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Economic Feasibility Study on the Use of Certain Amendments in the Bioremediation of Sewaged Soil

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Authors' contributions

This work was carried out in collaboration between the authors. All authors shared in the design and wrote the protocol. Author AF designed the study, performed the economic analysis. Author HFA wrote the first draft of the manuscript. Authors MS, EMH, FAEZ and AMZ managed the analyses of the study and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Cairo is now served by six large wastewater treatments works which produce significant quantities of sewage water. The preferred option is to use this in agriculture, particularly in reclaimed desert land which is inherently deficient in organic matter, nutrients and trace elements. The aim of this study was to assess economic feasibility of a novel biotechnology for remediation of sewaged soils on a long term basis. A field study was carried out at Abu-Rawash Sewage Farm where the soil has been irrigated with water sewage for 32 years and the site provides a possible model of the potential long-term effects of heavy metals and other pollutants on crops in the contaminated sewaged soils in Egypt. The high contaminated sewaged soil was bioremediated for 60 days with sole or combined remediative amendments in different treatments including uncultivated control, cultivated control, inoculation with AM, inoculation with a mixture of *Thiobacillus thiooxidans & Thiobacillus ferrooxidans*, treated with probentonite or treated with

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combined mixture of all the aforementioned remediative amendments before sowing. Canola was sowing in winter season as a hyperacumulator plants after remediative periods. Save grains, seeds and oil yield were determined after canola and maize harvest. The costs for land preparation, bioremediation materials and processing, cultivation operation and requirements for growing and harvesting canola and maize (summer season) were calculated. Three scenarios have been conducted i.e. rent the land and buying the variable and fixed production factor, without yield useful, the second scenario similar to the first one but take a yield from maize in the first year, and the third scenario is rent all production factors with sold a maize yield in the first year. The final results indicate that the internal rate of return for the first, second and third scenarios were 21.1%, and 44.2%, and 38.3% respectively. Accordingly, the 2nd scenario was the best one under our experimental conditions after bioremediation of contaminated soils, and may also be applied by the farmers whom do not have a large capital for the purchase the fixed assets.

Keywords: Feasibility study; discount rate; internal net return; economic; bioremediation; payback period.

1. INTRODUCTION

Reuse of sewage effluent in agriculture is largely well thought-out of as a workable friendly environmental opportunity. Sewage effluent, however, is impregnated with huge amount of contaminants, particularly potential toxic elements (PTEs) that accumulate in sewaged soils and could easily enter the food chain, ensuing crucial adverse environmental and public health difficulties. Potentially toxic elements (PTEs) [such as cadmium (Cd), copper (Cu), chromium (Cr), lead (Pb), nickel (Ni), and zinc (Zn)] in soils are mainly associated with the solid phase, bound to the surface of solid components, or precipitated as minerals. For most PTEs, only a small portion is dissolved in the soil solution [1]. Elevated levels of PTEs in agricultural soils may adversely affect soil's quality and may represent an ecological and human health risk if they enter the food chain or leach into ground waters, ultimately causing metabolic disorder and chronic diseases in humans. Potentially toxic elements accumulation in soils and, in some cases, in crops has been reported when biosolids have been applied for a long time [2].

Elevated levels of different heavy-metals in soils irrigated regularly with sewaged water have been reported [3,4]. Certainly, safe and sustainable reuse of sewage effluent in farming necessitates the removal of soil contaminants. The concept of phytoremediation of contaminated sewaged soils has been recently highlighted using certain hyper-accumulator plants capable to remove PTEs contaminants from them, or to at least assist in their degradation to less toxic forms [5]. Not only are the biological activity and physical structure of soils maintained after phytoremediation but this technique is potentially cheap, visually unobtrusive and offers the possibility of bio-recovery of PTEs [6,7,8]. No adverse impacts should be associated with any remediation biotechnology to reach a successful bioremediation of sewaged soils. Perveen et al. [9] reported that the rate of uptake of such toxic metals by plants is governed by their concentration in the soil solution. So the crops grown on such soils may accumulate heavy metals in excessive amounts in various food parts, which ultimately may results in clinical problems'in animals and human beings throughout the world.

Sustainable implementation of a wastewater treatment and reuse project must address technical as well as social, cultural, and economic factors. Consumers, farmers, and others stakeholders must be involved in the decision making process [10].

To date, most wastewater related research in developing countries has largely focused on issues related to improvements in water quality, environmental and health impacts of wastewater use [11,12,13]. Few research papers about the feasibility study of utilization treated wastewater for economic crops in highly contaminated sewaged soil after bioremediation were found in the literature, except some fact sheets [10].

Marchiol et al. [14] reported that recently, the coupling of phytoextraction with other soil treatments (e.g. soil washing, soil vapor extraction) in so-called ‘‘treatment trains’’ is gaining interest; this may be especially useful in cases where mixed contaminants necessitate the use of more than one technique to effectively remediate sites [15].

Concerning the economic aspects of phytoremediation acceptability early estimates on the costs have shown that plants could do that same job as a group of engineers for one tenth of the cost. The plants are also more pleasing to look at than many such operations are. The soil or water need not be gathered in and stored as hazardous waste, requiring large amounts of land, money, and manpower. Plants can be planted, watered, and then harvested with less manpower. If need be, the storage of the harvested plants as hazardous waste would be a far smaller amount. The main drawback on the use of this technology is that it isn’t good for all sites. If the contamination runs too deep or the contaminant concentration is too great, the plants alone can’t efficiently remediate the contaminated site [16].

The objective of this study was to appraise the feasibility of bioremediation processes in contaminated sewaged soil and the economical return of the agriculture product from this soil and net return. In addition evaluate the three suggest scenarios (the first scenario: acquisition the equipments and machinery, but rent the land and cultivated land in the Year Zero with maize only, without selling the product, then growing the crops in the following year; the 2nd scenario: acquisition of machinery and equipment and rent the land, cultivated land in the Year Zero with maize only, without selling the product, then growing crops in the following year. The land added will be grown with the two crops, but selling the maize only. While in the 3rd scenario, renting the machines, equipments and land (as in the second scenario). Exploitation this land after bioremediation will take place through analysis of some important economic indicators affecting the production of these crops.

1. MATERIALS AND METHODS

1.1 Site of the Project

Abou-Rawash farm is a Governmental institution. In this work, evaluation of different remediation techniques was took place to minimize the hazards of pollutants. The chemical and biological characterizations of the farm and the evaluation of remediation techniques applied were previously documented [17,18]. This study was carried at Abu-Rawash sewage farm to determine the economic return of reusing the wastewater treatment in remediated soils for growing economical crops. The soil has been irrigated with sewaged effluents for more than 32 years and concerns were created about using such soils in cultivation especial that the contamination index of PTEs was 633.9, beside the presence of enteric pathogens.

The site provides a model of the potential long-term effects of heavy metals and other pollutants on crops in the soils irrigated with sewage water in Egypt.

1.1.1 Experiments and bioremediation treatments

The selection of the crops was depended on that such crops considered hyperaccumulators species for potential toxic elements and the work try to evaluate the best of these crops to be applied under such contaminated conditions. A completely randomized field experiment with four replicates were carried out during the winter season using the hyper-accumulator canola (*Brassica napus*) to decontaminate a high contaminated sewaged soil, after being bio-remediated with certain remediative amendments. The experiment consisted 24 plots (3mx3.5m=10.5m^2, with 5 ridges 3.5÷0.7m) irrigated with treated sewage effluent using furrow irrigation. The high contaminated sewaged soil was bioremediated for 60 days with sole or combined remediative amendments in different treatments including fallow soil (irrigated without growing crop plants), cultivated control [canola (*Brassica napus* L.)], inoculated with arbuscular mycorrhiza (AM), soil inoculation with *Thiobacillus* (a mixture of *Thiobacillus ferrooxidans* and *Thiobacillus thiooxidans*), soil treated with a mixture of 250g probentonite mixed with 250g rock phosphate per kg soil and inoculated with phosphate dissolving bacteria and soil treated with mixture of all the aforementioned remediative amendments.

1.1.1.1 Economic study data base

To accomplish the given objectives the data were collected from the project and from the conventional farmers in the regions who have the same crops (canola and maize).

Estimating the costs associated with the each treatment step of the overall bioremediation and production process i.e. beginning the soil preparation up to the end economic product was carried out by the authors. Most treatment cost estimates are based on field (pilot-scale) tests for the treatment technologies, information provided by the Data of Agriculture Ministry in Egypt as well as from the farmers in the district.

1.2 Analytical Procedure

The study used the descriptive and quantitative analysis method to estimate the general trend of indicators of costs, production, revenue and some important relationships that affect production. Data were obtained from the Ministry of Agriculture and Land Reclamation, free market prices, and average costs of the agronomic practices in the traditional farms.

Some simple averages calculations for the costs and revenues of producing canola and corn crops were taken to calculate the net return (revenue). Also, a series of costs and revenues after treatment were calculated by a factor of a suitable discount during the years of the study to calculate some financial indicators contained in the financial and economic feasibility study.

The costs data of materials and microorganisms used in bioremediation of the contaminated sewaged soils was obtained from the project data (Agricultural Microbiology Department, Biological and agricultural division, National research center.

2.2.1. Three scenarios have been conducted

2.2.1.1 First scenario

Renting the land (the land rent was estimated by 1500 LE/acre and buying the machines and equipments.

Hypothesis: In the year zero, after addition the bioremediation amendments and microorganisms, maize crop only were growing in summer, without selling the product. In the 1st year canola could grown in winter and maize in summer in 5 acres with selling their products.

2.2.1.2. Second scenario

Rent the land and buying the machines and equipments.

Hypothesis: As in the first scenario for year zero and the first year, but the corn is sold only for each land added.

2.2.1.3. Third scenario

Rent the land, machines and equipments.

Hypothesis: as in the second scenario.

3. RESULTS AND DISCUSSION

Its worthy mentioned that the chemical analysis of the end product of maize (grains and straw) and canola (seed and oil) indicated that these products were save according to the permissible maximum limits of WHO [19].

3.1 The Feasibility Study for the First and Second Scenarios

3.1.1 Investment Costs

The following items of the investment costs of the project were estimated:

3.1.1.1 Fixed costs

Include machinery and equipment for cultivation and harvesting. The types and quantities and prices of assets required for the project and their prices are shown in Table (1).

The data in Table (1) showed that the biggest influence factors on agricultural investment efficiency are costs of the tractor and trailer which exceed more than half the fixed costs (55.2%), followed by the costs of both leveling machine and combine grain harvester which estimated by 13.8% for each.

3.1.1.2 Working capital

Include a productive cycle costs in year zero, which reflects the cost of maize cultivation in summer season only. These costs are estimated by about 26.5 thousand L£ as will be mentioned after that for the suggested area (5 acres). The land rent was estimated in the total costs by 1500 LE/acre.

Table 1. Costs of equipments and materials (LE '000) for project (fixed costs).

Equipment*	Number	Price	% of costs
Tractor	1	80	55.2
Leveling machine	1	20	13.8
Planting and seeding machines	1	15	10.3
Pesticides sprayer	1	8	5.5
Combine grain harvester	1	20	13.8
Irrigation Pipes	-	2	1.4
Total	-	145	100

**Source: calculated by authors from the project data.*

3.1.1.3 Establishment, *declaration and other expenses (deferred revenue)*

Include the costs of registration and declaration farm. These expenses were amounted by about 1200 LE (paid once at the beginning of the project).

Table 2. Investment cost of the project (LE '000) in year zero.

Item	Price	%
Tractor	80	46.3
Leveling machine	20	11.6
Planting and seeding machines	15	8.7
Pesticides sprayer	8	4.6
Combine grain harvester	20	11.6
Irrigation pipes	2	1.2
Total fixed costs	145	84.0
Working capital (one production season -6 months)*	26.5	15.3
Registration and declaration costs	1.2	0.7
Investment cost	172.7	100

Source: calculated by economist and agronomist team of the project.

The data in Table (2) showed that the total value of the investment costs of the project, amounting to about 172.7 thousand Egyptian pounds, divided by about 84%, 15.3% and 0.7% for each of the fixed assets, working capital and declaration and establishment expenses with other expenses, respectively.

3.1.2 Annual production costs

3.1.2.1. Amount and values of cultivation one acre

Data in Table (3) showed the amount and prices of the requirements of cultivation one acre, which include the seeds and pesticides costs. The seeds presents about 61.2%, while the pesticides costs presents 33.8% from the total costs of the requirements which reached about 670 LE.

Table 3. Quantity and costs of canola and maize (LE/acre)

Requirements	Canola		Maize		Value (LE)	%
	Amount (kg)	Value (LE)	Amount (kg)	Value (LE)		
Seeds	4	60	7	350	410	61.2
Pesticides*	-	80	-	180	260	38.8
Total	-	140	-	530	670	100

Source: calculated by authors from the project data.

3.1.2.2. Labor costs

Data in Table (4) showed the number of workers needed for cultivation one acre. The average wage rate for the worker was estimated by 30 LE/day.

Table 4. Number of workers used for growing one acre canola and maize year^{-1} (2011/2012)

Labor Costs	Canola		Maize		Total costs (LE)
	Number/day	Value (LE)	Number/day	Value (LE)	
	20	600	30	900	1500

Source: calculated by authors from the project data.

3.1.2.3. Amount and costs of the remediation materials

Probentonite, Rock phosphate and sulpher were used in the soil remediation treatment. Also specific microorganisms (*Thiobacillus* and Arbuscular mycorrhiza; AM) that prepared in the laboratories of the Agricultural Microbiology Department, NRC) were used. Sole or combined mixture of the experimented microbial remediative amendments was used to inoculate the contaminated sewaged soils at a rate of 100g impregnated mordant 400g^{-1} sewaged soil.
Data in Table 5 show the amount of the remediator substances and their prices and percentage of each material for both crops individually or collected.

Table 5. Amount and value (LE) of remediation materials for growing one acre canola and maize in 2011/2012 season

Remediation materials	Canola			Maize			Total (LE)	%
	Amount (T)	Value (LE)	%	Amount (T)	Value (LE)	%		
Probentonite	1.325	330	33.7	1.650	660	41.8	990	38.7
Rock phosphate	0.625	270	27.5	1.35	540	34.2	810	31.6
Thiobacillus	-	150	15.3	-	150	9.5	300	11.7
AM	-	80	8.2	-	80	5.1	160	6.2
Sulpher	0.150	150	15.3	0.150	150	9.5	300	11.7
Total	-	980	100.0	-	1580	100.0	2560	100.0

Source: calculated from the project data.

3.2 Depreciation, Consuming and Residual Values of Machinery and Equipment of the Project

This element (Table 6) showed that the duration of premium depreciation and depreciation and depreciated value, scrap value and the residual value (if any) for each machine and stomach of project equipment. According to these indicators when calculating each of:

- A list of annual income.
- Statement of cash flows and calculates the internal rate of return.

Table 6. Depreciation, consumed and residual values (LE '000) of machinery and equipment of the project

Item	Value (LE)*					
	Primary	Period	Depreciation period	Depreciated value	Scrap value	Residual value
Tractor	80	20	2.8	28.0	24.0	28
Leveling machine	20	10	1.6	16.0	4.0	-
Planting machines	15	10	1.2	12.0	3.0	-
Pesticides sprayer	8	10	0.64	6.4	1.6	-
Combine grain harvester	20	10	1.6	16.0	4.0	-
Irrigation pipes	2	10	0.2	2.0	-	-
Total	145	-	8.04	80.4	36.6	28

** Source: Calculated from the data in Table 1.*

3.2.1 Total *costs* of cultivation one acre (LE) by the winter and summer season crops

Due to the variation in the cultivated area during the first six years of the project, because it's difficult to cultivation the whole area (100acres) at the same time of starting the project, under limited capital availability for financing, therefore the cultivated area estimation will be as follows 5, 10, 20, 35, 55, 75 and 100acres. This area will be planting, only, with maize in the summer season in 5 acres in the year zero, without selling the product. In the 1st year (following year) the area will be planted with canola in winter season and maize in summer season with selling the safe product, where the soil was bioremediated well in the year zero. Each year the cultivated added area (5acres) will cultivated by canola as hyperaccumulator plants without taken oil, and cultivated maize as economic crop in summer season as in the 1st season), and repeated the same agronomic practices every year. Due to the volatility of market prices for both inputs and labor costs and the annual rent, oils, fuels and other expenses of these items, it was increased by about 30% in the 6th year of the value listed in the first five years. From the 6th year, costs of pipes will be added value each year when calculating the cost schedule of cash flows, because the plastic pipes will be consumed after the winter and summer seasons for irrigation and agriculture (no residual value or residual for these pipes). These costs start of the second year and ending in the 6th year after planting the entire farm (100acres).

The maintenance cost for machinery and equipment estimated by about 5% of its value and divided on the 5 years, starting from the sixth year. Other expenses were included in each of the investment costs and annual costs to meet any malfunctions in the first five years as an alternative to cash reserve). Data in Table (7) shows the items of annual costs and its distribution, as well as their value in the first five years after the increase in the sixth year.

Table 7. Total costs (LE/acre) for growing canola (winter season) and maize (summer season). (2011/2012 seasons)

Factors of production	Canola	Maize	Total costs (1)	
			1st– 5th year	6th– 10th year
Seeds and pesticides	140	530	670	871
Labor costs	600	900	1500	1950
Remediation materials	980	1580	2560	3328
Land rent	-	-	1500	1950
Oils and fuels	200	500	700	910
Maintenance	-	-	-	1450
Others	-	-	300	390
Total	1920	3510	7230	10849

**Maintenance=7.25 (LE ‘000) (5% of fixed costs) divided on 5 years starting from the 6th year (1.45 LE ‘000),[1]Costs of irrigation tubes will add every year to the addition new lands, and the costs will increase 30% from the 6th year, Source: calculated by disciplinary (agronomist & economist) team of the project.*

3.3 Annual Revenue

The data in Table (8) showed the quantity and value of production per acre of each crop. Canola crop was classified as oil crop, while maize is classified as a forage crop and now its flour was mixed with wheat flour in different percents. These amounts and values reflect the product at market prices. The total annual income of farmers from growing the two crops in one acre about 10360 Egyptian pounds, which amounted by about 71% for maize and 29% for canola.

Table 8. Amount and prices (LE ‘000) of canola and maize yields per acre in 2011/2012 seasons

Crop	Canola		Maize		Total prices (LE)
	Amount (T)	Price (LE)	Amount (T)	Price (LE)	
Main product	1.5	3000	2.8	7000	10000
Secondary product	-	-	3.0	360	360
Total	-	3000	-	7360	10360

Source: calculated by authors from the project data.

3.4 Net (Returns)

Data in Table (9) showed both revenue and annual costs throughout the life of the project, taking into account the above-mentioned of land distribution whether cultivated or added in the following year, with increasing the costs by about 30% and revenue by 10% at the 6th year of the project. Year Zero includes all the investment costs of project, particularly the costs of planting corn in summer as working capital without selling (the cultivated area are 5 acres).

Table 9. Total costs and total revenue (LE '000) of acre growing with canola in winter and maize in summer (2011/2012 seasons)

Year	Farmland Area	Costs*		Revenue**		Net return	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
0	5	172.7	172.7	0.0	0.0	-172.7	-172.7
1	5+5=10	64.7	63.7	51.8	88.6	-12.9	24.9
2	10+10=20	129.4	147.4	103.6	177.2	-25.8	29.8
3	15+20=35	230.2	253.0	207.2	317.6	-23.0	64.6
4	20+35=55	367.2	483.2	362.6	509.8	-4.6	26.6
5	20+55=75	511.8	627.8	569.8	717.0	-58.0	89.2
6	25+75=100	890.5	1177.7	854.7	1249.3	-35.8	180.3
7	100	939.9	1084.9	1139.6	1249.3	199.7	164.4
8	100	939.9	1084.9	1139.6	1249.3	199.7	164.4
9	100	939.9	1084.9	1139.6	1249.3	199.7	164.4
10	100	939.9	1084.9	1232.1	***1341.6	292.2	256.7
-	100	6126.1	7265.1	6800.6	8149	674.5	883.9

** The costs will increase 30% from the 6th year. ** The revenue will increase 10% from the 6th year*
**** The residual values of equipments and machines, investment, working capital to the 10th year.*

3.5 Financial Analysis

Financial analysis was carried out to measure the private profitability of any project [20]. Financial analysis includes these items:

1. List annual income (Table 10).
2. List of financial flows (Table 11).

Table 10. List annual income

Item	Year							
	1	2	3	4	5	6	7-9	10
Revenue 1	51.8	103.6	207.2	362.6	569.8	854.7	3418.8	1232.1
Revenue 2	88.6	177.2	317.6	509.8	717	1249.3	3747.9	1341.6
Costs 1	64.7	129.4	230.2	367.2	511.8	890.5	2819.7	939.9
Costs 2	63.7	147.4	253	483.2	627.8	1177.7	3254.7	1084.9
Depreciation	8.04	8.24	8.84	9.64	10.44	11.44	34.32	11.44
Total costs 1	72.7	137.6	239	376.8	522.2	901.9	2854	951.3
Total costs 2	71.7	155.6	261.8	492.8	638.2	1189.1	3289	1096.3
Net income 1	20.9-	34-	31.8-	14.2-	47.6	47.2-	564.8	280.8
Net income 2	16.9	21.6	55.8	17	78.8	60.2	458.9	245.3

Indicators of feasibility study of the first and second scenarios.

<u>3.5.1 Undiscounted measures</u>

1- Return on Invested pound = (total revenue /total costs).

In Scenario 1=6800.6/6126.1= 1.11. In Scenario 2=8149.0/7265.1=1.12

2- Return on investment=Net annual income/investment costs.

In Scenario 1= (172.7/74.50)×100= 43.1%. In Scenario 2=(172.7/95.45)×100=55.3%.

Average annual income of the project = Total Annual Net Income/project period

In Scenario 1=745.1/10=74.5 (LE ‘000). In Scenario 2=954.5/10=95.45 (LE ‘000).

3.6 List of Cash Flow of the First Scenario

Table 11. Net cash flow of the project in the case of zero yields in the zero years (with using appropriate discount rate during the project period)

[1]Y	[2]IF	[3]DR 25%	[4]CVIF	[5]ECF	[6]CVEF	[7]CV	[3]DR 12%	[4]CVIF	[6]CVEF	[7]CV
0	0.0	1.000	00.0	172.7	172.7	-127.7	1.000	0.0	172.7	-127.7
1	51.8	0.800	41.4	64.7	51.8	-10.3	0.893	46.2	57.8	-11.5
2	103.6	0.640	66.3	129.4	82.8	-16.5	0.797	82.6	103.1	-20.6
3	207.2	0.512	106.1	230.2	117.9	-11.8	0.712	147.5	163.9	-16.4
4	362.6	0.410	148.7	367.2	150.6	-1.89	0.635	230.2	233.2	-2.9
5	569.8	0.328	186.9	511.8	167.9	19.00	0.567	323.1	290.0	32.9
6	854.7	0.262	223.9	890.5	233.3	-09.4	0.507	433.3	451.5	-18.1
7	1139.6	0.210	239.3	939.9	197.4	41.94	0.452	515.1	424.8	90.3
8	1139.6	0.168	191.4	939.9	157.9	33.5	0.404	460.4	379.7	80.7
9	1139.6	0.134	152.7	939.9	125.9	26.7	0.361	411.4	339.3	72.1
10	1232.1	0.107	131.8	939.9	100.6	31.3	0.322	396.7	302.6	94.1
Total	6800.6	-	1488.6	6126.1	1558.7	-70.0	-	3046.6	2918.9	172.8

[1]Y: year: [2]IF: internal flow, [3]DR: Discount rate, [4]CVIF: Current values of internal flow, [5]ECF; External cash flow, [6]CVEF: Current values of external cash flow, [7]CV: Current net value

3.7 List of Cash Flow of the Second Scenario

Table 12. Net cash flow of the project in the case of zero yield in the zero year (with using appropriate discount rates during the project period

[1]Y	[2]IF	[3]DR 25%	[4]CVIF	[5]ExF	[6]CVEF	[5]CV	[3]DR 12%	[4]CVIF	[5]CVEF	[5]CV
0	0.0	1.0	0.0	172.7	172.7	-127.7	1.00	0.0	172.7	-127.7
1	88.6	0.8	70.9	63.7	51.0	19.9	0.69	61.1	43.9	17.2
2	177.2	0.64	113.4	147.4	94.3	19.1	0.476	84.3	70.1	14.2
3	317.6	0.51	162.6	253.0	129.5	33.1	0.328	104.2	83.0	21.2
4	509.8	0.41	209.0	483.2	198.1	10.9	0.226	115.2	109.2	6.0
5	717.0	0.33	235.2	627.8	205.9	29.3	0.156	111.8	97.9	13.9
6	1249.3	0.26	327.3	1177.7	308.5	18.8	0.108	134.9	127.2	7.7
7	1249.3	0.21	262.3	1084.9	227.8	34.5	0.074	92.4	80.2	12.2
8	1249.3	0.17	209.9	1084.9	182.3	27.6	0.051	63.7	55.3	8.4
9	1249.3	0.13	167.4	1084.9	145.4	22.0	0.035	43.7	38	5.7
10	1341.6	0.11	143.5	1084.9	116.0	27.5	0.024	32.2	26	6.2
Total	8149	-	1901.5	7265.1	1831.5	115	-	843.5	903.5	-15

[1]Y: year, [2]IF: Internal flow, *[3]DR: Discount rate, [4]CVIF: Current values of internal cash flow, [5]ExF: external flow, [6]CVEF: Current values of external cash flow, [7]CV: Current net value*

3.7.1. Discount measures

Reflects the expense of the opportunity available for capital investment in the community. Discount rate represents changes in the value of money with time for the sake of using its real value in given time. These costs (Table12) include the risk premium which represents the difference between the expected return on a market portfolio and the risk-free rate, or the minimum amount of money by which the expected return on a risky asset must exceed the known return on a risk-free asset, or the expected return on a less risky asset, in order to induce an individual to hold the risky asset rather than the risk-free asset [21,22].

1- Discount rate (DR) =1/(1+IR)N. Where IR =interest rate and N years number of the project life

   A- Payback Period= total costs of investments/ mean net of cash flow (1). In scenario 1 =145.o/17.3= 100.5 months.
   B- Net Present Value (NPV) at DR 12% for scenario 1=172.8 (LE '000)

Net Present Value at DR 25% for scenario 2=115.0 (LE '000)

   C- Percentage of inflow/outflow at DR 12% in scenario 1=1.04

Percentage of inflow/outflow at DR 25% in scenario 1=1.04

   D- Internal Rate of Return: This is computed by setting the Net Present Value equal to zero and solving for the discount rate such that the discounted net returns sum to the initial cost of the investment.

In scenario 1: NPV =12+13 (115/120)×100=21.2%
In scenario 1: NPV =20+25 (115/120)×100=44.2%.

3.8 The Feasibility Study for the Third Scenario

3.8.1 Annual production costs

I: The cost of machinery and equipment rent: Data in Table (13) shows the number of hours and cost of machinery and equipment required for acre. The cost of using the tractor in preparing one acre before planting represents about 59.5 % of the total cost of rental machinery of canola crop, which amounting by 420 LE, while costs of leveling machine and spraying machine represent 21.4 and 19%, respectively. While in maize the cost of tractor in soil preparation before planting represent about 49.6 % of the total cost of rental machines (about 1210 LE/acre). The cost of leveling, combine (harvester) and spraying machines represent 16.5%, 17.3% and 16.5 %, respectively. On average of two crops, the costs of 4 machines represent about 52.1%, 17.2%, 12.9%, 17.8%, respectively, of the total cost (1630 LE) of two crops.

II: The quantity and value of the requirements and labor and the amount and value of bioremediation materials for cultivation one acre: as the two previous scenarios.

III: Total cost of cultivation (LE/acre) the two crops in this study: the land area presumed will be planting in about 5, 10, 20, 35, 55, 75 and 100acres. Planting 5acres in year zero without sold the end product, then planting this are in the first year (following year) by the two crops and sold the production. While the add land (5 acres) will planted with the two crops in this year without selling canola and selling corn only, and so on every year for the area added. Due to the instability of market prices for both inputs, labor costs, the annual rent, oils, fuel and other expenses, these items was increased by about 30% in the sixth year of the value listed in the first five years.

Table 13. Costs of machines rent for cultivation of canola (winter) and maize (summer) (LE/acre) in 2011/2012 seasons

Machine	Canola			Maize			Total costs	
	Hours	Costs	%	Hours	Costs	%	Costs	%
Soil preparation[1]	4	250	59.5	7	600	49.6	850	52.1
Planter	1	80	19	2.5	200	16.5	280	17.2
Sprayer	4.5	90	21.4	*10	200	16.5	290	17.8
Combine	-	-	-	3	210	17.3	210	12.9
Total	-	420	100	-	1210	100	1630	100

*[1]Tractor and attachments for plowing, leveling and Tractor and attachments to plow, settlement and land planning, *The pest infestation increased in summer compared to winter, and maize has more pests than canola plants, Source: collected and estimated by the authors and common data of the two crops*

Table 14. Total costs (LE) of cultivation canola (winter season) and maize (summer season) in 2011/2012

Variable	Canola	Maize*	Total cost	%
Equipment rent	420	1210	1630	19.5
Seeds and pesticides	140	530	670	8
Workers	600	900	1500	17.9
Bioremediation material*	980	1580	2560	30.6
Irrigation plastic pipes	-	-	400	4.8
Rent /year	-	-	1500	17.9
Other costs**	-	-	100	1.2
Total	2140	4220	8360	100

**The value of pipes will consumed at the end of the project (no salvage value).*

- *The costs of microorganisms use will be increase in summer season.*
- *The data estimated and collected by the authors in the project.*

Source: collected and estimated by the authors and common data of the two crops

Data in Table (14) shows that the largest factor in these costs was the bioremediation materials which estimated by 27.6 %, followed by wages (19.4%), and the annual rent (16.2 %) of the total cost of cultivation one acre in 2011 /2011.

3.8.2 Annual revenue

Data in Table (15) shows the quantity and value of production per acre for both crops. These values, which estimated by the market prices at harvest time, expressed the revenue from the two crops/year. The total annual income of two crops/acre/year was estimated by about 10360 LE. The Maize revenue constitutes about 71% of the total income, while canola gave 29%.

Data in Table (16) showed that total costs and perineum revenue during the project period, taking into account the above-mentioned distribution of land whether cultivated or added in the following year and increased costs by about 30% and revenue by 10% starting from the sixth year of the project. These undiscounted values are used for calculation of some indicators, as will be mentioned after that (not adjusted using appropriate discount rates).

Table 15. Amount and prices (LE) of the main and secondary product of canola and maize yields per acre in 2011/2012 seasons

Crop	Canola		Maize		Total value (LE)
	Amount (ton)	Price (LE)	Amount (ton)	Price (LE)	
Main product	1.5	3000	2.8	7000	10000
Secondary product	-	-	3.0	360	360
Total	-	3000	-	7360	10360

Source: calculated by authors from the project data,

Year Zero include the investment costs of the project represented by the costs of planting the two crops as working capital without sold the product (the cultivated area was 5 acres).

Table 16. Total costs and total Revenue (LE '000) of acre growing with canola in winter and maize in summer (2011/2012 seasons)

Year	Farmland Area	Costs *	Revenue**	Net return
0	5	33.1	0.0	-33.1
1	10	74.9	88.6	13.7
2	20	149.8	177.2	27.4
3	35	299.6	354.4	54.8
4	55	524.3	620.2	95.9
5	75	823.9	974.6	150.7
6	100	1460.5	1461.9	1.4
7	100	1947.4	1949.2	1.8
8	100	1947.4	1949.2	1.8
9	100	1947.4	1949.2	1.8
10	100	1947.4	1949.2	1.8
Total	100	11122.6	11473.7	351.1

** The costs will increase 30% from the 6th year. ** The revenue will increase 10% from the 6th year. *** No economic product in the year zero.*
Source: the data collected and estimated by the authors.

3.9. Financial Analysis: Includes Financial Statements: Statement of Cash Flows Indicators of the Feasibility Study for the third Scenario

First: Measurements undiscounted:

1- Return on Invested Egyptian pound=11473.7÷11122.6=1.03.
2- The rate of return on investment =35.1÷33.1 = 106%
3- Average annual income of the project = 351.1÷10 = 35.1 (LE '000).

3.9.1 Statement of cash flows

Table 17. Net flows of the project in the case of not selling the crop year zero, using appropriate discount rates during the project lifetime

[1]Y	[2]IF	[3]DR 25%	[4]CVIF	[5]ExF	[6]CVEF	[7]CV	[3]DR 12%	[4]CVIF	; [6]CVEF	[7]CV
0	0	1	0	(*)33.1	33.1	-33.1	1	0	33.1	-33.1
1	88.6	0.8	70.9	33.1	26.5	44.4	0.69	61.1	22.8	38.3
2	177.2	0.64	113.4	74.9	47.9	65.5	0.476	84.3	35.6	48.7
3	354.4	0.512	181.4	149.8	76.7	104.7	0.328	116.2	49.1	67.1
4	620.2	0.41	254.3	299.6	122.8	131.4	0.226	140.2	67.7	72.4
5	974.6	0.328	319.7	524.3	172.0	147.7	0.156	152.0	81. 8	70.2
6	1461.9	0.262	383.0	823.9	215.9	167.2	0.108	157.9	89.0	68.9
7	1949.2	0.21	409.3	1460.5	306.7	102.6	0.074	144.2	108.1	36.2
8	1949.2	0.168	327.5	1947.4	327.2	0.3	0.051	99.4	99.3	0.1
9	1949.2	0.134	261.2	1947.4	260.9	0.2	0.035	68.2	68.2	0.1
10	1949.2	0.107	208.6	1947.4	208.4	0.2	0.024	46.8	46.7	0.04
Total	659.55	-	2529.3	6209	1798	731.2	-	1070	701.5	369

[1]Y: year; [2]IF: Internal flow; *[3]DR: Discount rate; [4]CVIF: Current values of internal cash flow; [5]ExF: external cash flow; [6]CVEF: Current net values of external cash flow, [7]CV: Current net value*
** Calculated working capital to compensate for the investment costs of the project.*
Source: the data collected and estimated by the authors.

3.9.2 Discounted measures

In the case of non-sale crop year zero (in the reclamation and pilot cultivation):

(1) Payback period=Cost of investment/Average net cash flow=11 months.
(2) Net present value at a discount rate (25%)=731.2 LE.
(3) Ratio (inflows / outflows) when the discount rate (25%) =1.4.

The summarized data in Table (16) clearly indicated that growing the contaminated sewaged soil after bioremediation process economic successfully. Similar finding was reported with Sun et al. [6] who reported that using Cd hyperaccumulators to remedy contaminated soils is regarded as an economic and ‘‘green’’ method.

As shown above, the project can be implemented destination economic successfully, may also be applied by growers do not have a large capital for the purchase of fixed assets.
There are sufficient guarantees to secure the occurrence of any sudden changes or harmful, both in plant and equipment or prices for inputs and outputs are as follows:

- Do not sell crop year zero, and also the winter crop in the following year the new land added.
- The existence of maintenance expenses for machinery and equipment.
- Increased costs by about 30% from the sixth year.
- Increase revenue by only about 10% of the sixth year.

Summary of the Study Data

Scenario	Undiscounted Measures		Discounted Measures	
	Measurement	**Value**	**Measurement**	**Value**
1	Revenue on Invested	1.11	Payback period	100.5 months
	Rate of return on investment	43.1	Net present worth at discount factor 25%	127.8 (LE ‘000)
	Average yearly income of the project	74.5 (LE ‘000)	Benefit/cost ratio at the discount rate (25%)	1.04
			Rate of the internal return	21.2
2	Revenue on Invested pound	1.12	Payback period	20 months
	Rate of return on investment	55.3	Net present worth at discount rate 25%	115 (LE ‘000)
	Average yearly income of the project	95.45 (LE ‘000)	Benefit/cost ratio at the discount rate (25%)	1.04
			Rate of the internal return	44.2
3	Revenue on Invested pound	1.03	Payback period	11 months
	Rate of return on investment	106	Net present worth at discount rate 25%	731.2 (LE ‘000)
	Average yearly income of the project	35.1 (LE ‘000)	Benefit/cost ratio at the discount rate (25%)	1.4
			Rate of the internal return	38.3

4. SUMMARY

This article addressed economic evaluation aspect of Abu-Rawash farm (100 acres), this farm irrigated with sewage effluents for long time. The treatments economically evaluated depend on integrated managements included phytoremediation by grown canola and maize after biochemical remediation of contaminated soils. The feasibility study showed the following results:

1. When applying the first scenario (acquisition the equipments and machinery, but rent the land): cultivated land in the Year Zero with maize only, without selling the product, then growing the crops in the following year. The same practices will be repeats in the added land and so on. In this scenario the payback period on the investment occurred after more 8years, and the internal rate of return was 21.1%.
2. When applying the second scenario acquisition of machinery and equipment and rent the land): cultivated land in the Year Zero with maize only, without selling the product, then growing crops in the following year. The land added will be grown with the two crops, but selling the maize only. In this scenario the payback period on the investment occurred after 20 months and the internal rate of return was 44.2%.
3. When applying the third scenario, renting the machines, equipments and land (as in the second scenario) the recovery of the investment costs will be achieved after 11 months and the internal rate of return estimated by 38.3 %.

4. CONCLUSION

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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