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Private and Social Cost-Benefit Analysis of Biodiesel Produced from *Salvia leriifolia*

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ABSTRACT: Through changing cetane number, substitution of biodiesel instead of gas oil would reduce fossil fuels usage and subsequently greenhouse gas emissions. Biodiesel, as one of the most important biofuels, is environmentally advantageous, even if it is more expensive than gas oil. This paper investigates the possibility of producing biodiesel from *Salvia leriifolia*, a wilding self-growing plant in Iran, as well as economic cost-benefit analysis from private and social viewpoints. To do this, a biodiesel-producer plant with the annual capacity of 300, 135, and 15 thousand tons of respectively biodiesel, meal, and glycerin is considered and economically evaluated. The results indicate that cost price of each liter biodiesel produced in such plant is estimated 0.06 USD that is not much less than domestic gasoil price (0.10 USD), receiving subsidies, but also is less than the Persian Gulf FOB that is about 0.5 USD per liter gasoil. Social cost-benefit analysis suggests that establishment of biodiesel plant with the capacity of 300 thousand tons will annually reduce 37 million USD in social costs. Moreover, farming *Salvia leriifolia* has positive externalities, other than direct benefits. Accordingly, government supports for establishment of biodiesel plant seems essential to utilize its private and social benefits.

Keywords: Economic evaluation, *Salvia leriifolia*, Biodiesel, cost-benefit analysis, Sensitivity Analysis

INTRODUCTION

Biodiesel is an ethyl ester or methyl ester, made of vegetable oils or animal fats, applied as fuel in diesel engines or thermal systems (DU *et al*, 2004; Demirbas, 2003; Ghobadian and Rahimi, 2004). Since its environmental benefits, biodiesel will be utilized as the primary fuel in transportation sector in the following years; then, bioethanol plays a major role in providing transportation fuel (Panoutsou *et al,* 2008) because by using biodiesel, the positive external benefits will be even greater than revenues (Wassell and Dittmer, 2005). Biofuels are easily obtained from common biomass resources, are environmentally friendly, renewable, and have great contributions in environmental sustainability (Puppan, 2002). Most likely due to rising prices of fossil fuels in the future, the use of biomass will be economically significant. Production of biofuels from biomass due to low carbon dioxide emissions and lower sulfur content has very positive impact on the environment. Utilizing renewable plant fuels is a common way to reduce environmental pollution and offsetting limitations of fossil fuels. Furthermore, vegetable fats are the main raw materials for biodiesel production and accounted as a large part of biodiesel production cost (Martin *et al*, 2006). However, since over 95% of the world biodiesel production is produced by edible oils, continuing this process may reduce the world food supply and it is suggested that other sources of biodiesel production to be taken into account. For example, inedible oils or waste edible oils can be used to product biodiesel (Gui *et al,* 2008).

Biodiesel is derived from naturally occurring vegetable oils or animal fats that have been chemically modified (esterified) to run in a diesel engine. Compared to petroleum diesel, biodiesel is renewable, has better emissions properties, and supports domestic agriculture (Johnston and Holloway, 2007).

Of course, in addition to environmental criteria, economic criteria must also be considered in selecting the plant producing biodiesel. High prices of fossil fuels are considered as good stimulus in replacing biofuels instead of fossil oils (Booth *et al,* 2005). The main factor determining the biodiesel price is the raw material price employed for biodiesel production. Therefore, the biggest portion of cost of biodiesel is allocated to raw materials. Economic benefits of biodiesel production includes developing added value, creating jobs in rural areas, increasing tax revenues and investing in biodiesel production equipment (Leduc *et al*, 2009; Demirbas, 2007).

The other economic advantage of using biodiesel rather gasoil is producing byproducts such as meal and glycerol causing import reduction. Another criterion considered in selecting plant used in biodiesel production is the issue of food security. Utilizing inedible herbs could aid to improving food security. Although, because of their high performance, plants such as soybean and canola can be used as suitable feedstock in producing biodiesel, maintaining food safety particularly in developing countries such as Iran leads to employing inedible plants instead of edible ones. Therefore, regarding environmental, economic and food security concerns, *Salvia leriifolia* is selected as the main raw material for biodiesel production. *Salvia leriifolia* is a native plant in Iran and contains high fat. This herb is classified within Lamiaceae family growing in North East of Iran and some parts of Afghanistan (Rechinger, 1982). Production of this herb is similar to of Canola. In any bush of this plant, there are about 8 to 14 thousand seeds (Hadad Khodaparast, 1993).

Stems and petioles of the plant are straight and have a pile of white cotton. The leaves have oblong base along with a border with irregular teeth covered with pressed cotton piles. Calyx is tubular or cup-shaped and is usually associated with 4 seeds. Each flowering stalk contains 4 to 10 floors. On each floor, there are 4 to 6 flowers, the number of seeds in each floor reaches to 16 to 36. If all capsules have seeds, in a bush of plant around 8 to 14 thousand seeds are estimated. The seed diameter is 3 to 8 mm. In regard to the wide spread in rocky heights, high resistance to water deficit and high temperature conditions, this plant is considered as a valuable species in arid and desert areas (Fille Kesh, 2003). The present paper analyzes manufacturing a biodiesel-production plant utilizing *Salvia leriifolia* as feedstock with an annual capacity of 300 thousand tons of biodiesel as well as meal and glycerin by-products. Costs and benefits are analyzed in Comfar III software and the project is exposed to break-even and also sensitivity analysis according to project's performance summary table.

MATERIALS AND METHODS

For cost-benefit analysis of biodiesel production, the plant annual capacity of 300 thousand tons is taken into consideration. For this, the information of feasibility study of LidCo enterprise for construction of a biodiesel plant utilizing *Jatropha curcas* in Iran is employed. Information of construction and operation phase of plant including fixed and variable investment costs, studying costs before exploitation, etc. are estimated in current prices of 2013 and other information such as land prices and wages of labor are computed based on domestic prices. Additionally, since the plant feedstock is not provided by imported oil, in contrast to *Jatropha*, an oil extraction unit to this plant is considered. Oil extraction unit information was adopted from feasibility study of Ministry of Cooperatives (Iran Ministry of Cooperatives, Design and Planning Assistance, Economic and Banking facilities Affairs Department, 2007); the data were estimated based on desired capacity and year. Glycerin and meal are the byproducts of this plant. Each bush of *Salvia leriifolia* occupies one square meter so there are 10000 bushes per hectare of agricultural land. According to empirical studies, in each 1,000 grams of seed, 450 ml biodiesel can be obtained. In this paper, the number of seeds of each bush is averagely considered 11000. Thus, on average, there are 110 million of seeds in each hectare. As the weight of 1000 seeds is assumed 70 g, the weight of the harvested seeds is 7700 kilograms per hectare; thereby, 3465 liters of biodiesel is obtained per hectare approximately considered 3,500 liters. The price of each kilogram meal of *Salvia leriifolia* is considered equal to of canola, 0.4 USD (www.itpnews.com, 2014). Table 1 illustrates number and weight of seeds as well as the estimated amount of produced biodiesel in each hectare of *Salvia leriifolia.*

Table 1: Number and weight of seeds and biodiesel amount produced from *Salvia Leriifolia.*

Extracted biodiesel (Thousand liters)	weight of each Seed (Million grams)	Number of Seeds (Million items)	Number of plant bushes (ten thousand items)	Area (hectare)
3.5	7.7	110	1	1

Production cost of *Salvia leriifolia* includes costs of land preparation, planting and harvesting. Since, planting and harvesting conditions of Salvia leriifolia, according to conducted studies, is similar to canola and considering that no data and statistics are published for *Salvia leriifolia* production costs; so, in this paper, production cost of *Salvia leriifolia* is assumed equal to canola production cost. Accordingly, the average cost of per hectare *Salvia leriifolia* in 2013 considered equivalent to 516 USD. As Biodiesel density is 880 kilograms per cubic meter, the volume of 300 thousand tons biodiesel is 340 million liter. Since 3500 liters of biodiesel will be produced from each hectare of *Salvia leriifolia*, in order to produce 300 thousand tons of biodiesel, whose volume is 340 million liter, 97402 hectares of land is needed. In the present study, considering the plant feasibility study data, the plant construction phase is considered 2 years; the operation phase are studied in two different scenarios of 20 and 50 years. Biodiesel plant product is assumed 24 hours operation in a day (three shifts) and 300 working days per year. The discount rate represents the rate at which the cash flows of other times (mostly future) will be converted to cash flow of the present time.

And include factors such as currency devaluation (inflation) the utility of consumption and the return on investment risks.

The discount rate is used for equalizing prices in different times and obtaining the equivalent prices at a common time (Williams *et al,* 1988). The discount rate in the project analysis is equal to Iran bonds rate in 2013; according to the data issued by Central Bank of Iran, assumed 25% from which 20% is considered as long-term profit of bonds while 5% added for considering the risk.

A. Biodiesel plant costs

Biodiesel plant costs are divided into two categories: fixed and variable costs. Fixed costs are expenses that do not change in different production values. Variable costs are those varying with changing production level. Cost of biodiesel production units includes variable and fixed costs presented as follows.

Fixed Costs (FC): Fixed costs are referred to the costs not directly related to production level may even remain at production level zero (Debertin, 2012). These are costs that do not directly impact on production, but must be regarded in the calculating total costs as part of the costs (Bragg, 2011). In biodiesel production unit, variables such as fixed staff's salaries, insurance payments, depreciation costs, the opportunity cost of fixed assets, and other associated items are considered as fixed costs.

Investment costs consist of land, landscaping, buildings, machinery and manufacturing equipment, laboratory equipment, workshop equipment, public utilities, general office equipment, vehicles, unforeseen costs and pre-operation costs. This study measures the amount of fixed investment in a biodiesel plant with the capacity of 300 thousand tons as 32 million USD. In Table 2, the fixed costs of the plant are presented. Depreciation rate of industrial projects in Iran is linearly calculated in regard to project effective lifetime.

The rate of depreciation of projects is estimated for depreciation is saved for investment to renovate the equipment, building and continuing production as a result. In general, rate of depreciation of industrial projects in Iran is calculated linearly and with respect to the useful life of the project. For example, if a project has a useful life of n years, its depreciation rate is calculated using Equation (1):

$$x = 1/n \quad \ldots(1)$$

In this regard:

x: rate of depreciation

n: the useful life of the project

Table 2: Fixed costs of biodiesel plant.

Item	Total cost (thousand USD)
Land	3125
Landscaping	125.625
Building	1233.425
Machinery and production equipment	27118.41
Laboratory Equipment	25.625
Workshop Equipment	11.025
Public facilities	875.625
Office and general equipment	66.4375
Vehicles	222.5
Unforeseen (5%)	577.9781
Pre-operating costs	487.475
Fixed investment costs	32555

In the straight-line depreciation method. As in equation (2) is shown, depreciation costs are equal in all years.

$$(D_1 = D_2 = \cdots = D_{T-1}) = D_T \quad \ldots(2)$$

In relationship (2), D_1, is the calculated depreciation for the Year *i*. However, in the financial analysis of projects the depreciation rate is calculated according to the value of salvage. However, the rate of depreciation and the salvage value are entered separately in the software. The software has the capability to analyze the project financially and economically by integrating value of salvage and value of depreciation.

As the lifetime of project is 20 years, the depreciation rate is considered equal to 5 percent in the present study. In Table 3, depreciation rate and salvage value of biodiesel plant are determined. Considering that in economic analysis, the economic parameters are calculated according to the present value, applying rates of inflation has no effect on the calculations' results. Meanwhile, the inflation of wholesale average general index, in this paper, is extracted from Central Bank of Iran in the last 10 years. Inflation rates enforced in calculations are in three different scenarios of 20%, 10% and 15%.

Table 3: Depreciation rate and salvage value of biodiesel plant.

Cost type	useful life (years)	Depreciation Rate (%)	Rate of salvage value (%)
Main machinery	20	5	30
Public instruments	20	5	10
Transportation vehicles	20	5	30
Building	20	5	30
Office furniture	20	5	10
Unforeseen expenses	-	5	-
Fixed capital	20	5	-
Pre-operation costs	-	5	-

Three fourth of financing sources is provided by loans and the rest is the trade-in of investor. Loan repayment period is determined 5 years following a 6-year breathing of concessional loan repayment period (National Development Fund, 2012). According to Article 105 of Direct Taxation Act, income earned from profit activities is taxed at 25% rate. In addition, according to Article 132, taxable income in factories or mining units of cooperatives or private sectors that received the operation license since 2002 are exempt from tax (www.intamedia.ir, 2002).

There is a time interval between producing a product and selling it so that investor enables to pay the production costs from products' sale income. In the meantime, there is a need to invest. This distance is defined as coverage days. This is not seen in most investment projects causing failure of some of these projects. Therefore, in this paper coverage days are determined depending on costs. Coverage days are specified in Table 4.

Table 4: Coverage days of biodiesel plant.

Items	Days of coverage
Feedstock	60
Energy	30
Inventory of under-construction commodities	60
Inventory of constructed commodities	60
Repairs	60
Depreciation	60
Facilities	90
Cost of sales and insurance	90

Variable Costs (VC): Variable costs contain those expenditures that are directly dependent to the level of production (Debertin, 2012). The main part of variable costs involves staff wages, costs associated with planting and harvesting oilseed, oil extraction, repair costs, transportation, water, electricity, gas, telephone, etc. 12 months salary plus 4 months benefits are considered for plant staffs and 23% of the annual salary of staff is considered as the employee's insurance.

Costs of planting and harvesting of oilseed per hectare is achieved by adding total land preparation, planting, maintaining and harvesting costs. The average cost of land preparation, including irrigation, plow, disc, partial clearing, plot layout, line drawing, creating streams, dredging trees and other land preparation operations. The average cost of planting, includes: animal manure, carrying animal manure, spraying organic fertilizers, chemical fertilizer, carrying animal manure, spraying animal fertilizers, seed consumption, seed sterilization, carrying the seed, nursery supply, procurement of transplanting, digging and transport of transplanting, seeding and transplanting and other costs of growing. The average cost of maintaining includes water cost, irrigation, animal manure, fertilizer, crust breaking and weeding, thinning, pesticides, spraying, biological control of pests, etc. Furthermore, The average cost of harvesting includes: harvesting, collecting and transporting in the farm, threshing, cleaning and winding the product, packaging and shipping to warehouses and shopping centers, etc. Accordingly, the annual variable costs of biodiesel plant using *Salvia leriifolia* is estimated 36 million USD. Variable costs of biodiesel plant are separately determined in Table 5.

Table 5: Variable costs for biodiesel plan.

Item	Total cost (thousand USD)
Salvia Leriifolia	48906.25
Chemical Additives	7509531
Energy	155.4469
Maintenance and Repair	90.75
Cost of salary and wage	272
Transportation costs	911.5625
Overhead costs	487.4688
Total	58330

B. Biodiesel plant revenues

The main product of plant is biodiesel that is produced 210, 240, 255, 270, and 285 thousand tons respectively in plant factors of 0.7, 0.8, 0.85 and 0.9. Production amount will be 300 thousand tons since year 2022. By-products obtained from biodiesel plant are meal and glycerin. Selling these products can decrease the rate of glycerin and meal import in Iran. Price of ach kg meal is equal to 0.4 USD (Information and Communication Technologies Institute of Poultry and Livestock Industry in Iran, 2014) and the price of each ton glycerin is considered 203 USD.

Table 6: Revenue earned from byproducts of biodiesel plants.

Description	Nominal Capacity (thousand tons / year)	2017	2018	2019	2020	2021	2022
Plant factor		0.70	0.80	0.85	0.90	0.95	1
Glycerin	15	68.250	78	82.8	87.750	92.62	97.500
Meal	135	1228	1404	1491	1579	1667	1755

Sales revenue from 2022 onwards is assumed constant according to plant factor 1. Byproducts revenue of biodiesel plant is presented in Table 6.

C. Biodiesel plant social costs

Social cost is imputed to harmful effects of a pollutant or activity on agricultural products, ecosystems, materials and human health; and, is not considered in estimation of cost price of products. Alternatively, the sum of money offsetting the damage caused by emissions of pollutants and greenhouse gases is called "demolition cost" or "social cost" (Iranian Balance of Energy, 2013). To calculate the demolition costs, quantifying the effects of pollutants and activities influencing on human and natural environments is required. Since substitution of biodiesel instead of gasoil reduces social costs, it is important to calculate the social costs reduced by developing a plant with the capacity of 300 thousand tons is. In addition, massive biodiesel production can greatly reduce the social costs. First, the social costs of polluting gas emissions in the energy sector are calculated based on 2011 constant prices; and next, considering the amount of pollutant emissions per liter of gasoil and changing the pollutant amount through replacing the biodiesel, the reduced social cost is calculated. In Table 7, the social costs of energy sector emissions are identified based on pollutant gas according to 2011 constant prices. Since plants' conventional fuel is mostly gasoil, the social costs estimations will be saved as a result of replacing biodiesel by gasoil.

Table 7: Social costs of energy sector emission separated by polluting gas based on constant prices of 2011.

Type of pollutant	NO_X	SO_2	CO	SPM	CO_2	CH_4
Damage (Thousand USD /ton)	0.74	2.2	0.23	5.3	0.012	0.26

In the suggested plant, production of 300 thousand tons of biodiesel is considered. As the density of diesel and biodiesel is considered 880 kilograms per cubic meter (Sreenivas *et al,* 2011), the volume of produced biodiesel is calculated based on relationship (3).

$$\rho = m/v \quad \ldots(3)$$

In relationship (3), ρ is density in terms of kilograms per cubic meter (kg / m^3); *m* is the mass in terms of kilograms (kg) and *v* is the volume in terms of cubic meters (m^3). Therefore, by consuming 300 thousand tons biodiesel, based on density relationship, 340 million liters of biodiesel will be used. To compute the reduced social cost of biodiesel consumption, the pollution level of per liter gasoil is determined in Table (8). Table 8 shows that consuming each liter gasoil produces 2785.502 grams of pollutant with high levels of carbon dioxide; and by replacing biodiesel this amount can decrease. Applying biodiesel in conventional engine leads to major unburned hydrocarbons, CO and suspended particles. Nitrogen oxides emitting will slightly decrease or increase depending on the duty cycle and test methods.

Table 8: Emission of pollutants resulting from consumption of each liter of gasoil.

Type of pollutant / Type of fuel	**NO_X**	SO_2	CO	SPM	CO_2	CH_4
Gasoil (grams per liter)	32.95	17.062	36.61	14	2684.7	0.18

Reference: Environmental Protection Agency Statistics, 2013

Table 9: Average of pollutants change by replacing one liter of biodiesel instead of one liter of gasoil.

Type of pollutant	**NO_X**	SO_2	CO	SPM	CO_2	CH_4
Pollutant decrease (percent)	10+%	100-%	48-%	47-%	0	67-%

Reference: National Biodiesel Board; www.biodiesel.org

Table 10: Reduction of Social cost by replacing 300 thousand tons of biodiesel instead of gasoil.

Type of pollutant	**NO_X**	SO_2	CO	SPM	CO_2	CH_4
Damage (thousand USD per ton)	9187.5	12968	1500	13468	0	5.18

Table 11: Reduction of Social cost by replacing each liter of biodiesel.

Type of pollutant	**NO_X**	SO_2	CO	SPM	CO_2	CH_4
Damage (USD)	0.02	0.03	0.004	0.03	0	$1.5 * 10^{-5}$

Reference: research findings

Utilizing biodiesel fuel can decline the carbon contribution to the suspended particles (since the oxygen available in biodiesel enables complete combustion to carbon dioxide); moreover, the sulfate can also be disappeared (since, there is no sulfur in biodiesel), yet some of the solution or hydrocarbon remains the same or increases. The average percent of pollutants changing is determined by replacing each liter of biodiesel with one liter of gasoil in Table 9.

Hence, replacing 300 thousand tons of biodiesel with gasoil produces less pollutant. Regarding Tables 7 and 8, the social cost savings of replacing 300 thousand tons B 100 -which is a fuel completely made of biodiesel- with gasoil is calculated in Table 10. Thus, the total social cost savings of producing and consuming 300 thousand tons in biodiesel plant is calculated 37 million USD. The social cost savings of replacing every liter of biodiesel (B100) instead of one liter of gasoil is presented in the Table 11 as well. Table 11 evinces that the social cost savings resulted from replacement of each liter of biodiesel instead of gasoil is equal to 0.109 USD.

D. Investment Decision making criteria

In order to assess the project economic feasibility, the economic indicators are calculated by considering project construction and operation period. However, these indicators may not necessarily give the precise answers in all cases, but can help the investor in deciding to invest. This study considered indicators including payback period (PP), net present value (NPV), internal rate of return (IRR), benefit to cost ratio (B/C), and modified internal rate of return (MIRR).

Payback period (P.P): Payback period is an approximation method to compare the economic feasibility of projects. The project with a shorter payback period is more economical. As most employers avoid risk taking so they prefer the capital to be returned in the shortest time. However, this method ignores the time value of money and the payback period (Radev, 2003). The investment costs during construction for purchasing, installation and commissioning the equipment necessary to use will be carried out to be prepared for the exploitation and producing a product or anticipated service delivery. After the operation of the plan, delivery of products or services to market begins that causes income for the investor. The proceeds from sales of products and services are used primarily to pay for the product manufacturing costs, such as raw materials, energy, personnel and other required costs.

After deducting these costs and estimated costs related to the duties and taxes, the final balance is calculated as net profit which is the ultimate goal of the project. Annual net income is paid to an investor who has attempted to invest in the construction period during operation. The time period in which the cumulative net profit of the plan over different years is equivalent to the figure for the investment carried out during construction (or during operation) is called payback period whose unit is year.

Net present value (NPV): In fact, a project's net present value is the difference between the expected discounted profits: cash flows and initial investment (Damodaran, 2003). In evaluating a project, if the NPV be greater than or equal zero, the project is economically feasible. Otherwise, no economic justification for this approach can be offered. In this method, the project with a greater net present value or the project with less current spending is selected as the optimal plan.

Internal Rate of Return (IRR): Internal rate of return is the discount rate at which the net present value is equal to zero. In other words, it is a discount rate that according to it the present value of benefits will be equal to the costs' present value. If the IRR is greater than or equal to the Minimum Attractive Rate of Return (MARR), the project is economically justified. Otherwise, the project may not economically be justified. The major advantage of this method is to show the real rate of return on investment (Radev, 2003).

Benefit-cost ratio (BC): Benefit-cost ratio is attained by dividing the present value of profits by costs' present value. According to this method, the larger than one the benefit-cost ratio is, the project will be more economically feasible. Otherwise, no economic justification can be offered (Mikesell, 1991).

Modified Internal Rate of Return (MIRR): Modified Internal Rate of Return is defined as the discount rate equating the present value of output cash flows with the present value of input cash flows' final value. The modified internal rate of return has a major benefit compared to the conventional internal rate of return because modified internal rate of return assumes that cash flows with the project capital cost rate are re-invested. Whereas, the internal rate of return assumes that cash flows with the project internal rate of return are re-invested (Stermole, 2001). For calculating the internal rate of return whether from the viewpoint of total investment (IRR) whether from the viewpoint shareholders (IRRE), it is assumed that all costs are borrowing at the same rate on which all income reinvestment rates are reinvested. In other words, for calculating internal rate of return it is assumed that all costs and revenues are discounted at a constant rate .But if due to market conditions, discount rate of costs and discount rate of revenues, be different, each of these two rates should be determined. And accordingly, the calculated internal rate of return is expressed as Modified Internal Rate of Return and Modified Internal Rate of Return on Equity.

RESULTS

Biodiesel plant analysis results regarding private and reduced social costs are classified into two categories. First, the results of analysis from the view point of private sector is investigated and analyzed by comparing to different prices. Then, we investigate the analysis from the view point of social and ecological benefits. The results are provided regarding different scenarios and compared to common prices in order to evaluate the biodiesel production from *Salvia leriifolia*. Finally, the results are utilized to make it obvious for the recommendation for using the fuel in the future.

A. Results of cost - benefit analysis in private sector perspective

Cost - Benefit Analysis has been conducted from the perspective of the private sector in operation phase (20 years and 50 years) and three inflation scenarios including 15 percent that is the average inflation in the last ten years of Iran and inflations of 10% and 20% indicating the country's maximum and minimum inflation. Furthermore, in biodiesel plant analyses, the Cost - Benefit Analysis with Persian Gulf FOB price, Cost - Benefit Analysis of plant with gasoil price available in the country (0.109 USD) with no byproducts at the plant were also conducted. First, all projects' Cost - Benefit Analysis are presented from private sector perspective. In this analysis, internal rate of return (IRR), overall net present value (NPV), Modified Internal Rate of Return (MIRR), Benefit-Cost Ratio (B / C) and payback period (PP) indices are calculated.

Cost - Benefit Analysis of biodiesel production plant at minimum price: The results of cost - benefit private analysis of biodiesel plant construction from perspective of private sector sensitivity analysis to inflation and operation phase (along with by-product) are provided in six different scenarios including net present value and internal rate of return, modified internal rate of return, payback period and the ratio of benefit - cost in Table 12. As shown in Table 12, internal rate of return, and modified internal rate of return are greater than 25 percent. Payback period is about 7 years and means return of investment in less than 7 years. Cost per liter of biodiesel produced by *Salvia leriifolia* depended on the presence and absence of by-products is 0.06 and 0.23 USD, respectively.

Table 12: Results of the private cost – benefit analysis of manufacturing biodiesel plant and sensitivity analysis to inflation and the operation phase.

Scenario of operation phase (year)	20			50		
Inflation scenario (percent)	10	15	20	10	15	20
1) Biodiesel plant with byproducts						
NPV (million USD)	1	31	86	6	53	180
IRR (percent)	25.26	29.51	33.75	26.13	30.58	35.02
MIRR (percent)	25.10	26.81	28.82	25.20	26.19	27.64
Payback period (year)	7.64 (year 2022)	7.41 (year 2022)	7.26 (year 2022)	7.64 (year 2022)	7.41 (year 2022)	7.26 (year 2022)
Benefit-Cost Ratio	1.04	1.10	1.14	1.06	1.12	1.18
Cost price (USD)	0.06	0.06	0.06	0.06	0.06	0.06
2) Biodiesel plant without byproducts						
NPV (million USD)	3	24	62	6	37	120
IRR (percent)	25.77	29.64	33.45	26.37	30.40	34.40
MIRR (percent)	25.25	26.67	28.86	25.21	26.01	27.24
Payback period (year)	6.75 (year 2021)	6.53 (year 2021)	6.35 (year 2021)	6.75 (year 2021)	6.53 (year 2021)	6.35 (year 2021)
Benefit-Cost Ratio	1.04	1.07	1.10	1.05	1.09	1.13
Cost price (USD)	0.23	0.23	0.23	0.23	0.23	0.23

Reference: research findings

(i) The impact of discount rate change on the project net value: The basis of financial analysis is, understanding the meaning of this sentence telling that each anticipated figure for cash flows in future years is equal to an investment with an annual interest rate at the present time. According to what was presented for the time value of money in financial analyses, to eliminate the time factor in the calculations the cash value of the currents that can be achieved in the coming years in the case of the annual interest rate of i that is regarded as the rate of invested profit in a risk-free market will be considered as discount rate. In calculation of financial analysis of plans to predict discount rate, investment in the project is compared to investing in a risk-free method such as investing in bank that has a constant annual profit commonly. To be precise, investing on a project, an investor loses the Opportunity to invest in another project that potentially could increase the value of asset.

Low discount rate will put the project in an unrealistic, seemingly ideal way; on the contrary, the high discount rate may lead the investor to be reluctant to perform projects. The project net value at different discount rates due to the projects assessment sensitivity to discount rate changing was calculated and presented in Table 13.

Table 13: The effect of discount rate on the net present value of the biodiesel plant.

Discount rate (percent)	Net present value (milliard USD)
0	1.223807
10	0.236669
20	0.036121
30	-0.017897
40	-0.035542
50	-0.041695
60	-0.043501
70	-0.043464
80	-0.042598
90	-0.041363
100	-0.039981

Reference: research findings

It can be concluded that discount rate changing significantly influences on the project economic and financial evaluation; and as it is observed increasing discount rate can decrease the net present value so that at the discount rate 30 percent, the net present value is even negative. It is necessary to note that as the discount and inflation rates were considered identical for all the projects any changes in these two parameters may not impact on the comparison result of the studied projects assessment.

(ii) Sensitivity analysis of the project internal rate of return : Sensitivity analysis is referred to examining the project sensitivity over each involved parameter. Sensitivity analysis is the financial calculations repetition by changing basic parameters and comparing the obtained results with the results of the initial data.

In this section, the project's internal rate of return sensitivity index is analyzed. As the internal rate of return is mainly influenced by sales revenue, fixed assets as well as operational costs, each of these three parameters are changed as much as ±20 % compared to the base case and the internal rate of return has been exposed to sensitivity analysis. Sensitivity analysis result observed in the internal rate of return has been calculated on the assumption that by changing each of the three parameters all other parameters will remain fixed.

For biodiesel production plants using *Salvia leriifolia*, any small changes in sales revenue significantly influences the internal rate of return; in other words, this rate is highly sensitive to changes in sales revenue. The same conclusion applies to operating costs. But any change in increase factor of fixed assets influences the internal rate of return less indicating that the rate of internal return is less sensitive to an increase in fixed assets. In Table 14 the impact of changes in sales revenue, operating costs and initial investment of biodiesel plant on the IRR are illustrated.

Table 14: IRR sensitivity analysis resulting from changes of revenues, operating cost, and initial costs.

Changes of IRR (percent)	Sales revenue (percent)	Increase in fixed assets (Percent)	Operating costs (percent)
20-%	7.35	27.84	38.82
16-%	11.32	27.27	36.01
12-%	15.00	26.73	33.25
8-%	18.50	26.22	30.55
4-%	21.19	25.74	27.89
0	25.27	25.27	25.27
4%	28.62	24.83	22.68
8%	31.99	24.41	20.11
12%	35.38	24.01	17.53
16%	38.81	23.62	14.94
20%	42.28	23.25	12.28

Reference: research finding

(iii) Break-even analysis of Biodiesel Production Plant: Since the project evaluation often is considered in conditions of uncertainty and the future is not known, earlier estimates may be mistaken. Final project in any form, its various components should be considered to enhance carefully. Many investment decisions are influenced by many political, social, economic and technological changes, the prices and the availability of production. Therefore to ensure the conducted estimates, break criteria analysis should be performed. In Cost-benefit analysis and economic evaluation of projects, sometimes problems happen in which for one of the parameters sufficient data are not available. The goal may be that the lowest price and quantity to be determined. So that price and value of the project can continue to operate without endangering their financial situation. In such cases, the method used is called breakeven analysis in economic terms. From a technical viewpoint, breakeven point is an important technique applied for studying the relationships between costs, revenue and profit. According to definition, break-even point is a point in which neither profits nor losses caused by operation of the Plan. In other words, breakeven analysis, determines a point at which sales revenue is equal to production costs.

And thus is used to analyze the effect that a change in product volume causes on profit. Break-even analysis reveals the production volume in which sales revenue covers production costs. Production more than break-even point shows locating in the profit area and production below the break-even point indicates locating in losses region. Break-even point implies the project high risk against unforeseen factors. Break-even analysis consists of biodiesel plant financial costs of *Salvia leriifolia* presented.

Break-even point in biodiesel plant with *Salvia leriifolia* is about 15 percent. This means that if the production is about 15 percent of the annual capacity, the break-even point will be obtained at the last year suggesting low risk investment.

Cost - Benefit Analysis with considering the least price of Persian Gulf FOB: To conduct an economic analysis of Persian Gulf FOB, the price of per liter biodiesel was assumed 0.5 USD for the Persian Gulf FOB per ton gasoil is 909.5 USD and each ton of gasoil is equivalent to 1190 liters. The project was economically evaluated in six different scenarios. Table 15 shows the results of Biodiesel Plant Cost - Benefit Analysis in private sector perspective and sensitivity analysis with respect to price and operation phase of the FOB Persian Gulf minimum price. As seen in Table 15, biodiesel plant applying *Salvia leriifolia* regarding the minimum price of FOB Persian Gulf is economic. In addition, the internal rate of return and modified internal rate of return are more than 100% indicating the project high economic benefit. The ratio of biodiesel plant expenditures applying *Salvia leriifolia* to minimum FOB Persian Gulf price is approximately 3.5 representing the project high interest. The payback period for this project due to its high income in operation phase, is low and about 2 years.

Table 15: Results of private Cost – Benefit Analysis of manufacturing Biodiesel and sensitivity analysis with respect to price and operation phases in regard to the minimum price of Persian Gulf FOB (0.5 USD).

Operation phase scenarios (year)	20			50		
Inflation scenarios (percent)	10	15	20	10	15	20
NPV (million USD)	953	1431	2222	1027	1721	3413
IRR (percent)	268.88	285.14	301.41	268.88	285.14	301.41
MIRR (percent)	42.54	44.53	46.81	32.32	33.37	34.88
Benefit-cost ratio	3.39	3.52	3.62	3.43	3.60	3.74
Payback period (year)	2.36 (year 2017)	2.34 (year 2017)	2.33 (year 2017)	2.45 (year 2017)	2.34 (year 2017)	2.33 (year 2017)

Reference: research findings

Table 16: Results of Cost - Benefit Analysis of manufacturing biodiesel plant from the perspective of the private sector in free price gasoil (0.10 USD).

NPV (million USD)	IRR (percent)	MIRR (percent)	Benefit-cost ratio
85	43.05	29.93	1.25

Reference: research findings

Cost - Benefit Analysis of Biodiesel production plant using *Salvia leriifolia* with the price of gasoil in free market: One of the costs - benefit analyses has been conducted with the price of free gasoil; although, these prices in the market are unreal due to subsidies. In Table 16 the results of biodiesel plant construction Cost - Benefit Analysis from private sector perspective are provided in terms of price of free gasoil (0.10 USD). Considering the results of Table 16, in the case that the biodiesel plant final product to be sold out based on available fuel prices in the market, regarded as real prices, more caution must be taken. However, biodiesel plant with *Salvia leriifolia* is economically efficient.

B. Cost - Benefit results from social sector perspective

Since replacing 300 tons of biodiesel with gasoil will approximately cut 37128 thousand USD of social spending, this amount should be included within the social cost-benefit analysis. Therefore, the results of the cost - benefit analysis related to construction of a biodiesel plant are identified from social perspective; and sensitivity analysis toward inflation and operation phase were also determined.

Economic evaluation (cost - benefit social analysis) of biodiesel plant in social sector attitude is much beneficial than the perspective of the private sector. Because such projects, despite little benefits usually bring into the private sector, cause many extra advantages for the entire community. If the social benefits are added to private benefits the cost of per liter of biodiesel can be estimated less than 0.60 USD. In Table 17, the net present value, internal rate of return, benefit-cost ratio and payback period of common capital are socially compared. The high net present value and high internal rate of return reflect the economic feasibility from social perspective. Thus, according to the results, creating a biodiesel plant will lead to great social benefits.

Table 17: Results of Cost - Benefit Analysis of manufacturing biodiesel plant from the perspective of the social sector and sensitivity analysis to inflation and operation phase.

Operation phase scenarios (year)	20			50		
Inflation scenarios (percent)	10	15	20	10	15	20
NPV (million USD)	210	338	548	230	419	889
IRR (percent)	73.27	79.99	86.71	73.27	80	86.72
MIRR (percent)	34.16	36.12	38.36	28.98	30.05	31.57
Benefit-cost ratio	1.56	1.63	1.68	1.58	1.66	1.74

Reference: research findings

CONCLUSION

Given that Salvia leriifolia is an indigenous species in Iran, planting this herb can reduce pressure on extracting fossil fuels followed by a reduction in the country' desertification. In addition, this plant has the ability to grow in low water and warm, hot regions. Planting it in arid areas where constituting area broad range of country's regions makes possible producing a significant amount of biodiesel.

As biodiesel fuel is unknown in Iran, it must overcome regulatory obstacles before entering the market, and its price become more competitive. Biodiesel with the current market is likely to be used as fuel in buses fleet, trucks and heavy vehicles.

This research studied the biodiesel production in a plant with the capacity of 300 thousand tons. Moreover, constructing of the plant was analyzed in economic terms. The results demonstrated that constructing a biodiesel production plant with *Salvia leriifolia* in Iran with the annual capacity of 300 thousand tons, the overall cost of per liter biodiesel will get to 0.06 USD that is even lower than the price of subsidized gasoil in the country.

This plant, in different scenarios of inflation and operation phase, has a positive net present value and the internal rate of return greater than the discount rate which operates as a measure of the Minimum Attractive Rate of Return of investor. Economic evaluation of minimum price of FOB Persian Gulf indicates that the estimated price is lower than Persian Gulf FOB price of gasoil. Additionally, the return period of this plan, with the lowest price is about 7 years and short payback period is another reason to justify the project.

Short payback period in biodiesel production plant with Salvia leriifolia, also in addition to the high ratio of benefit to cost suggested that the project is economically feasible. Economic assessment of biodiesel plant construction with no byproducts of Salvia leriifolia revealed that the overall cost of per liter biodiesel will be 0.23 USD. So, even if there is no possibility of producing byproducts in biodiesel plant, per liter biodiesel price will be much less than Persian Gulf FOB price of gasoil. To obtain an estimate of the investors' interested minimum rate, it has been assumed that MARR is equal to sum of the bank's long-term interest rates which is about 20% along with 5% as the investment risk. Thus, the discount rate was considered 25% in calculations. Given that the project internal rate of return is always more than 25 in various scenarios; thus, manufacturing biodiesel production plant using *Salvia leriifolia* is regarded economic from private point of view.

Nowadays, because of renewability and less polluting properties, biodiesel is known as the best alternative for diesel fuel. Many countries to escape the crisis of declining fossil fuel resources and pollution caused by the use of these fuels have attempted to produce biodiesel through vegetable oils and animal fats.

From a macro perspective (societal perspective), manufacturing a plant with the annual capacity of 300 thousand ton will lead to a reduction of 37 million USD in social expenditures. However, obstacles such as plant financing discourage the private sector. Since, in private sector attitude, social benefits are regarded insignificant; the national industrial projects in developing countries are implemented not due to private sector profit but to the ultimate goal of development; and sometimes the indirect effects of these plans on macroeconomic variables are more considerable than direct impacts. In addition, the effects of employment and foreign exchange savings are also important. However, the benefits are even considerable in private sector perspective. Therefore, it is recommended to encourage the private sector to invest in these projects, necessarily facilities constructing a plant to be provided by the responsible parties or even investors benefited from tax cuts so that the entire community is benefited from implementing such plans.

Construction of the biodiesel plant, using Salvia leriifolia as its raw material, both from the perspective of the private sector, as well as the social sector, is economic. So taking advantage of biodiesel to replace diesel is possible.

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