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RESEARCH ARTICLE

ECONOMIC FEASIBILITY FOR THE PRODUCTION OF JATROPHA ON A SMALL SCALE IRRIGATED BY TREATED WASTEWATER

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ABSTRACT

Energy is a vital driving force for development; access to energy can alleviate poverty, improve living conditions and propel economic development. Biofuels as a fossil energy alternative has gained worldwide attention for many years. Drastic changes in the energy system are needed. However, the establishment of the required new energy technologies and associated infrastructure will in itself lead to GHG emissions. Other important aspect affecting Egypt's agriculture income is water scarcity. Egypt will need to improve the way they manage their water resources and associated services. However, expansion of Jatropha plantation largely depends on profitability from such plantations on small- scale level. The study reveals that Jatropha is a potential renewable energy resource with advantage of grown on marginal lands and irrigated by treated of waste water. The main objective of the study is to assess the profitability of Jatropha through discounted indicators in order to enhancing the sustainable development in Egypt. This study has shown positive returns from Jatropha plantation during the period 2008- 2022. Although the net present value at discount ratio of 30% was LE 8.2 thousand, while the benefit/ cost ratio was 1.45.

KEYWORDS

Benefit cost ratio, Egypt, Jatropha, Internal rate of return, Net present value, Sewage water

1. INTRODUCTION

Egypt is the largest oil producer in Africa and is the largest consumer of oil on the continent. The country's use of oil account is 20 percent of Africa's total consumption (EIA, 2018). Egypt is an importer of oil because the country's consumption of oil has been increasing due to economic and population growth (Park, 2015). Global production of biofuels has increased considerably during the last ten years (FAO, 2008), between 1998 and 2008, worldwide ethanol production increased from 19.2 to 66 billion liters and biodiesel production from 0.6 to 14.7 billion litres. Ethanol can be produced by the fermentation process of high sugar crops such as sugar cane, sugar beets, sweet sorghum and corn. Biodiesel can be produced from plants that contain vegetable oil such as palm, soybean, algae, Jatropha or animal fat. Biofuels have contributed to food security problems since agricultural lands have been used for the production of energy instead of food (Babcock, 2008).

Jatropha plantings are used as hedges for gardens and protection against animals and erosion control. Oil from seeds is used for soap production, as a lighting fuel, cooking and for biodiesel production (Henning 2004b). A group researcher concluded that under poor levels of fertilisation, irrigation and soil fertility, Jatropha produces less seeds with inferior oil quality then plantations that receive such inputs (Brechje et al., 2006). They suggested the need for additional fertilisers, water, and qualified labour to be successful. Some researchers also reported high yields of 7800 kg/ha starting in year three with 500- 600 mm of rainfall per year (Jongshaap et al., 2007). Tomomatsu and Brent also presented low yields of 3705 kg/ha after eight years, but his results were based on a project without fertiliser and irrigation (Tomomatsu and Brent, 2007). The economic viability of the use of Jatropha as an alternative fuel is being investigated since it has been optimistically presented as a plant that grows under marginal land conditions where other food crops are not grown and this offers an opportunity for sustainable rural development in the context of some developing countries (Chachage, 2003; Ghosh et al., 2007; Henning, 1998d).

Jatropha appropriate for growth under harsh conditions, such as drought, low nutrient supply and salinity, as well as Jatropha, could be cultivated and irrigated with treated wastewater without any negative effects (Abou Kheira and Atta, 2009; Fakhry et al., 2016). The real opportunity for Egypt is using treated wastewater to grow Jatropha. (Swanberg, 2009). El-Gamassy found that the payback period of Jatropha plantation is approximately four years, with an internal rate of return of 47% (El-Gamassy, 2008). In addition to that he concluded that the Jatropha, as a source of biofuel, on the national level should be part of the energy sector strategy of Egypt. Reedy concluded the profitability of Jatropha plantation in Fiji over its 30-year lifespan (Reedy, 2020). Moreover, some researchers concluded that Jatropha biodiesel has higher costs than conventional diesel, while Jatropha PPO is competitive with conventional diesel, but only in a family labour system (Van Eijck et al., 2012). The goal of this paper is to focus only on economic viability of Jatropha production as an alternative to conventional diesel when growing on a small scale in Egypt. Therefore, at the Jatropha processing a few organizations carry out oil extraction for experimental or small level.

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2. Methodology

2.1 Location

The research was carried out in private farm in South Sohag, Sohag Governorate, Upper Egypt, from 2008, the experiment arranged in completely randomized block design. Seeds of *Jatropha curcas* were planted directly in infertile, sandy soil on mid-February 2008; during establishment, spacing applied were two meters between plants and three meters within rows, giving plant densities of 660 plants/ acre. Three seeds were used per each hole while plants thinning was carried out after three months of germination and one healthy plant was left.

2.2 Irrigation and Nutrient Requirements

Jatropha plants were irrigated with treated wastewater using a drip irrigation system with four adjustable discharge emitters/ trees through two irrigation lines besides the tree, all trees received equal irrigation water quantity three time per week during the first year, and two time per week from the second year. During establishment, fertilizer was applied one time before seed cultivating as follow: Urea (10 g tree^{-1}), super phosphate (10 g tree^{-1}), potassium sulphate (5 g tree^{-1}), from the second-year super phosphate (20 g tree^{-1}) and potassium sulphate (10 g tree^{-1}) was applied per tree in mid-January.

2.3 Calculations

Rapid rural appraisal was used to collect data, in addition to a primary and historical data from different sources. The study used 15 years data during the period of 2008- 2022. A cost–benefit ratio approach was the core of analyses the profitability of Jatropha cultivation. In this context, discounted financial evaluations measures such as net present value (NPV) and internal rate of return (IRR) were applied (Perman et al., 2003).

3. Results and Discussion

More than 160,000 acres in Egypt are available for Jatropha plantations (Zalesny et al., 2011). Egypt biofuels production was at level of 0.6 thousand barrels per day in 2016, up from 0.52 thousand barrels per day previous year; this is a change of 16.67% (World Bank, 2017). Wastewater and marginal land become a source of income to the country's GDP. A per acre estimated cost at farmer level, associated with different stages of Jatropha plantation are discussed in brief below.

3.1 Establishment Cost

Table one presents the establishment costs which include different items such as the value of land, land preparation for planting, the component of irrigation system, etc. A total establishment cost was estimated as LE 8900 which was paid in the first year of the project. Value of land could be observed that the most important, in terms of percentage of establishment costs, is the land value representing 56% of total establishment costs, while irrigation system implies about 34% of total establishment costs.

Table 1: Establishment and Replacement Costs of Jatropha (LE)

No.	Items	No. of Units	Price/ Unit	Total Value	Lifespan (Years)	Replacement Year	
						6	11
1	Land (acre)	1	5000	5000	-	-	-
2	Land preparation (acre)	1	50	50	-	-	-
3	Irrigation system (acre)	1	3000	3000	5	3000	3000
5	Jatropha seeds	10 kg	50	500	50	-	-
6	Planting (man/day)	5	30	150	-	-	-
7	Others	-	-	200	-	-	-
	Total			**8900**		**3000**	**3000**

3.2 Operating Costs

Table two presents the operating costs which include tree holes improvement, irrigation cost, pruning cost, maintenance, electricity requirements and seed collection cost. These are evaluated on a per acre basis (for each year of the project)

Table 2: Operating Costs of Jatropha During the Period of 2008- 2022 (LE)

Years	Tree holes Improvement	Irrigation	Maintenance of Irrigation System	Pruning	Seed Collection	Others*	Total Costs
2008	-	500	-	-	-	-	**500**
2009	200	650	50	-	150	300	**1350**
2010	300	700	50	350	180	350	**1930**
2011	400	900	50	450	250	450	**2500**
2012	400	1100	50	550	350	600	**3050**
2013	500	1300	50	7000	400	900	**10150**
2014	700	1500	50	1000	750	1200	**5200**
2015	800	1700	50	1200	1000	1450	**6200**
2016	1000	2000	50	1450	1600	1600	**7700**
2017	1100	2300	50	1700	2000	1750	**8900**
2018	1200	2500	50	1900	2500	1750	**9900**
2018- 19	1200	2500	50	1900	2500	1750	**9900**
2020- 21	1500	2900	50	2250	2800	2000	**11500**
2022**	1500	2900	50	2250	2800	2000	**11500**

*Including: fertilization, pesticides, etc.

** Projections based on 2021 prices.

3.3 Total Costs of Jatropha During the Study Period

Table three presents the total costs of Jatropha during the period 2008-2022. Establishment cost was LE 8900 which was paid in 2008; Replacement costs were paid in years 2013 and 2019 due to lifespan estimation of irrigation system.

Table 3: Total Costs of Jatropha During the Period of 2008- 2022 (LE)				
Years	**Establishment**	**Replacement Cost**	**Operating Costs**	**Total Costs**
2008	8900		500	**9400**
2009			1350	**1350**
2010			1930	**1930**
2011			2500	**2500**
2012			3050	**3050**
2013		3000	10150	**13150**
2014			5200	**5200**
2015			6200	**6200**
2016			7700	**7700**
2017			8900	**8900**
2018			9900	**9900**
2019		3000	9900	**12900**
2020-21			11500	**11500**
2022*			11500	**11500**

* Projections based on 2021 prices.

3.4 Seed Yield Prices

Seed yields, total production and prices have been presented in Table four; plants were assumed to become fully matured in the sixth year of plantation (2016) with stable total production reached 2640 kg per acre. Pruning wood residuals quantities were estimated as shown in Figure one, residuals quantities has been found to range from 660 kg per acre to 2310 kg per acre during the study period.

Table 4: Seed Yields, Total Production, Prices and Value of Acre During 2008- 2022				
Years	**Kg/Tree**	**Kg/ Acre**	**Price LE/ Kg**	**Value of Acre (LE)**
2008	-	-	-	-
2009	0.5	330	4	1320
2010	1.0	660	5	3300
2011	2.0	1320	5	6600
2012	3.0	1980	6	11880
2013	4.0	2640	6	15840
2014-2015	4.0	2640	7	18480
2016-2017	4.0	2640	9	23760
2018-2019	4.0	2640	10	26400
2020-2020	4.0	2640	11	29040
2022*	4.0	2640	11	29040

* Projections based on 2021 prices.

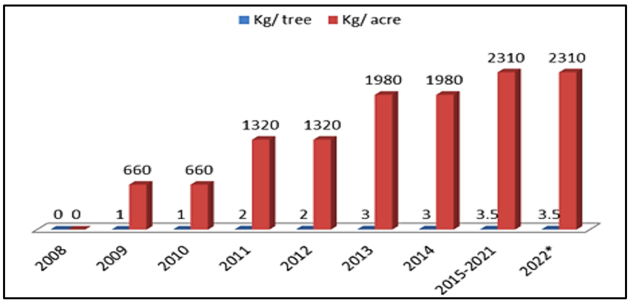

Figure 1: Tree pruning residual and total residual per acre during 2008-2022 (* Projections based on 2021 prices).

3.5 Jatroph Total Returns

The returns of Jatropha plantation during 2008-2022 were calculated, from two different sources of returns as shown in figure two. These are evaluated on a per acre basis (for each year of the project). Figure two shows an increase in net return of Jatropha plantation during the study period reached the minimum around LE 1650 in 2009, and the maximum was LE 30195 in 2021.

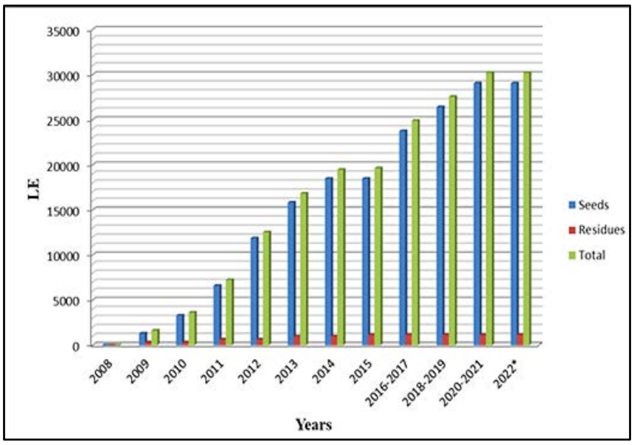

Figure 2: Jatroph total returns during the period 2008- 2022 (LE) (* Projections based on 2021 prices).

The price of L.E. 0.5/kg for Jatropha wood residues

3.6 Financial Viability of Jatropha Production

Financial viability for Jatropha production was calculated during the period 2008- 2022. Discounted cost, discounted benefit, and incremental net benefit (INB) are shown in (Table five).

- The net present value at discount rate of 30 per cent was LE 8.2 thousand.
- The benefit/ cost ratio at discount rate of 30 per cent was 1.45.
- The internal rate of return (IRR) reached about 48 per cent, and it's higher than interest rate (30%).

Table 5: Discounted Costs, Discounted Benefits, NPV And IRR of Jatropha During the Period of 2008- 2022 (LE)						
Years	**Total Costs**	**Total Benefits**	**D.F 30%**	**Discounted Costs**	**Discounted Benefits**	**NPV**
2008	9400	-	0.769	7229	-	-7229
2009	1350	1650	0.592	799	977	178
2010	1930	3630	0.455	878	1652	774
2011	2500	7260	0.35	875	2541	1666
2012	3050	12540	0.269	820	3373	2553
2013	13150	16830	0.207	2722	3484	762
2014	5200	19470	0.159	827	3096	2269
2015	6200	19635	0.123	763	2415	1653
2016	7700	24915	0.094	724	2342	1618
2017	8900	24915	0.073	650	1819	1169
2018	9900	27555	0.056	554	1543	989
2019	12900	27555	0.043	555	1185	630
2020	11500	30195	0.033	380	996	617
2021	11500	30195	0.012	138	362	224
2022	11500	30195	0.019	219	574	355
Total	**116680**	**276540**		**18131**	**26359**	**8227**

4. Conclusion

Jatropha curcas simply one tool that can be used toward sustainable development in isolated energy-scarce places, The study observes that growing Jatropha on small- scale in Egypt is profitable; all these discounted indicators refer to a promising alternative to protect environment and depend on clean energy. There are marginal lands and wastewater available for jatropha plantation in Egyptian Governorates that would not compete for land with food production. Many of the projects in the past were focusing on small-scale community development; Jatropha was never explored as a real large-scale plantation crop. In this regard, local efforts should be directed towards supporting small scale Jatropha projects to be more economically viable and has the potential to increase rural incomes as well as to increase access to energy to the poor people.

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