.8 |322.3×100 = 58.2
Drip Irrigation 571.9 – 399.7 =172.2
171.2 |399.7×100 = 43.08

Table 8: Showing the Statistical Results

Standard	Surface Irrigation	Drip Irrigation
Net Present Value (NPV)		
At discount facter 8%	261.3	306.8
At discount facter 10%	187.8	271.2
Benefit-Cost Ratio (BCR)		
At discount facter 8%	1.93	1.89
At discount facter 10%	1.58	1.43
Return on investment (ROI)		
At discount facter 8%	93.1	89.1
At discount facter 10%	58.2	43.0
Internal Rate of Return (IRR)	32.6 %	14.5 %

Although the statistical criteria used are not in favour of sprinkler and drip irrigation, the goal is achieved by saving water and increasing the productivity of wheat and corn crops.

Conclusions

- Drip irrigation avoids deep water seepage compared to surface irrigation.
- There is no need to dig irrigation canals or establish a field drainage network.
- Fields can be irrigated regularly and according to plant needs.
- It can be used in sandy and gypsum soils, as well as in undulating soils.
- Compared to surface irrigation, there is no need for large pumping stations, continuous maintenance, or electrical power requirements.
- Surplus surface irrigation water can be utilized after adopting a drip irrigation system for horizontal agricultural expansion.
- Chemical fertilizers can be added in the form of solutions dissolved in irrigation water. This method facilitates plant uptake of fertilizers and prevents their inhibition in the soil.

Recommendations

In light of the above, the following recommendations can be made

- Adopt a drip irrigation method for growing maize, with initial trials to be conducted in limited areas in some governorates interested in growing these two crops
- The drip irrigation system for maize can be used with another crop in the same year, contributing to increased imports
- The General Authority for Plant Protection should prepare a scientific guide on how to use the required pesticides to combat pests and diseases affecting maize using drip irrigation
- The Ministry's Fertilizer Committee should issue recommendations regarding the use of fertilizers, particularly nitrogen and potassium fertilizers, under drip irrigation
- Given the existing problems associated with drip irrigation (clogged drippers), it is necessary to prepare and train specialized personnel and hold training courses for beneficiaries to address such problems.
- The Ministry of Agriculture should import 7,000-8,000 drip irrigation systems annually, or the Ministry of Industry should manufacture them locally.
- Supporting maize prices due to changes in agricultural production cost inputs, at least for farmers who use modern irrigation method.

Data Availability Statement

The data used in this research is available upon reasonable request through the following Through the internet, as in the electronic links in references

Conflicts of Interest

The author declare no conflicts of interest.

Funding Declaration

The authors declare that he received no external funding.

Acknowledgments

The author would like to thank the experts from the Department of Soil Sciences and the Department of Crops, Faculty of Agriculture, Erciyes University, Turkey: Professor Ali Irfan, Professor Abdullah Ulaş, and Professor Yusuf Konca.

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