

Economic Analysis of Agricultural Sustainability in a Grape Production Farm

Abbas Abd Ahmed Al-Tamimi^{1*}, Haifa Malik Ali²

¹Department of Soil Sciences and Water Resources, College of Agriculture, University of Diyala, Iraq.

²Department of Marketing, Kirkuk Technical Institute, Northern Technical University, Iraq.

*Corresponding Author: Altimimiabab8@gmail.com

Article history:

Received: 3 May 2025

Accepted: 29 July 2025

Published: 30 December 2025

Keywords: *Economic efficiency, Solar energy, Sustainable farm, Grape fruit, Economic indicators.*

Abstract

This study is conducted for an existing grape production farm relies on traditional methods of production and irrigation, and a grape farm that relies on sustainable energy, and a drip irrigation system is proposed. Some economic analysis tools were used to determine the feasibility of adopting solar energy in a sustainable grape farm. The study aimed to compare the two farms through some economic indicators, by adopting the method of quantitative tabular analysis with some investment indicators in addition to descriptive analysis. The results of study are that the use of solar energy in grape production farms achieves economic revenue under normal production conditions and under risk conditions. It was found that adopting solar energy systems in sustainable grape production farms achieved estimated revenue of 7538.8 dollars/hectare, and under risk conditions it reached 5026.2 dollars/hectare, and the return on the invested dollar reached 2 dollars under efficiency conditions, and under risk conditions 1.3 dollars. While the estimated revenue of the studied grape farm in the current reality reached 6881 dollars/hectare, this is compared to the high costs of the sustainable grape farm due to the use of solar energy technologies. The study also concluded that the technical efficiency of the sustainable grape farm reached 83%, while the economic efficiency reached 84%. The study concludes the necessity of adopting sustainable energy in grape production farms because it reduces environmental pollution and the use of fossil fuels in irrigation operations, and the necessity of investing in grape farms because they are economically feasible.

<https://dx.doi.org/10.52951/dasj.25170205>

This article is open-access under the CC BY 4.0 license (<http://creativecommons.org/licenses/by/4.0/>).

Introduction

Agricultural production depends mainly on energy in its various forms, as the lack of energy at the right time negatively affects agricultural production in terms of high costs or low production, which means a decrease in food production and high prices. An energy source must be available to carry out various agricultural operations such as irrigation or air conditioning systems in greenhouse farming techniques. Renewable energy sources are that generate energy naturally and sustainably, this energy does not result in environmental pollution when it is used, so it is called clean energy such as solar energy (Al-Jubouri and Al-Jubouri, 2010). In 1978, NASA's Lewis Research Center began establishing the first solar PV system by installing a (3.5) kilowatt photovoltaic station on a reservation in the Papago - Indian village in southern Arizona. The system is activated to pump water and provide electricity to 15 houses until 1983 (Muhammad and Al-Khayat, 2019).

Renewable energy is effective in preserving the environment as well as being renewable in a short period, unlike fossil energy, which is non-renewable, the sunshine are considered one of the resources that can be relied upon to produce useful energy, that can be consumed and reproduced. Therefore, this will reduce the waste of economic resources (Norouzi and Norouzi, 2020). Al-Saidi and Lahham (2019) Conducted a study of using solar energy on farms, and concluded that the use of solar energy sources achieves many goals, the most important of which are the dissemination of clean energy sources, efficient use of irrigation water, and efficient agricultural production. In additional, adopting clean energy in agriculture leads to increased profits, which prompts producers to follow the integrated technology (FIT) model in agricultural production. In a study conducted by (Al-Qassar *et al.*, 2015) to compare irrigation using fuel-powered pumps with farms that rely on clean energy irrigation, concluded to, the costs of the irrigation pumps that operates on clean energy are lower than those of the pumps that operates on fuel by 82%. Pascaris *et al.* (2021) published a study on the market impact of using solar energy in agricultural production. The researchers concluded that adopting solar energy in agricultural production helps agricultural and economic development and helps preserve agricultural lands, as there is societal acceptance of this technology. In a study by Mohammed and Jassim (2021) on the possibility of exploiting clean energy in remote areas for domestic and agricultural purposes, they found that, generating electricity using solar panels is economically feasible, as the solar panel system produces 1000 watts at a cost of 2 dollars, while the electricity generator that operates on traditional fuel produces 1000 watts at a cost of 9.6 dollars. In addition, solar panels help to reduce environmental pollution resulting from burning fuel for electricity generators.

Arias-Navarro *et al.* (2023) also conducted a study on the establishment of solar energy systems with grape farms in the province of Alicante - Spain, aiming to find clean energy sources and exploiting the Agricultural lands, the researchers concluded, through a questionnaire conducted using the (Google form) via the Internet, that 30% of the research sample is refused to establish solar energy systems with grape farms to preserve the environmental landscape, while 70% were in favor of using solar energy panels. The results of the above previous studies are consistent with the goals of sustainable development, which considered the global outlet for reducing pollution and encouraging the use of alternative energy, especially in agricultural production. From here, the research gap appears in the study of adopting clean energy technologies and using them at the farm level. The research problem revolves around the continued use of fossil fuels in vineyard irrigation pumps in the study area. This wastes economic resources, such as irrigation water consumption and increased fuel consumption, in addition to increased environmental pollution. Therefore, alternatives must be studied to provide sustainable energy in vineyards, to improve productivity, reduce production costs, and limit environmental pollution. The aim of this article is to conduct an economic study of a sustainable grape production farm that relies on the use of solar energy and drip irrigation pattern compared to an existing grape farm that relies on the traditional irrigation and production pattern for evaluating the results through some economic indicators.

Materials and Methods

The research was conducted in a grape farm from January - June 2024, during production season in Diyala Governorate, Iraq. It relied on a set of economic indicators to help achieve the specific research objectives, including quantitative and descriptive analysis of investment and production costs, returns, and profits.

The studied grape farm

Grape farms in Diyala Governorate still rely on the traditional style of agriculture and production, as well as the traditional irrigation method that consumes large quantities of water, which causes a great waste of water resources and an increase in the growth of harmful weeds. The basic data of the farm studied in the current situation, is shown in Table 1, it shows that grape tree and soil service are carried out using traditional methods, which leads to high production costs, increased time consumption, and soil pollution due to the chemical pesticides used.

Table 1. Data of the studied farm for the season 2024

| No. | Grape Farm Data | Style | Details |
|-----|-------------------------|---------------------------|-----------------------------|
| 1 | Farm location | Diyala Province | North Diyala Province |
| 2 | Farm area | 3 hectares | ----- |
| 3 | Planting pattern | Arbor shed | Traditional agriculture |
| 4 | Irrigation method | Flood irrigation | Fuel and electric pumps |
| 5 | Type of energy used | Fuel - Electricity | ----- |
| 6 | Type of labor used | Human labor | Difficulty of mechanization |
| 7 | How to combat jungles | Chemical pesticides | ----- |
| 8 | Pest control method | Chemical pesticides | ----- |
| 9 | Irrigation water source | river | ----- |
| 10 | Fertilization method | Traditional fertilization | ----- |
| 11 | Age of trees | ----- | 7 years |

Reference: Author based on personal interview with the producer.

Sustainable Grape Farm

1. Environmental factors

The appropriate environment: Environmental factors greatly affect grape trees, as the activity of the roots begins at a temperature of 7.2° - 7.8°. While the activity of the buds 10° - 12°, and flowering requires a temperature ranging between 18 - 20 degrees Celsius, while fruit setting requires a temperature of 20° -25°, and grapes ripen well at a temperature of 25° -30° (Al-Alaf, 2016).

2. Technical operations of the farm

2.1. Soil plowing: The plowing is to provide suitable soil for the growth of grape seedlings; the plowing depth is 20-25 cm.

2.2. Basic fertilization: An organic fertilizer is used to create a decomposable food stock in the soil that is gradually absorbed by the plant. The quantities of basic fertilizer are determined after conducting a soil test. The organic fertilizers required for the soil are estimated at approximately 10-40 tons/Hec. of animal fertilizers.

2.3. Land plot planning: In all cases, land plot planning depends on planting in rows at regular distances, leaving sufficient distances for the movement of agricultural machinery.

2.4. Digging holes and planting seedlings: The dimensions of the hole for grape seedlings are 40 × 40 × 50 cm, and the holes may be prepared mechanically (Arab Organization for Agricultural Development, 2020).

2.5. Determining the number of trees: The number of grape trees per hectare can be determined, based on the distances between the trees through the following relationship (Al-Baytar, 2015):

$$\text{Number of trees per hectare} = \text{Area of the hectare in meters} / \text{Square of the distance between one tree and another in meters}$$

3. Tree care and soil service

3.1. Vegetative propagation: The best way to propagate grape trees is vegetative propagation, which is increasing the number of plants by using the possible vegetative parts of a single plant. (Al-Baytar, 2015).

3.2. Fertilizing grape trees: Fertilization is necessary to compensate for the depletion of nutrients in the soil due to the presence of trees for decades.

3.3. Pruning grape trees: Pruning grape trees depends on selecting good buds and its purpose is to reduce the excessive growth of the grape tree to regulate production and achieve good fruits in terms of quality and quantity.

3.4. Prevention of agricultural pests: Selecting plant varieties that are less susceptible to diseases and taking good care of irrigation, pruning and feeding programs can reduce the effects of pests (Arab Organization for Agricultural Development, 2020)

3.5. Drip irrigation system: The drip irrigation system consists of the following parts:

3.5.1. Water pump: draws water from the main tank and pumps it back into the irrigation network.

3.5.2. Water quantity gauge: It is a gauge placed on the line carrying irrigation water from the source to the irrigation network for knowing the quantities of water used.

3.5.3. Main valve: It is a plug placed at the end of the main line carrying irrigation water.

3.5.4 Automatic one-way valve: A valve allows water to pass from its source to the irrigation network and prevents the return of water contaminated with chemicals to the water tank to preserve it from contamination with water mixed with fertilizer.

3.5.5. Fertilizer tank valve: It is used to calibrate the pressure of the water mixed with fertilizer flowing into the irrigation network, where the water enters at a certain pressure and then exits at a lower pressure.

3.5.6. Filter: The filter is used to filter the irrigation water flowing into the irrigation water network.

In Table 2, the pump used in this farm, according to the capacity shown, achieves operational efficiency with a water flow capacity of 109 meters and a capacity of 4 inches for the inlet and outlet pipes. The main pipe transporting water from the pump is 100 meters per hectare. The branch pipe is 100 meters long according to the layout of the plot of land. Irrigation water drippers are installed every two meters according to the cultivation method, in addition to the fertilizer tank that holds 100 liters of liquid fertilizer. To secure the end of the main irrigation water line, it is closed with a tight valve, as in Figure 1.

Table 2. Components of the drip irrigation system and their cost according to the prevailing prices in the local market

| Irrigation system components | Unit cost (\$) | Quantity | Total cost (\$) | Details |
|------------------------------|-------------------------|---|-----------------|--------------------------------|
| Water pump | (309) \$ | 1 | 309 | (20) HP |
| Main pipes | (1.2) \$/meter | (50) meters | 60 | Pipe diameter (4) inch |
| Branch pipes | (0.268) \$/meter | (40) pipes * pipe length (50) meters = 2000 meters | 536 | Pipe diameter (0.5 – 0.8) inch |
| Water drippers | (17) \$ per 100 dripper | 1600 | 272 | (1600)dripper/ Hec. |
| Fertilizer mixing tank | (110.3) \$ | 1 | 110.3 | Capacity (100) liters |
| Large valves | (7) \$ | 1 | 7 | Number (1)/hectare |
| one way valve | (10) \$ | 1 | 10 | Number (1)/hectare |
| Filter | (13.5) \$ | 1 | 14 | Number (1)/hectare |
| Backup tools | (16) \$ | undefined | 16 | As needed |
| Total | ----- | ----- | 1334 | ----- |

Reference: Author based on personal interview with sellers in the production inputs market.

* Exchange rate: (1 \$ = 1490 I.Q.) according to the exchange rate prevailing in the Iraqi market for the year 2024.



Figure 1. Irrigation water storage basin

Costs of constructing a grape arbor shed: In general, the number of trees per hectare is determined based on the distance between one row and another, as well as the distance between one tree and another. In the method of planting grape trees on a arbor shed, the distance between one row and another is 2.5 meters, and the distance between one tree and another is 2.5 meters, taking into account the type of soil and its degree of fertility (Arab Organization for Agricultural Development, 2020) Since the distance between one tree and another is 2.5 meters and the area of the hectare is equal to (10,000) meters square, the number of grape trees per hectare can be determined using the following equation (Al-Baytar, 2015):

$$\begin{aligned} \text{Number of trees per hectare} &= \text{Area of hectare in square meters} / \text{Square distance between trees in} \\ &\quad \text{meters} \\ &= 10000 / 6.26 = 1600 \text{ Tree / hectare} \end{aligned}$$

4. Grape arbor shed parts

4.1. Main wooden pegs: are used to tie the main thick wire, which is tensioned to a certain degree to support the wire mesh.

4.2. Wooden arbors: are used to raise grape seedlings on them to the top. The arbors are fixed to the ground and a metal wire is attached to them.

4.3. Grape Arbor Fixing Wires: are used to tie and secure the main wooden stakes to a concrete block fixed in the ground to stabilize the pergola network and protect it from wind shocks.

4.4. Thick metal wire: is used to form a square shape and hold the grape arbor net, achieve a certain degree of tension, and prevent it from falling.

4.5. Thin metal wires: are used to hang grape vines and maintain their growing branches.

4.6. Tie wires: are used to tie thick and thin wire to the main wooden pegs.

4.7. Small concrete bases: which are created in the ground to hold the main connection wires that extend from the grape arbor network to the ground.

5. Irrigation water basin: is constructed of concrete and its storage capacity is determined according to the area of the farm.

6. Agricultural service road: is used to transport fertilizers and other supplies to the farm.

7. Main irrigation canal: is used to transport irrigation water from the source to the storage basin for later use in irrigating the grape farm.

8. Grape seedlings: The variety of grape trees is determined according to the conditions surrounding the farm site and the purpose of grape production, as shown in Figure 2.

Table 3 shows that the costs of grape arbors, the costs of digging holes and planting seedlings each constitute the highest percentage, amounting to 21.73%, followed by the cost of purchasing grape seedlings, which is constituted a percentage of 16.19%, then followed by other cost items.

Table 3. Parts of the grape arbor shed and their cost according to the prevailing prices for the year 2024

| No. | Fixed components of the farm | Quantity per hectare | Average cost (\$/unit) | Cost (\$/Hec.) | Contribution rate (%) |
|--------------|--------------------------------------|----------------------|------------------------|----------------|-----------------------|
| 1 | Main wooden pegs | (40) peg | 5 | 200 | 1.35 |
| 2 | Wooden arbors | (1600) peg | 2 | 3200 | 21.73 |
| 3 | Grape Arbor Fixing Wires | (200) meters | 1 | 200 | 1.36 |
| 4 | thick metal wire | (400) meters | 2 | 800 | 5.43 |
| 5 | thin metal wires | (400) meters | 0.540 | 216 | 1.47 |
| 6 | Tie wires | (3) rolls | 3 | 9 | 0.06 |
| 7 | Small concrete bases | (200)concrete base | 4.5 | 900 | 6.11 |
| 8 | Irrigation water basin | undefined | undefined | 1050 | 7.13 |
| 9 | Agricultural service road | undefined | undefined | 20 | 0.14 |
| 10 | Main irrigation canal | undefined | undefined | 32 | 0.22 |
| 11 | Buy grape seedlings | (1600)seedlings | 1.490 | 2384 | 16.19 |
| 12 | Basic organic fertilizer | (45) tons | (11.5) \$/ ton | 517.5 | 3.51 |
| 13 | Digging holes and planting seedlings | (1600) hole | 2 | 3200 | 21.73 |
| 14 | farm fence | (400) meters | 5 | 2000 | 13.57 |
| Total | | ----- | | 14728.5 | %100 |

Reference: Author based on personal interview with sellers at prevailing prices in the production requirements market.



Figure 2. Grape arbor shed

Indicators for investing in sustainable grape farm

The economic indicators for investing in sustainable grape farm can be measured based on the value of the costs incurred as well as the estimated profits. The most important of these indicators are:

1. Net cash flow: This criterion represents the minimum revenue achieved, as it gives the farmer an indication of achieving technical efficiency. This criterion can be calculated based on total variable costs. The revenue and cash flow rates calculated using the following equation (Qatf and Khalil, 2004):

$$\text{Revenue} = \text{Quantity of Output} \times \text{Selling Price}$$

$$\text{Cash Flow} = \text{Total Revenue} - \text{Total Variable Costs}$$

2. Capital payback period: which is the period required to recover the capital invested in the production process through annual cash flow. This indicator is calculated using the following equation (Arab Monetary Fund, 2022):

$$\text{Capital payback period} = \frac{\text{Total investment costs}}{\text{Total annual cash flow}}$$

3. Return on invested dollar: This criterion is considered an indicator of achieving economic efficiency by spending on the production process and it can be calculated using the following equation (Al-Sanfi, 2013):

$$\text{Return on invested dollar} = \frac{\text{Income per hectare}}{\text{Total cost per hectare}}$$

4. Measuring technical efficiency: Technical efficiency means achieving the same volume of output using a smaller volume of available production resources. The technical efficiency of a sustainable grape farm can be measured by comparing the productivity of the farm studied in reality with the following equation (O'Donnell, 2018):

$$\text{Technical efficiency} = \frac{\text{Current farm productivity (kg)}}{\text{Sustainable farm productivity (kg)}} \times 100$$

Measuring Economic Efficiency

Economic efficiency means achieving the maximum possible profit at a given level of production costs (O'Donnell, 2018). The economic efficiency of a sustainable grape farm can be measured by adopting the variable production costs of the grape farm studied in the current reality, as follows:

$$\text{Economic efficiency} = \frac{\text{Variable costs of a sustainable grape farm}}{\text{Variable costs of the studied grape farm}} \times 100$$

Results and Discussion

Investment and production costs of the studied grape farm

Investment costs

These costs include the invested capital, which is a statement to know the economic indicators of the grape production farm based on the prevailing prices in the production factors market. Table 4 shows that the average cost of the irrigation pump constitute the highest percentage among the investment cost items, as it is amounted to 29.73%, followed by the costs of purchasing seedlings (assets), as it is amounted to 18.97%, then the costs of establishing a fertilizer store, as it is amounted to 11.08%. Then, the other cost items in order, the total average cost per hectare is amounted to 1803 dollars, which represents the capital invested per hectare.

Table 4. Investment costs per hectare for the studied grape farm for the 2024 season

| No. | Expenditure items | Average cost (\$/ha) | Relative importance (%) |
|--------------|---|----------------------|-------------------------|
| 1 | Land rent | 35 | 1.94 |
| 2 | Land preparation | 25 | 1.39 |
| 3 | Establishing a fertilizer store | 200 | 11.08 |
| 4 | Construction of irrigation canals and digging holes | 70 | 3.88 |
| 5 | Buy seedlings | 342 | 18.97 |
| 6 | Transport | 20 | 1.11 |
| 7 | Agricultural mechanization labor | 23 | 1.28 |
| 8 | Human labor hired | 58 | 3.22 |
| 9 | thin metal wires | 134 | 7.43 |
| 10 | thick metal wire | 148 | 8.21 |
| 11 | Cost of pegs and worn tires | 77 | 4.27 |
| 12 | irrigation pump cost | 536 | 29.73 |
| 13 | Cost of irrigation pump pipes | 44 | 2.44 |
| 14 | Cost of working tools | 40 | 2.22 |
| 15 | Cost of establishing electricity | 51 | 2.83 |
| Total | | 1803 | 100 |

Reference: Author based on personal interview with the producer.

Variable production costs

- Nitrogen fertilizer:** The farmer used this fertilizer twice during the production season at a rate of 130 kg/hectare and at a price of 1 dollars/kg.
- Superphosphate fertilizer:** The farmer used phosphate fertilizer once during the production season at a rate of 60 kg/hectare and at a price of 1.3 dollars/kg.
- Animal manure:** The farmer used an amount of 8 tons of animal manure distributed over 3 hectares. The total cost of animal manure amounts to 90 dollars, with an average cost per ton of 11.25 \$/ton. Organic fertilizers are the most important soil fertilizers. Al Tamimi (2019) concluded, through analyzing the production function of orange farms in Diyala, that animal fertilizers have a positive effect on the amount of production.

4. **Cost of hired labor:** includes the costs of hired labor during the production period starting from January until June, and the average labor wage was 17 \$ for each worker who works 6 hours during the day.
5. **Irrigation canal maintenance and farm road:** The costs included cleaning the farm's main irrigation channels and maintaining the farm's service road.
6. **Irrigation pump maintenance:** This is the cost of maintaining the irrigation pump.
7. **Cost of irrigation pump fuel and oil:** The costs of irrigation pump fuel and operating oil were included and the fuel purchase price was 0.5 \$/liter.
8. **Electricity cost:** Includes the cost of operating an electric irrigation pump.
9. **Irrigation cost:** includes irrigation costs during the production period, which starts from February until July, depending on weather conditions and temperatures.
10. **Grape Arbor Maintenance:** Includes maintenance costs for stakes or metal wires.
11. **Agricultural pesticide costs:** include the costs of purchasing the pesticide, which costs 9 \$/liter.

Fixed production costs

1. **Land rent:** Land rent, for the farm under study, is based on a personal interview with the farmer, and the rent per hectare amounts to 35 \$/hectare.
2. **Cost of depreciation of grape arbor shed:** Depreciation is calculated by the annual depreciation installment law of deducting the value of the debris from the top of the asset, then dividing by the expected life of the asset (Al-Kalidar and Al-Dabash, 2018), and the estimated life of the shed in addition to the fixed assets, is 15 productive years.
3. **Cost of farm fence depreciation:** The estimated lifespan of farm fence (BRC) and concrete pickets is five years.
4. **Family labor cost:** includes the cost of transplanting the regenerated trees as well as irrigation during the dormant period.
5. **Tree consumption costs:** This means the estimated period for trees from planting until the season of low production, as the productivity of the tree decreases. After that period, it becomes economically unviable, so it is replaced with new seedlings (Ahmed and Ibrahim, 2010).
6. **Interest rate on capital:** The interest rate on operating capital 10% is determined according to the Agricultural Cooperative Bank in Diyala, 2023.
7. **Cost of irrigation pump depreciation:** Estimated lifespan of irrigation pumps is 8 years.

Production cost structure: Table 5 shows that the interest rate on capital constituted the highest percentage among the production cost items is amounting to 14.94%, followed by the cost of nitrogen fertilizer and phosphate fertilizer, which is constituted 10.79% and 10.79% respectively, followed by the cost of fixed labor, which is constituted 9.96%, followed by other cost items.

Table 5. Production cost structure in the studied grape farm for the 2024 season

| Type of costs | Cost items | Quantity, number | Value (\$/he) | Relative importance (%) |
|---|--|------------------|---------------|-------------------------|
| Average variable production costs | Nitrogen fertilizer | 130 | 130 | 10.79 |
| | Phosphate fertilizer | 100 | 130 | 10.79 |
| | Animal manure | 2.6 | 29 | 2.41 |
| | Pesticides | 6 | 54 | 4.48 |
| | hired human labor | 5 | 85 | 7.05 |
| | Maintenance of irrigation canals and farm road | ---- | 20 | 1.66 |
| | Irrigation pump maintenance | ---- | 13 | 1.08 |
| | Irrigation pump fuel and oils | ---- | 110 | 9.13 |
| | Electricity taxes | ---- | 14 | 1.16 |
| | Irrigation labor cost | ---- | 26 | 2.16 |
| | Grape arbor shed maintenance | ---- | 22 | 1.83 |
| Total average variable production costs per hectare | | | 633 | %52.53 |
| Average fixed production costs | Grape arbor shed extinction | ---- | 60 | 4.98 |
| | Land rent | 1 | 35 | 2.90 |
| | Extinction of irrigation canals and road | ---- | 4 | 0.33 |
| | Farm fence collapse | ---- | 75 | 6.22 |
| | Irrigation pump extinction | ---- | 62 | 5.15 |
| | Family labor cost | 3 | 120 | 9.96 |
| | Tree extinction | 12 | 36 | 2.98 |
| | Interest rate on capital | ---- | 180 | 14.94 |
| Total average fixed production costs per hectare | | | 572 | %47.47 |
| Average total production costs per hectare | | | 1205 | 100 |

Reference: Author based on personal interview with the producer.

Production and Marketing

Since the theory of production is concerned the study farm, it is necessary to study the achieved production and the role of the producer (Al-Hasnawi, 2011). The productivity of a hectare is achieved by the influence of the production resources used and weather factors in addition to the efficiency of farm management. Table 6 shows that the quantity of grapes produced was the highest among the farm's products, but secondary products have an impact on the producer's revenue in that they constitute a part of the consumer's needs. By-products it added from an accounting perspective to the farm accounts as a cost account and the revenue generated from them (Ahmed and Ibrahim, 2010).

Table 6. Quantities of studied grape farm products for the 2024 season

| No. | Type of product produced | Quantity | Unit of measure |
|-----|---------------------------------|----------|------------------|
| 1 | Grape fruit | 9500 | Kg/Hectare |
| 2 | Grape leaves | 177 | Kg/Hectare |
| 3 | Vegetative propagation branches | 510 | Branches/Hectare |
| 4 | dried raisins | 30 | Kg/Hectare |

Reference: Author based on personal interview with the producer.

Marketing and revenue for the studied grape farm

Marketing ensures the distribution of agricultural products in a regular manner as well as directing consumption and benefiting from agricultural products to the greatest extent possible to achieve benefit. (Salam *et al.*, 2011) The expenses incurred by the producer in the marketing process are called marketing costs and they start after the end of production costs from transporting the produce from the farm until it reaches the consumer and they affect the net profit obtained by the producer (Al-Rubaie, 2012). Table 5 include the marketing costs and selling price of the studied farm products, to know the value of the revenues achieved by the producer during the production season, the revenue from selling grapes was the highest among the revenues of by-products, achieving 6650 \$/Hec. Followed by the revenue from selling vegetative propagation branches, which reached 127.5 \$/Hec. After which come the revenues of other products.

Table 7. Marketed products and selling prices for the studied grape farm for the 2024 season

| No. | Type of products marketed | Quantity (kg, branch /Hec.) | Selling price (\$/kg, branch) | Revenue generated (\$/Hec) | Marketing costs (\$) |
|-----|--|-----------------------------|-------------------------------|----------------------------|----------------------|
| 1 | grape fruit | 9500 | 0.7 | 6650 | 1103.5 |
| 2 | Grape leaves | 177 | 0.5 | 88.5 | 4.425 |
| 3 | dried raisins | 30 | 0.5 | 15 | 2.01 |
| 4 | Vegetative propagation branches | 510 | 0.250 | 127.5 | 28.05 |

Reference: Author based on personal interview with the producer.

Profits achieved for the studied grape farm: Profits is defined as the total revenues minus the total production and marketing costs, which is called economic profits. Table 7 shows the profits of the studied farm in Diyala.

Table 8. Production and marketing costs and profits achieved in the studied grape farm for the 2024 season

| No. | Total revenue (\$/Hectare) | Marketing costs (\$/Hectare) | Production costs (\$/Hectare) | Net profit (\$/Hectare) |
|-----|----------------------------|------------------------------|-------------------------------|-------------------------|
| 1 | 6881 | 1138 | 1205 | 4538 |

Reference: Author based on personal interview with the producer.

Resources needed for a sustainable grape farm

Solar energy system: This system is the main source of providing the energy needed to operate the irrigation water pump, and its purchase costs are part of the investment costs, as in Table 9.

Table 9. Components of the solar energy system and the cost of purchasing it for a sustainable grape farm

| Solar energy system parts | Life expectancy | System capacity (per/ hectare) | Total cost (\$) |
|---------------------------|-----------------|--------------------------------|------------------|
| Photovoltaic panels | (20) years | 27Amp (6 K.W.) | 5143 |
| Connecting wires | ----- | | |
| Current transformer | (10) years | | |
| Energy storage batteries | (5) years | | |

| | | | |
|--|------------|-------|------|
| Iron structure for carrying solar panels | (20) years | ----- | 80 |
| Total | ----- | ----- | 5223 |

Reference: Author based on data from Muhammad and Al-Khayat (2019).

*The electricity generation capacity is calculated using the relationship $(6 \text{ kW} \times 1000)$ divided by 220 volts = 27.2 amps. (General Organization for Technical Education and Vocational Training, 2020).

A solar energy system is an essential part of an agricultural production project, providing the energy needed to operate the irrigation pump. It is also an ideal alternative for reducing environmental pollution, so its high cost does not constitute an obstacle to sustainable agriculture, as shown in Table 7, Figures 3, and 4 show the solar panels and system.



Figure 3. Components of the solar energy system

Figure 4. Installation of solar energy system panels

Investment is using of saved resources, as it involves employing money for generating additional income (Yousef and Marhej, 2018). The saved money, when enters the field of investment work, is called investment costs. These costs start from the value of the agricultural land rent, as a main production factor, and end at the beginning of production costs, which are shown in Table 10, which shows the cost of grape arbors constituted 56.93%, which is the highest percentage among investment cost items, while the cost of land rent constituted 1.84% of the total investment cost, which is the lowest percentage among investment cost items.

Table 10. Investment cost items for a sustainable grape farm according to 2024 prices

| No. | Cost item | Cost (\$/ Hectare) | Contribution rate (%) |
|-------|--------------------------------|--------------------|-----------------------|
| 1 | Land rent | 400 | 1.84 |
| 2 | Cost of drip irrigation system | 1334 | 6.15 |
| 3 | Solar energy system cost | 5223 | 24.09 |
| 4 | Grape arbor shed cost | 12344.5 | 56.93 |
| 5 | Grape seedlings purchase costs | 2384 | 10.99 |
| Total | | 21685.5 | %100 |

Reference: Author based on personal interview, and Tables 2, 3, and 9.

The total investment costs amounted to 21685.5 \$/Hec. This represents the capital invested in the sustainable grape farm. Al-Timimi (2020) concluded in a study in Diyala, Iraq, by analyzing the Cobb-Douglas production function on barley production farms, that organizing the use of capital with other production resources, and limited farm area achieves increased productivity and thus achieves profitable profits for producers. If the investment costs are high, this requires a practical partnership between the public and private sectors to provide farm capital and achieving higher efficiency in agricultural production, as (Bintariningtyas *et al.*, 2024) indicated the importance of the partnership

between the public and private sectors in determining agricultural policies. Regarding to the weakness of the partnership in agricultural production projects between the public and private sectors.

Fixed production costs

The estimation of these costs is based on the prevailing prices in the production requirements market, noting that the operating capital amounted to 1372 dollars/hectare (the interest rate on capital amounted to 137 dollar/hectare, which is 10%), and included variable production costs, fixed labor, and expenses for installing irrigation systems, solar energy, and the grape arbor network, as shown in Table 11. It is clear that the cost of installing grape arbors constituted the largest proportion of the total fixed costs, amounting to 23.22%, followed by the costs of installing the solar energy system and the cost of security, which constituted 17.33% and 17.33% respectively, followed by other cost items.

Table 11. Fixed production costs for a sustainable grape farm

| Cost item | Costs (\$/Hec.) | Contribution rate (%) |
|--|-----------------|-----------------------|
| Service road work | 7 | 0.61 |
| grape arbor installation work | 268 | 23.22 |
| Solar power system installation | 200 | 17.33 |
| Irrigation system installation | 160 | 13.86 |
| Security costs | 200 | 17.33 |
| Estimated annual depreciation of irrigation system | 21 | 1.82 |
| Estimated annual depreciation of the solar system | 72 | 6.24 |
| Estimated annual depreciation rate of grape arbor | 89 | 7.72 |
| Interest rate on capital (%10) | 137 | 11.87 |
| Total | 1154 | 100 |

Reference: Calculated by the author based on prevailing labor prices for the year 2024.

*Depreciation was calculated using the annual depreciation rate (Al-Kalidar and Al-Dabash, 2018).

Variable production costs

Variable costs estimated according to the prevailing prices in the production input market in the study area, as in Table 12. It is clear that maintenance costs constituted the largest proportion among variable cost items, amounting to 65.18%, followed by the cost of organic fertilization, which constituted 16.75%, and then the other variable cost items.

Table 12. Variable costs of a sustainable grape farm according to the prices of the production input market for the year 2024

| Cost item | Quantity (Worker, tons/Hec.) | Cost (\$/Hec.) | Contribution rate (%) |
|---------------------------------|------------------------------|----------------|-----------------------|
| Hired labor | 2 | 33 | 6.15 |
| Manual weeding | 2 | 34 | 6.33 |
| Secondary organic fertilization | 6 | 90 | 16.75 |
| Irrigation water taxes | --- | 30 | 5.59 |
| Maintenance and other costs | --- | 350 | 65.18 |
| Total | ---- | 537 | %100 |

Reference: Author based on questionnaire and personal interview.

Estimated production of a sustainable Grape farm

In the first and second years, grape trees only grow, so they do not bear fruit. Since grape trees come in many varieties, the speed of growth and ripening varies according to the variety, in addition to the influence of the prevailing weather conditions (Al-Alaf, 2016). Grape trees start producing in the third year of the tree's life, then production calculations can be made and then marketing. From the studies

conducted on grape tree productivity (Al-Tamimi and Bakr, 2023), Who found the average productivity of a grape tree under normal conditions reached 26 kg in a study conducted in Diyala, Iraq. (Abd, 2021), also found the average productivity of a mature grape tree reached (26.5) kg, in a study conducted in Salah al-Din, Iraq. In Egypt, (Mohamed, 2021) conducted a study on a grape farm that follows the intensive cultivation pattern, he concluded that the average productivity of a mature tree is 17 kg, that due to the difference in environmental conditions between one country and another and the difference in the cultivation pattern. These studies show that the productivity of the grape tree depends on many factors, including the environmental conditions surrounding the tree, the age of the tree, as well as soil activity in addition to tree service operations.

Estimated productivity with risk

Due to the biological nature of agricultural production, the risk of production may be natural, which is result of weather fluctuations such as floods, or agricultural pests that affect fruits and trees, in addition to the lack of efficiency of farm management (Razdaq and Basyouni, 2011). The expected productivity can be estimated based on the productivity of the farm that is studied in the current reality as a comparison farm. Table 13 shows that productivity can be increased if farm management efficiently exploits production resources, thus achieving high productivity that can generate profitable profits if selling prices are also profitable.

Table 13. Estimated productivity of the sustainable grape farm compared to the farm relies on traditional methods

| Productivity adjustment ratio | Actual farm productivity (kg/Hec.) | Estimated sustainable farm productivity (kg/ha) | Influencing factors |
|--------------------------------|------------------------------------|---|--|
| Increase productivity by (20%) | 9500 | 11400 | Efficiency of farm management in exploiting productive resources |
| Equal productivity | 9500 | 9500 | Traditional farming pattern |
| Decrease in productivity (20%) | 9500 | 7600 | Inefficiency of farm management in exploiting productive resources |

Reference: Author based on Table 7.

Estimated revenues for a sustainable grape farm

The estimated revenues for a sustainable grape farm can be calculated by knowing the value of both the production costs and the selling price of the product. Table 14 shows that the lack of farm management efficiency also causes a decrease in profits, but it does not lead to economic losses, which means that the producer is still in the stage of increasing yields and can achieve the first case (increasing productivity by 20%) if the production resources are optimally exploited.

Table 14. Estimated revenue for a sustainable grape farm

| Productivity adjustment ratio | Estimated productivity (kg/Hec.) | Product selling price (\$/kg) | Production costs (kg/Hec.) | Estimated revenue (\$/Hec.) |
|--------------------------------|----------------------------------|-------------------------------|----------------------------|-----------------------------|
| Increase productivity by (20%) | 11400 | 0.637 | 1691 | 7261.8 |
| Productivity decrease (%20) | 7600 | 0.637 | 1691 | 4841.2 |

Reference: Author based on Table 11, 12, and the selling price of grapes in the central market in Diyala Province, Iraq, 2024 season.

*Average revenues were calculated using the total revenue law (Qatf and Khalil, 2004).

By-product revenue

The revenue from by-products of a sustainable grape farm can be calculated in the same way that grape yield is estimated. Table 15 shows that the total estimated revenue from by-products in the case of increased productivity is amounted to 277 \$/Hec. While it is amounted to 185 \$/Hec. In the case of a 20% decrease in production, based on the prevailing prices in the agricultural products sales markets.

Table 15. By-products and selling price of sustainable grape farm

| Productivity adjustment ratio | Product Type | Quantity per hectare | Selling price (\$/unit) | Estimated revenue (\$/Hec.) |
|-------------------------------|-------------------------------|----------------------|-------------------------|-----------------------------|
| Increase productivity (%20) | Grape leaves | 212 | 0.5 | 106 |
| | dried raisins | 36 | 0.5 | 18 |
| | Vegetative reproduction parts | 612 | 0.250 | 153 |
| Total | ----- | ----- | ----- | 277 |
| Decreased productivity (%20) | Grape leaves | 142 | 0.5 | 71 |
| | dried raisins | 24 | 0.5 | 12 |
| | Vegetative reproduction parts | 408 | 0.250 | 102 |
| Total | ----- | ----- | ----- | 185 |

Reference: Author based on Table 4 and the productivity adjustment ratio.

Calculating investment indicators in sustainable grape farming

Net cash flow

Table 16 shows the product can achieve profitable profits even in the case of low productivity, as the estimated cash flows in the case of low productivity amounted to 4489.2 \$/hectare during the production year, which means the sustainable grape production farms are economically profitable.

Table 16 Calculating the annual net cash flow of a sustainable grape farm

| Productivity adjustment ratio | Variable production costs (\$/Hec.) | Estimated revenue (\$/Hec.) | Net cash flow (\$/Hec.) |
|-------------------------------|-------------------------------------|-----------------------------|-------------------------|
| Increase productivity (%20) | 537 | 7538.8 | 7001.8 |
| Decreased productivity (%20) | 537 | 5026.2 | 4489.2 |

Reference/ Author based on Table 12, 14, and (15).

Capital payback period: Payback period is linked to efficiency of farm management, as the increased productivity is achieved by the efficiency of the farm manager leads to a reduction in the period required to recover the invested capital. While the inefficiency of farm management leads to a decline in productivity then increasing the period required recovering the farm capital, as it increases from 2.9 years to 4.6 years:

$$1- \text{When productivity increases (20\%)} = \frac{20774}{7001.8} = 2.9 \text{ years}$$

$$2- \text{When productivity decreases (20\%)} = \frac{20774}{7001.8} = 4.6 \text{ years.}$$

Return on invested dollar: One dollar generated 1.38 \$ in estimated revenue, when productivity decreased by (20%), while increasing productivity by 20%, the invested dollar will generate 2 \$, which means that investing in sustainable grape farms is economically feasible:

$$1- \text{When productivity increases (20\%)} = \frac{7538.8}{3638} = 2 \$$$

$$2- \text{When productivity decreases (20\%)} = \frac{7538.8}{3638} = 1.38 \$$$

Measuring technical efficiency: It is clear from the technical efficiency, which is 83%, it is possible to achieve production efficiency in a sustainable grape farm, as the producer can increase productivity by 17% by relying on the amount of available resources to achieve 100% production efficiency:

$$= \frac{9500}{11400} * 100 = 83\%$$

Measuring Economic Efficiency: The economic efficiency rate of the sustainable grape farm reached 84%, which indicates a surplus in expenses of 16%, as variable cost expenses can be reduced to achieve economic efficiency of 100% during the production season, and these surplus results from adopting the different prices in the production inputs market:

$$= \frac{537}{633} * 100 = 84\%$$

Conclusions

From the economic analysis between the studied grape farm and the sustainable grape farm, it was found that the total production costs of the sustainable grape farm were higher than those of the studied grape farm due to the use of modern technical requirements. Total production costs amounted to 1691 \$/ hectare while the total production costs of the studied grape farm amounted to 1205 \$/ hectare. Fuel costs for the irrigation pump also accounted for 9.13% of the total production costs in the studied grape farm, while electricity tax costs accounted for 1.16% of the total costs of the same farm. In the sustainable grape farm, the annual depreciation of the solar energy system accounted for 6.24% of the total fixed costs. By measuring investment indicators, total revenues in the studied grape farm amounted to 6881 \$/ hectare, while revenues for the sustainable grape farm amounted to 7538.8 \$/ hectare under highly efficient farm management, while under risk conditions, they amounted to 5026 \$/ hectare. The return per dollar invested in the sustainable grape farm was 2 \$, and under risk conditions 1.3 \$. In conclusion the investing in a vineyard using sustainable energy and regulated irrigation is economically viable. Furthermore, the technical efficiency of the sustainable grape farm reached 83%, while the economic efficiency of the same farm reached 84%. This means that the producer can achieve full efficiency if production resources are optimally utilized.

Acknowledgments

The authors would like to thank the staff of the Diyala Agriculture Directorate.

Conflict of Interest

The authors declare that there are no conflicts of interest.

Funding Declaration

No funding was allocated for this article.

Author Contribution

The first author writes the original draft and finalizes the manuscript, and the second author performs the statistical analysis.

References

- Abd, Z. F. (2021). Economic analysis of Grape Production farms in Salah Al-din Governorate for the 2019 Productive season (Balad district as a model). *Mesopotamia Journal of Agriculture*, 49(4), 1-10. https://magrj.uomosul.edu.iq/article_168929.html
- Mohamed, I. A. (2021). Estimation of the Optimum Size of Grape Farms in Minya Governorate. *Alexandria Science Exchange Journal*, 42(4), 2151-2165. <https://dx.doi.org/10.21608/asejaiqsae.2021.209884>
- Ahmed, M. G., and Ibrahim, E. N. (2010). *Agricultural Cost Accounting*. Arab Community Library for Publishing and Distribution, Amman, 1st ed, Amman, Hashemite Kingdom of Jordan.
- Al-Tamimi, A. A. A. (2019). Economic analysis for the most important obstacles to the production of orange crop in Diyala/a study for the season of 2018. *IOP Conference Series: Journal of Physics*, 1294(9), 1-9. <https://doi.org/10.1088/1742-6596/1294/9/092008>
- Al-Alaf, I. H. (2016). *The appropriate environment for the growth of fruit crops*. First ed., Al-Moataz Publishing and Distribution House, Hashemite Kingdom of Jordan, p. 123.
- Al-Baytar, A. D. (2015). *Fruit Trees, Basics, Care, and Production*. Al-Quds Open University, 1st ed., Deanship of Graduate Studies, Jerusalem, Palestine. https://www.qou.edu/ar/sciResearch/pdf/book/Fruit_trees_basics_cultivation_nurturing_and_production.pdf
- Pascaris, A. S., Schelly, C., Burnham, L., and Pearce, J. M. (2021). Integrating solar energy with agriculture: Industry perspectives on the market, community, and socio-political dimensions of agrivoltaics. *Energy Research & Social Science*, 75, 102023. <https://doi.org/10.1016/j.erss.2021.102023>
- Al-Hasnawi, K. M. (2011). *Principles of Economics*. Legal Library, Baghdad, Baghdad, Republic of Iraq.
- Al-Jubouri, O. K. A., and Al-Jubouri, A. H. A. (2010). *Principles of Renewable Energy*. Renewable Energy Research Unit, Technical Education Authority, Technical Institute - Hawija, Ministry of Higher Education and Scientific Research, Iraq.
- Al-Kalidar, Q. Q., and Al-Dabash, A. H. (2018). *Theoretical and Applied Farm Business Management*. National Library and Archives, Baghdad, first ed, Baghdad, Iraq.
- Al-Qassar, H., Al-Sagheer, S., Al-Khalil, B. and Muhammad, Y. (2015). *Technical and economic feasibility of using renewable energies (solar energy and wind energy) to pump water from wells at the farm level*. Ministry of Agriculture and Agrarian Reform, Ministry of Electricity - Syrian Arab Republic.
- Al-Rubaie, Y. A. R. (2012). *Marketing Costs*. University of Science and Technology Center, Sana'a, Yemen, First Edition.
- Al-Sanfi, A. A. (2013). *Financial Management*. University Book House Press, Sana'a, 2nd ed, Sana'a, Republic of Yemen.
- Al-Tamimi, A. A., and Bakr, U. T. (2023). Determining the optimal size of production and measuring the specialized efficiency in grape production farms in Diyala Governorate - Iraq for the season 2021. *Tikrit Journal for Agricultural Sciences*, 23(4), 117-135. <https://doi.org/10.25130/tjas.23.4.11>
- Al-Timimi, A. A. A. (2020). Effect of Agricultural Operations and Production Inputs for Barley Farms Land in Diyala Governorate for Season 2019. *Journal of Green Engineering*, 10, 4826-4835.

- Arab Organization for Agricultural Development. (2020). *League of Arab States. Guide to Grape Cultivation and Handling*, Cairo - Arab Republic of Egypt. <https://aoad.org/website/en/guide-to-grape-cultivation-and-handling/>
- Arias-Navarro, I., Del Campo-Gomis, F. J., Agulló-Torres, A. M., and Martínez-Poveda, Á. (2023). Environmental sustainability in vineyards under a protected designation of origin in view of the implementation of photovoltaic solar energy plants. *Land*, 12(10), 1-25. <https://doi.org/10.3390/land12101871>
- Bintariningtyas, S., Gravitaniani, E., Prasetyani, D., Sasanti, I. A., and Juwita, A. H. (2024). Palm Oil Plantations in West and Central Kalimantan, Indonesia: Sustainability Analysis Using a Hierarchy Process Method. *Diyala Agricultural Sciences Journal*, 16(2), 125-140. <https://doi.org/10.52951/dasj.24160210>
- General Organization for Technical Education and Vocational Training. (2020). *Industrial Electronics and Control*. First ed. Kingdom of Saudi Arabia. <https://tvtc.gov.sa/En/MediaCenter/DocumentsLibrary/Documents1/TVTC-at-a-Glance.pdf>
- Mohamed, C. Y., and Al-Khayat, M. M. (2019). *Solar Water Pumping Systems*. Ministry of Trade and Industry - Arab Republic of Egypt, Cairo, Egypt. <https://www.scribd.com/document/506167885/>
- Al-Saidi, M., and Lahham, N. (2019). Solar energy farming as a development innovation for vulnerable water basins. *Development in Practice*, 29(5), 619-634. <https://doi.org/10.1080/09614524.2019.1600659>
- Mohammed, S. K., and Jassim, I. H. (2021). Calculating the cost of establishing a solar-powered farm in remote areas. *Damascus University Journal of Agricultural Sciences*, 28(2), 413-431. <http://www.damascusuniversity.edu.sy/mag/farm/images/stories/2-2012/413-431.pdf>
- Norouzi, N., and Norouzi, M. (2020). *Energy Analysis Framework II an Introduction to the Energy Economics*. (e-Book), Scholars' Press publishing house. Germany, the European Union.
- O'Donnell, C. J. (2018). *Productivity and Efficiency Analysis*. University of Queensland Brisbane, Australia, Library of Congress, Springer Nature Singapore Pte. Ltd. <https://industri.fatek.unpatti.ac.id/wp-content/uploads/2019/03/225-Productivity-and-Efficiency-Analysis-Christopher-J.-ODonnell-Edisi-1-2018.pdf>
- Arab Monetary Fund. (2022). *Financial Evaluation of Investment Projects*. Issue (27), Economic Department Publications Series - Arab Monetary Fund, United Arab Emirates. <https://www.amf.org.ae/sites/default/files/publications/2023-04/Annual%20Report%202022.pdf>
- Qatf, I. S., and Khalil, A. M. (2004). *Principles of Microeconomics*. Dar Al-Hamed for Publishing and Distribution, First ed., Amman, Hashemite Kingdom of Jordan.
- Razdaq, A. A. R., and Basyouni, M. S. (2011). *Principles of Economic Feasibility Studies*. Faculty of Commerce, Benha University, Benha, Arab Republic of Egypt.
- Salam, W. Y., Sayed, S. M., and Shilabi, A. A. (2011). *Agricultural Marketing*. Electronic Edition, Egypt. https://www.agro-lib.site/2020/06/blog-post_13.html
- Yousef, A., and Marhej, M. (2018). *Project Evaluation and Feasibility Study*. Publications of the Syrian Virtual University, Syrian Arab Republic, Electronic version available at the link: <https://pedia.svuonline.org/>