ECONOMIC EFFECTS OF USING TREATED WASTEWATER IN PLANTING WOODY TREES IN THE DESERT HINTERLAND OF SOHAG GOVERNORATE (CASE STUDY)

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ABSTRACT

The research aims in general to measure the economic impacts of using treated wastewater in planting wood trees in the desert hinterland of Sohag Governorate. The results of the financial evaluation confirmed, according to the current situation, that the return-to-cost ratio ranged between (1.41-2), with a general average of about 1.56, and the net present value ranged between (29.7-77) thousand pounds, with a general average of about 42 thousand pounds, and the internal rate of return ranged between (22.8%-27.9%), with a general average for the total number of wood trees, amounting to about 25.2%, which means that the capital recovery period ranged between (3.6-4.4) years, with a general average for the total number of trees of about 4 years, according to the current situation during the 2022/2023 season. The results of the financial evaluation of planting wood trees using treated wastewater in the desert hinterland of Sohag Governorate also indicated, according to the sensitivity analysis, an increase in costs of 10% over the current situation, over the general average of the benefit-to-cost ratio, net value Present, internal rate of return, payback period, reached about 1.42, about 34.5 thousand pounds, about 21.8%, and about 4.6 years, representing about 97.4%, 82.1%, 86.5%, 115% of the current situation respectively.

Keywords: wastewater, desert hinterland, wooden trees, Sohag.

Introduction:

Treated wastewater is considered one of the potential solutions to increase the availability of water resources. It ensures the safe disposal of such water to preserve the environment **(Abdel Hady, 2001)**, protect public health, and provide an additional renewable source of water for agricultural purposes. The Egyptian government has given significant attention to implementing several national programs for the safe use of treated wastewater in forest plantations **(Abdel Khaleq, 2007).** These forests, established in the desert hinterlands of Egyptian governorates, represent a vital addition to Egypt's non-conventional water resources **(Allam, 2010).** Not utilizing this water poses an environmental burden, as it becomes a source of environmental and health pollution. Expanding horizontal agricultural development in desert hinterlands through the reuse of treated wastewater is thus a substantial contribution to Egypt's water security strategy **(Fathallah, 2017).**

Research Problem:

Egypt faces a significant challenge regarding the availability of freshwater resources. The per capita share of freshwater has drastically declined from approximately 1,893 m^3 in 1959 to 900 m^3 in 2000, continuing to drop to 700 m^3 by 2012. Projections indicate a further decrease to 534 m^3 by 2030—below the international water poverty threshold.

Additionally, developments in Sudan, Ethiopia, and other Nile Basin countries may further strain Egypt's water supply. Economic growth also threatens the quantity and quality of water resources, exacerbating existing issues such as:

- Shallow groundwater pollution from industrial chemicals,
- Excessive use of fertilizers and pesticides, and
- Persistent reliance on flood irrigation by farmers, leading to water loss through evaporation, over-irrigation, soil degradation, and rising groundwater levels.

Moreover, the increasing volume of wastewater poses a major obstacle to managing Egypt's limited water resources. It contributes to:

- Environmental pollution in agricultural drainage systems,
- Contamination of aquifers, and
- Deterioration of water quality.

Research Objectives

The study primarily aims to assess the economic impacts of using treated wastewater for cultivating woody trees in the desert hinterland of Sohag Governorate.

Methodology and Data Sources

The research examines the economic perspective and financial evaluation indicators of utilizing treated wastewater for woody tree cultivation in Sohag's desert hinterland (case study). Additionally, it explores the investment appraisal criteria for using treated wastewater to cultivate Jojoba trees—a key oil-yielding and biofuel species—in the desert hinterland of Beni Suef Governorate (case study).

The economic and financial analysis relies on data collected through a structured questionnaire, designed by the researcher during the first field visit in June-July 2022. Interviews were conducted with respondents, including farmers and officials managing forest plantations irrigated with treated wastewater in Sohag and Beni Suef.

Results and Discussion:

The West Sohag Forest is considered one of the oldest forests established in the desert hinterland across the country. This forest was established in 1987 to produce timber. The Sohag Governor issued a decision transferring ownership of the forest from the Sohag Local Administration to the Sohag Drinking Water

Company in 2008. The latter renovated the forest's drip irrigation system and re-planted the forest with eucalyptus, kaya, and casuarina trees in 2009.
The forest is irrigated with water from the Sohag Water Treatment Plant, which has been converted from treated water to treated water. The forest is now designated for the Sohag Water Treatment Plant. The forest's area is estimated at approximately 733 acres, of which only 488 acres are cultivated. The plant's actual discharge is estimated at approximately 45,000 m3 per day. Excess water from the forest is pumped into the Sohag Public Drain.

First: Area per acre and population density of hardy trees in the study area

Table No. (1) shows the relative importance of the planted area and population density of hardy trees within the forest in the West Sohag region in 2022. It is clear from this that:

1- Area per acre of hardy trees

The figures in **Table No. (1)** indicate that the area planted with hardy trees within the forest in the West Sohag region amounted to approximately 488 acres, of which camphor trees contributed approximately 310 acres, representing approximately 63.5% of the total planted area. The area of kaya trees amounted to approximately 120 acres, representing approximately 24.6% of the total planted area. Finally, the area of casuarina trees amounted to approximately 58 acres, representing approximately 11.9% of the total planted area in 2022.

2- Number of Trees in the Forest

The figures in Table No. (1) above indicate that the number of camphor trees ranked first among the number of planted trees, with approximately 144,500 trees, representing approximately 73.3% of the total number of trees in the forest. Casuarina trees came in second place in terms of number of trees, with approximately 32,500 trees, representing approximately 16.5% of the total number of trees. Finally, Kaya trees came in third and last place with approximately 20,200 trees, representing approximately 10.2% of the total number of trees. The total number of trees in the forest reached approximately 197,100 trees in 2022.

Table No. (1): Relative importance of the acreage and population density of various woody tree species within the Sohag Governorate Forest in 2022.

Tree Types	***Cultivated Area (Feddan)***	***%***	***Number of Trees (Thousand)***	***%***
Eucalyptus	310	63.52	144.46	73.29
Khaya	120	24.59	20.16	10.23
Casuarina	58	11.89	32.48	16.48
Total	**488**	**100**	**197.1**	**100**

Source: Compiled and calculated from the Sohag Drinking Water and Wastewater Company, Statistics Department, unpublished data, 2023.

Second: Economic Efficiency Indicators for Various Species of Timber Trees Grown Using Treated Wastewater in the Desert Backwaters of the Western Sohag Governorate Forest, 2022/2023 Season

1- Economic Analysis of Timber Tree Production Costs

The total costs of farms producing timber include two types of costs: fixed costs and variable costs.

Fixed costs are those that do not change with changes in production volume, but they contribute to the generation of the timber farm's productive capacity. Production capacity is generated by owning assets and other production elements that represent fixed costs.

The relative importance of the cost structure items for growing timber trees using treated wastewater in the desert hinterland in the West Sohag Governorate Forest for the 2022/2023 season. It is evident that:

1-1- Fixed Costs of Timber Tree Cultivation

The figures in Table (2) indicate that the fixed cost items for timber tree cultivation include permanent labor, planting and seedling costs, depreciation of irrigation networks, and finally, rent. The relative importance of the fixed cost items is shown in Table (2).

1-1-1- Permanent Labor Costs

The results indicated that the cost of permanent labor for various types of timber trees ranked first among the fixed cost items, with an average annual cost of approximately 3,628 Egyptian pounds per acre, equivalent to approximately 8.9 Egyptian pounds per tree, representing approximately 31.2% of the total costs.

The cost of permanent labor per tree reached its lowest value, approximately EGP 6.48 for Casuarina trees, compared to a maximum of approximately EGP 31.6 for Kaya trees, across the total tree population for the 2022/2023 season.

2-1-1 - Planting and Seedling Costs

The results showed that the cost of planting and seedlings for various woody tree species ranked second among fixed costs, with an average annual cost of approximately EGP 1,139 per acre, equivalent to approximately EGP 2.82 per tree, representing approximately 9.8% of total costs.

The cost of planting and seedlings reached a minimum of approximately EGP 1.73 for kaya trees, compared to a maximum of approximately EGP 2.96 per tree for eucalyptus trees, across the total tree population for the 2022/2023 production season.

3-1-1 - Irrigation Network Depreciation Cost

The results confirmed that the depreciation cost of the irrigation network for various woody tree species ranked third among fixed costs, with an average annual cost of approximately EGP 1,433 per acre, equivalent to approximately EGP 3.55 per tree, representing approximately 12.33% of total costs.

The depreciation cost for the irrigation network reached its lowest value, approximately EGP 2.05 for Casuarina trees, compared to a maximum of

approximately EGP 13.69 per tree for Kaya trees, across the total tree count for the 2022/2023 production season.

4-1-1- Rental Cost

The rental cost also reached its lowest value, approximately EGP 1.84 for Casuarina trees, compared to a maximum of approximately EGP 6.14 per tree for Kaya trees, across the total tree count for the 2022/2023 production season.

-1-1- Total fixed costs for woody trees

The total fixed costs for various types of woody trees, using treated wastewater within the desert hinterland of the West Sohag Forest, reached their lowest value at approximately 7,190 Egyptian pounds per acre annually, equivalent to approximately 15.43 Egyptian pounds per tree, for eucalyptus trees, compared to approximately 7,420 Egyptian pounds per acre annually, equivalent to approximately 13.25 Egyptian pounds per tree, for casuarina trees. The overall average fixed costs for various types of woody trees amounted to approximately EGP 7,232 per acre per year, equivalent to approximately EGP 17.91 per tree, representing approximately 62.23% of the total costs for the 2022/2023 season.

2-1 Variable Costs for Woody Trees

The variable cost items for planting woody trees using treated wastewater within the desert hinterland of the study area included temporary labor, fertilization, irrigation, and finally the cost of pesticides.

1-2-1 Complex Labor Costs

The results indicated that the cost of temporary labor for various types of woody trees ranked first among the variable cost items, with an overall average of approximately EGP 1,936 per acre per year, equivalent to approximately EGP 4.80 per tree, representing approximately 16.66% of the total costs..

2-2-1 - Fertilization Cost

Fertilization costs reached their lowest value, approximately EGP 2.88 for Casuarina trees, compared to a maximum of approximately EGP 9.60 per tree for Kaya trees, across the total tree population for the 2022/2023 production season.

3-2-1 - Irrigation Costs

The results indicated that irrigation costs for various woody tree species ranked third among variable costs, with an average annual cost of approximately EGP 517 per acre, equivalent to approximately EGP 1.28 per tree, representing approximately 4.45% of total costs.

Irrigation costs reached their lowest value, approximately EGP 0.92 for Casuarina trees, compared to a maximum of approximately EGP 3.08 per tree for Kaya trees, across the total tree range for the 2022/2023 production season.

4-2-1- Pesticide Costs

Pesticide costs also reached their lowest value, approximately EGP 0.58 for Casuarina trees, compared to a maximum of approximately EGP 1.92 per tree for Kaya trees, across the total tree range for the 2022/2023 production season.

It is clear that the total variable costs for various types of timber trees, using treated wastewater within the desert hinterland of the western Sohag Governorate forest, reached their lowest value at approximately 4,389 Egyptian pounds per acre annually, equivalent to approximately 7.84 Egyptian pounds per tree, for Casuarina trees, compared to approximately 4,389 Egyptian pounds per acre annually, as a maximum, equivalent to approximately 26.12 Egyptian pounds per tree, for Kaya trees. The overall average of the total variable costs for various types of woody trees reached approximately EGP 4,389 per acre per year, equivalent to approximately EGP 10.87 per tree, representing approximately 37.77% of the total costs for all trees for the 2022/2023 season.

3-1- Total Costs of Tree Cultivation

The total costs for various types of woody trees, using treated wastewater from the desert hinterland in the western Sohag Governorate forest, reached a minimum of approximately EGP 11,579 per acre per year, equivalent to approximately EGP 24.85 per tree, for eucalyptus trees, compared to a maximum of approximately EGP 11,809 per acre per year, equivalent to approximately EGP 21.09 per tree, for Casuarina trees. The annual average for the total costs of various types of wood trees using treated wastewater from the desert hinterland in the western Sohag Governorate forest amounted to approximately EGP 11,621 per acre annually, equivalent to approximately EGP 28.78 per tree, at the level of all trees during the 2022/2023 season.

2- Profit Margins for Timber Trees

Profit margins are an important indicator that helps economic decision-makers determine the extent to which environmentally friendly agricultural projects achieve their goals, as well as measure economic efficiency, most notably the profitability per pound spent on investment.

The profit margins for various types of timber trees grown using treated wastewater within the desert hinterland of the Western Sohag Governorate Forest during the 2022/2023 production season. This shows that:

1-2- Total Revenues

The average annual revenue per acre from growing woody trees with treated wastewater in the desert hinterland of Sohag Governorate's forest reached approximately EGP 24,860, equivalent to approximately EGP 61.58 per tree, for the total number of trees in the forest for the 2022/2023 production season.

2-2- Net Return on Woody Trees

The average net yield per acre from planting woody trees on treated wastewater in the desert hinterland in the western Sohag Governorate forest reached approximately EGP 13,240 annually, equivalent to approximately EGP 32.8 per tree, at the total tree level for the 2022/2023 production season.

3-2- Returns over Variable Costs for Trees

The overall average return above variable costs for various types of woody trees grown using treated wastewater within the desert hinterland of the West Sohag Governorate Forest reached approximately EGP 20.47 thousand annually,

equivalent to approximately EGP 50.71 per tree, for the total number of trees for the 2022/2023 production season.

4-2- Value Added of Woody Trees

The value added of various types of woody trees grown using treated wastewater within the desert hinterland of the West Sohag Governorate Forest reached its lowest value of approximately EGP 17.55 thousand per acre annually, equivalent to approximately EGP 37.65 per tree, for eucalyptus trees, compared to a maximum of approximately EGP 37.01 thousand per acre annually, equivalent to approximately EGP 220.3 per tree, for kaya trees. The overall average added value of various types of wood trees using treated wastewater in the desert hinterland of the western Sohag Governorate forest reached approximately EGP 22,410 annually, equivalent to approximately EGP 55.50 per tree, at the level of the total trees for the 2022/2023 season.

Table No. (3) Profit margins for various types of woody trees irrigated using treated wastewater in the desert hinterland in the western Sohag Governorate forest for the 2022/2023 season.

Profit Margins	Eucalyptus Per Feddan (EGP 000)	Per Tree (EGP)	Casuarina Per Feddan (EGP 000)	Per Tree (EGP)	Khaya Per Feddan (EGP 000)	Per Tree (EGP)	Overall Average Per Feddan (EGP 000)	Per Tree (EGP)
Total Revenue (1)	20.00	42.92	20.63	36.84	39.46	234.90	24.86	61.58
Total Costs (2)	11.58	24.85	11.81	21.09	11.64	69.28	11.62	28.78
Net Return (3)	8.42	18.07	8.82	15.75	27.82	165.62	13.24	32.80
Variable Costs (4)	4.39	9.42	4.39	7.84	4.39	26.12	4.39	10.87
Return Over Variable Costs (5)	15.61	33.50	16.24	29.00	35.07	208.78	20.47	50.71
Value Added (6)	17.55	37.65	18.17	32.45	37.01	220.30	22.41	55.50

3 = 1 – 2

5 = 1 – 4

6 = 1 – Agricultural supplies

Source: Compiled and calculated from the field study questionnaire.

3- Economic Efficiency Measures for Wood Tree Cultivation

The economic efficiency measures of agro-ecological projects contribute to judging the performance efficiency and evaluating these projects in terms of the management efficiency in using agricultural inputs and achieving project profitability over its productive life.

1-3- Cost-Benefit Ratio

The cost-benefit ratio for various wood tree species grown using treated wastewater within the desert hinterland of Sohag Governorate reached its lowest value of approximately 1.73 for eucalyptus trees, compared to a maximum of approximately 3.39 for kaya trees. The overall average return-to-cost ratio reached approximately 2.14 for all trees in the forest during the 2022/2023 season.

2-3- Producer's Profit Margin

The producer's profit margin for various types of woody trees grown using treated wastewater in the desert hinterland of Sohag Governorate reached its lowest value of approximately 42.1 pounds for camphor trees, compared to a maximum of approximately 70.5 pounds for kaya trees. The overall average producer's profit margin reached approximately 53.2 pounds, across all trees in the forest during the 2022/2023 season.

The profitability per pound spent on various types of timber trees grown using treated wastewater in the desert hinterland of Sohag Governorate reached its lowest value of approximately 1.51 pounds for camphor trees, compared to a maximum of approximately 3.18 pounds for kaya trees. The average annual profit per pound spent for all woody trees in the forest during the 2022/2023 season was approximately EGP 1.93.

It is clear that there is economic feasibility in planting woody trees grown using treated wastewater in the desert hinterland of Sohag Governorate, particularly kaya and eucalyptus trees. This necessitates expanding the cultivation of tree forests in the desert hinterland using treated wastewater, given its positive economic and environmental impacts, both in terms of generating profits for investors, improving climatic conditions, and developing the Egyptian desert and establishing new urban communities in these areas.

Third: Financial Evaluation Indicators for the Cultivation of Timber Trees Using Treated Wastewater in the Desert Backyard of Sohag Governorate Forest

The financial evaluation process aims to determine the project's ability to achieve the commercial objective of its establishment, which is to obtain the maximum possible profit. Therefore, financial evaluation primarily focuses on measuring the project's profitability by comparing its effectiveness with its revenues. The financial evaluation of timber production projects in the desert hinterland, using treated wastewater, was conducted in the Sohag Governorate Forest using four basic criteria:

* Net Present Value (NPV)
* Benefit Cost Ratio (BCR)
* Internal Rate of Return (IRR)
* Capital Payback Period (CPBP)

This part of the study was based on the following assumptions:

-The total investment costs of timber production projects were estimated based on their capital assets. These costs included preparing the land for planting, the cost of seedlings, and the cost of establishing an irrigation network.

- The average total costs and total revenues of timber production projects during the 2022/2023 season were estimated, assuming they remained constant throughout the project's productive life (10 years).

1- Investments directed towards planting timber trees in the desert hinterland during the trees' productive lifespan

Table No. (5) shows the structure of investments in planting timber trees in the desert hinterland using treated wastewater during the trees' productive lifespan (10 years) in the West Sohag Forest during the 2022/2023 production season. It is clear from this that:

1-1- Investments directed towards agriculture and seedlings

The results confirmed that the volume of investments directed towards agriculture and seedlings reached its lowest value of approximately 2.9 thousand Egyptian pounds per acre, equivalent to approximately 17.3 Egyptian pounds per tree, for Kaya trees, compared to a maximum of approximately 16.1 thousand Egyptian pounds per acre, equivalent to approximately 28.7 Egyptian pounds per tree, for Casuarina trees.

2-1- Investments Directed to the Irrigation Network System

The results indicated that the volume of investments directed to the irrigation network system in the West Sohag Forest reached its lowest value, approximately EGP 11,500 per acre, for both camphor and casuarina trees, equivalent to approximately EGP 24.7 and EGP 20.5 per tree for each of these two varieties, respectively. The maximum value for kaya trees was approximately EGP 23,000 per acre, equivalent to approximately EGP 136.9 per tree.

The average share of the irrigation network value per acre was approximately EGP 14,300, representing approximately 25.7% of the total investment volume, equivalent to EGP 35.5 per tree, for all trees during the productive lifespan (10 years) of each tree in the 2022/2023 season.

2-1 - Total Investment Volume for Timber Trees

The total investment volume directed towards planting timber trees during the productive lifespan using treated wastewater within the desert hinterland of Sohag Governorate, reached its lowest value of approximately EGP 25,300 per acre, equivalent to approximately EGP 54.3 per tree, for eucalyptus trees, compared to approximately EGP 27.6 per acre, equivalent to approximately EGP 49.2 per tree, for Casuarina trees. The total investment volume directed towards planting timber trees during the productive life of the trees (10 years), using treated wastewater, amounted to approximately EGP 25.7 thousand per acre,

equivalent to approximately EGP 63.7 per tree, for the total number of trees in the 2022/2023 season.

2- Operating expenses for planting timber trees using treated wastewater within the desert hinterland of the West Sohag Forest

The structure of operating expenses for various types of timber trees using treated wastewater within the desert hinterland during the productive life of the trees (10 years) in the West Sohag Forest for the 2022 season. It is clear from this that:

1-2- Permanent Labor Salaries

The average share of permanent labor wages per tree was approximately 77.9, 64.8, and 216.1 Egyptian pounds for eucalyptus, casuarina, and kaya trees, respectively.

2-2- Temporary Labor Wages

The average share of temporary labor wages per tree was approximately EGP 34.6, EGP 41.6, and EGP 115.5 for casuarina, eucalyptus, and kaya trees, respectively.

2-2- Fertilization Expenses

The average share of fertilization costs per tree was approximately EGP 28.8, EGP 34.5, and EGP 95.8 for casuarina, eucalyptus, and kaya trees, respectively.

4-2- Rent

The average share of rent per tree was approximately EGP 18.4, EGP 22.1, and EGP 61.3 for casuarina, eucalyptus, and kaya trees, respectively.

5-2- Irrigation Expenses

The average share of irrigation expenses per tree was approximately EGP 9.3, EGP 11.2, and EGP 30.9 for casuarina, eucalyptus, and kaya trees, respectively.

6-2- Total Operating Expenses for Woody Tree Cultivation

The total operating expenses for woody trees using treated wastewater within the desert hinterland during the trees' productive lifespan (10 years) in the West Sohag Governorate Forest amounted to an average of approximately 90.5 thousand Egyptian pounds per acre, equivalent to approximately 224.1 Egyptian pounds per tree. Total operating expenses amounted to approximately 161.6, 194.2, and 538.7 Egyptian pounds for casuarina, eucalyptus, and kaya trees, respectively.

3- Revenue Structure for Growing Timber Trees Using Treated Wastewater in the Desert Backwaters of the Western Sohag Governorate Forest

The revenue structure of various types of timber trees using treated wastewater in the desert backwaters during the trees' productive lifespan (10 years) in the Western Sohag Governorate Forest. It is clear from this that:

1-3- Tree Productivity of Primary Wood

The results indicated that the productivity per acre of primary wood during the trees' productive lifespan reached its lowest of approximately 73.9 tons, equivalent to approximately 158.6 kilograms per tree, for eucalyptus trees, compared to a maximum of approximately 195 tons per acre, equivalent to approximately 1160.7 kilograms per tree, for kaya The numbers trees.

2-3- Secondary Wood Productivity

The overall average per acre of secondary wood productivity reached approximately 10.3 tons, equivalent to approximately 19.5 kilograms per tree, during the trees' productive lifespan for the 2022/2023 season.

2-4- Tree revenue from primary wood

the per acre revenue from primary wood using treated wastewater within the desert hinterland in the study area reached a minimum value of approximately 103.5 thousand Egyptian pounds, equivalent to approximately 222 Egyptian pounds per tree, for eucalyptus trees, compared to a maximum of approximately 390 thousand Egyptian pounds, equivalent to approximately 2,321.4 Egyptian pounds per tree, for kaya trees. The average yield per acre from primary wood reached approximately EGP 178,700, equivalent to approximately EGP 442.8 per tree, during the productive life of the trees for the 2022/2023 season.

5-3- Secondary Wood Tree Yield

The results confirmed that the yield per acre from secondary wood, using treated wastewater within the desert hinterland of the study area, reached its lowest value of approximately EGP 1,600, equivalent to approximately EGP 3.4 per tree, for eucalyptus trees, compared to a maximum of approximately EGP 4,700, equivalent to approximately EGP 14.1 per tree, for kaya trees..

6-3- Total Revenues from Timber Trees

The total revenue from timber trees using treated wastewater within the desert hinterland of Sohag Governorate reached a minimum value of approximately 200.1 thousand Egyptian pounds, equivalent to approximately 427.9 Egyptian pounds per tree, for eucalyptus trees, compared to a maximum of approximately 394.7 thousand Egyptian pounds, equivalent to approximately 2,335.5 Egyptian pounds per tree, for kaya trees. The overall average total revenues from timber trees amounted to approximately 252.2 thousand pounds per acre, during the productive life of the trees (10 years), equivalent to approximately 622.3 pounds per shrub, at the level of all timber trees in the forest during the 2022/2023 production season.

4- Financial Evaluation Indicators for Growing Timber Trees Using Treated Wastewater from the Desert Backwater During the Trees' Productive Lifespan (10 Years) in the Forest West of Sohag Governorate

1-4- Financial Evaluation Indicators According to the Current Situation

The figures in Table (3) indicate the financial evaluation indicators for growing timber trees using treated wastewater from the Desert Backwater in Sohag Governorate during the 2022/2023 production season. From this, it is clear that:

1-1-4- Cost-Benefit Ratio (B/C)

The results in Table (3) indicate that the cost-benefit ratio, according to the current situation for growing timber trees using treated wastewater from the Desert Backwater in Sohag Governorate, reached its lowest value of approximately 1.39 for Casuarina trees, compared to a maximum of approximately 2 for Kaya trees.

The annual average return-to-cost ratio reached approximately 1.56 for all trees during the 2022/2023 season.

2-1-4- Net Present Value (NPV)

The results in Table (9) confirm that the net present value of timber trees, according to the current situation, using treated wastewater from the desert hinterland of Sohag Governorate, reached its lowest value of approximately 29.7 thousand Egyptian pounds for Casuarina trees, compared to a maximum of approximately 77 thousand Egyptian pounds for Kaya trees.

3-1-4- Internal Rate of Return (IRR)

The results in Table (3) above indicated that the internal rate of return for timber trees, according to the current situation using treated wastewater in the desert hinterland of Sohag Governorate, reached its lowest value of approximately 22.8% for kaya trees, compared to approximately 27.9% for eucalyptus trees.

4-1-4 Payback Period (CPBP)

The results confirmed that the payback period for timber cultivation, based on the current situation using treated wastewater from the desert hinterland in Sohag Governorate, reached its lowest value of approximately 3.6 years for eucalyptus trees, compared to a maximum of approximately 4.4 years for kaya trees. The average payback period for timber trees, based on the current situation, using treated wastewater from the desert hinterland in Sohag Governorate, is approximately four years for all trees during the 2022/2023 season. The above demonstrates the feasibility of investing in planting various types of timber trees using treated wastewater from the desert hinterland in Sohag Governorate.

Table No. (3): Financial evaluation indicators for various types of woody trees using treated wastewater from the desert hinterland in Sohag Governorate, according to the current situation for the 2022/2023 season.

Evaluation Criteria	Eucalyptus	Casuarina	Khaya	Overall Average
Benefit-Cost Ratio (B/C)	1.41	1.39	2.00	1.56
Net Present Value (NPV)	30.7	29.7	77.0	42.0
Internal Rate of Return (IRR) %	27.9	25.1	22.8	25.2
Capital Payback Period (CPBP)	3.6	4.0	4.40	4.0

Source: Questionnaire.

4-2 Financial Evaluation Indicators According to a Sensitivity Analysis

1-4-2 Investment Evaluation Results in a Case of Operating Costs Increasing by Approximately 10% over the Current Situation

The financial evaluation indicators for growing hardwood trees using treated wastewater from the Sohag Governorate's desert hinterland. This is based on a cost increase of approximately 10% over the current situation for the 2022/2023 season. From this, it is clear that:

1-1-4-2 Cost-Benefit Ratio (B/C)

The average annual cost-benefit ratio, based on a sensitivity analysis of approximately 10% increase in operating costs using treated wastewater from the

desert hinterland in Sohag Governorate, reached approximately 1.42, across all trees, during the 2022/2023 season.

2-1-4-2- Net Present Value (NPV)

The net present value of growing woody trees using treated wastewater from the desert hinterland in Sohag Governorate, based on a sensitivity analysis of approximately 10% increase in costs over the current situation, reached a minimum of approximately EGP 22,100 for Casuarina trees, compared to a maximum of approximately EGP 69,500 for Kaya trees. According to a sensitivity analysis based on a 10% increase in operating costs, the overall average net present value of timber trees using treated wastewater from the desert hinterland in Sohag Governorate reached approximately EGP 34,500, across all trees during the 2022/2023 season.

3-1-4-2 - Internal Rate of Return (IRR)

the annual average internal rate of return for timber trees using treated wastewater from the desert hinterland in Sohag Governorate reached approximately 21.8%, across all trees during the 2022/2023 season.

4-1-4-2 - Payback Period (CPBP)

The results confirmed that the payback period for timber trees grown using treated wastewater from the desert hinterland in Sohag Governorate, based on a sensitivity analysis with a 10% increase in operating costs over the current situation, reached a minimum of approximately 4.4 years for eucalyptus trees, compared to a maximum of approximately 4.9 years for casuarina trees.

According to a sensitivity analysis, the average payback period for timber trees using treated wastewater from the desert hinterland in Sohag Governorate was approximately 4.6 years, based on the total number of trees during the 2022/2023 season.

4-2-2- Investment Evaluation Results in a Case of a 10% Revenue Shortfall from the Current Situation

The financial evaluation indicators for growing hardwood trees using treated wastewater in the Sohag Governorate's desert hinterland, in the case of a 10% revenue shortfall from the current situation for the 2022/2023 season. From this, it is clear that:

1-4-2-2- Cost-Benefit Ratio (B/C)

The average annual cost-benefit ratio, based on a sensitivity analysis in the event of a 10% revenue shortfall, using treated wastewater from the desert hinterland in Sohag Governorate, reached approximately 1.4 for all trees during the 2022/2023 season.

2-4-2-2- Net Present Value (NPV)

According to a sensitivity analysis based on a 10% revenue shortfall in Sohag Governorate's treated wastewater harvesting, the annual average net present value (NPV) for the 2022/2023 season was approximately EGP 30,300.

3-4-2-2 Internal Rate of Return (IRR)

The IRR for growing woody trees using treated wastewater harvesting in Sohag Governorate's treated wastewater harvesting, based on a sensitivity analysis based on a 10% revenue shortfall compared to the current situation, reached its lowest value of approximately 20.1% for Casuarina trees, compared to a maximum of approximately 22.3% for Eucalyptus trees. The annual average internal rate of return, based on sensitivity analysis in the event of a 10% revenue shortfall, using treated wastewater from the desert hinterland in Sohag Governorate, reached approximately 21.4%, at the total tree level, during the 2022/2023 season.

4-4-2-2- Payback Period (CPBP)

The results confirmed that the payback period for growing woody trees using treated wastewater in the Sohag Governorate desert hinterland, based on a sensitivity analysis of approximately 10% less revenue than the current situation, reached its lowest value of approximately 4.5 years for eucalyptus trees, compared to a maximum of approximately 5 years for casuarina trees. According to a sensitivity analysis, the average payback period for a 10% revenue reduction using treated wastewater from the desert hinterland in Sohag Governorate was approximately 4.7 years for the total tree population during the 2022/2023 season.

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