The Economic Analysis of Biofuel Production: Case Study in Jordan

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Abstract: The world is facing many global challenges, such as sustainable production methods, and adapting to climate change. As a result of the climate change and the developing of the living standard of the people, the pressure on energy and water resource is increasing, and pollution of the air and water as well as the degradation of land are increasing in a tremendous way and will continue to grow. In Jordan, as a poor water country, a low quantity of rainfall, especially in southern Jordan, is a major cause of drought. Consequently, producers will face a bigger productivity drop. Cultivating special plants to produce energy and producing biofuel are considered alternative energy sources. Analysing the use of these alternatives is very complex because the technical issue, environmental, social and economic impact should be assessed. Nevertheless, using scare resources, such as water, and the impact on food security are other variables that should be considered. This study focuses on producing biofuel in an agricultural area from an economic point of view, with specific attention on food and water security as well as the environmental impact. The study depended on a case study that applies planting Jatropha to produce biofuel. As a conclusion the producing oil from Jatropha has high potential to be profitable. Socially and environmentally of producing biofuel from Jatropha is will not be on competition in using the resources with other crops, because it could be planted in marginal land and using low quality water. The growing global demand for liquid biofuel has been seen as a way to create new employment opportunities through the work in the farms or in the biofuel factories, thus leading to increase income generation and rural development, in addition to saving the energy from other sources.

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1- Introduction

Bio-energy is considered as an important alternative for the non-renewable energy. The concerns of bio-energy are increased in the last decade at the global level as results of rising global demand for energy, expected fossil fuel shortages and the impact of fossil energy consumption on our environment. Nevertheless the Energy prices are considered also one of the most important reasons of the increased interest in alternative of energy use. These prices influence the food and agriculture sector in several ways such as creating new markets for those products which can be used as biomass feedstock for the production of biofuel as substitutes for the petroleum-based fuels (petrol, diesel). Bio-energy offers many opportunities, but poses a number of risks such as the change of land use from food to fuel commodities which is increasing food prices and reducing food availability in some regions. FAO agreed that the current expansion of bio-energy production in developing countries presented potential costs as well as benefits; it could compromise food security and result in environmental damage, but also offered significant opportunities for sustainable development and poverty reduction in rural communities (FAO, 2007).

Governments of developed and developing economies are quick to respond to the energy challenge by formulating and putting in place bio-energy policies and programs. Fuel from plant sources, would greatly reduce carbon-dioxide emissions and, for some countries, would also reduce reliance on foreign oil. Many developing countries have already started to produce Jathropha, but still there is a need to assess the negative impacts of this production on the environment.

Biofuel production, despite all the negative affiliations attached to it, should be well evaluated and considered as an alternative to ever increasing oil dependency in all countries that have the potential and infrastructure suitable for biofuel development.

2- Objectives

- To explore the opportunities of Bio-energy practices in the Tropics and Subtropics countries.
- Discussion the experiences of using biofuel in different countries.
- Discussion the impact of using biofuel on land use, water and environment.

- To explore the conditions of planting Jatropha.
- To assess the economics of planting Jatropha in Jordan as a case study.

3- Methodology

The study evaluated the possibility concerning of producing biofuel, the following steps were conducted:

- Discussing biofuel production practices in detail for the selected countries which has a history of biofuel production.
- Analyzing the expected impact of producing biofuel from Jatropha on socio-economic and environment of semi-arid areas.
- Using the Cost-Benefits analysis of a case study of a-biofuel production in semi-arid area.

Detailed information was collected from the institutes about biofuel production in the selected countries. The selection of the countries depended on the experiences of these countries in producing the biofuel such as Brazil and Egypt or it has already the potential to plant crops of biofuel production such as Jordan.

Primary information has been collected directly from farmers, producers and businessmen who are producing bio-fuel. The data of cost benefit analysis has been collected from the research centres from the countries have the experience in this field and meetings key farmers were carried out to discuss the energy production process, cost and benefits. The analysis of all data and information led to a comprehensive view of biofuel use and the potential development which will be discussed below.

4- Experiences of Biofuel production in selected countries

A. Brazil

The two main biofuel in Brazil are ethanol and Biodiesel. The incentive production of ethanol started after the fall of sugar prices in 1975 with the Pro-Alcohol Program (Masiero e Lopes, 2008), which aimed to ensure energy supply as well as to support sugar industry by diversifying production (Kohlhepp, 2010). In 2002, the first flex-fuel engine vehicle which are powered by gasoline, ethanol or a mixture of both, was presented. The model was developed by German companies and mass-produced in Brazil from March 2003. In 2004, 16% of new cars sold in Brazil were already equipped with this engine type and in 2006 the rate reached 76.6%. Currently, Brazil is the second largest producer and consumer of ethanol 35%; about 55% of sugarcane harvest in 4.4 million ha is used to produce ethanol (Xavier, 2007).

Bio-diesel blend is legally established in Brazil since 2008. The rate for Bio-diesel from soybean is around 90% (EMBRAPA, 2008). However the small farmers in the Northeast produce biodiesel from castor bean and from palm oil in the North. Castor bean, with 0.5-0.9 ton oil/ha, and oil palm with 3-6 ton oil/ha yield much more than soybeans, with 0.4 ton oil/ha (MAPA, 2007). First, the required rate of mixture was 2%, which gradually increased to 5% in 2010. On the other hand, it is unclear whether the expected expansion of castor bean planting can be achieved with continuous supply of the required amounts of raw material in the medium term. Moreover, castor oil neither can be used alone in diesel engines because of its high density and viscosity, nor is suitable for biodiesel production (EMBRAPA, 2008, Kohlhepp, 2010). As for the production of biodiesel from soybean, there are both sufficient areas of planting and production quantity available. Due to new seeds, the appropriate conditions for planting in regions with tropical humid ecosystems were well spatially expanded (Kohlhepp, 2007, Kohlhepp, 2010).

B. Egypt

In Egypt, the interest in producing biogas has started in the eighties of the last century by the Ministry of Agriculture through the Agricultural Research Centre. In 1980 Training Centre for Recycling of Agricultural Residues was established and considered as a training centre for biogas technology. In the beginning of this century new stage of using waste has been started in Egypt, in which new units of gas production from plant residues (mainly rice straw), were established. In the beginning of the twenty first century new stage of producing biofuel by using plant residues and cultivated special crops was started in Egypt, in this stage new units of gas production from plant residues were established and the planting of Jatropha took place in Egyptian desert (Majdalawi *et al*., 2012). Egyptian government supports bio-fuel production for several reasons; the most important one is to conserve the environment through using plants residues and the waste of animals. Nevertheless it aimed to plant some kind of crops such as Jatropha in marginal and desert area and using water of low quality to irrigate it.

The production of bio-fuel in Egypt can be divided into the following categories:

- Producing Biogas by using the animals waste
- Producing Biogas by using plants and crops residues.
- Producing biodiesel from Jatropha.

C. Jordan

In the last years, interest to find other alternatives of energy sources in Jordan has increased. Producing bio-gas and solar energy are considered as alternatives to conventional oil. Since 1993 Jordan has adopted a special program for Bio-energy by which a feasibility study for the utilization of Municipal Solid Wastes for electricity generation has been prepared. The first biogas project in Jordan and in the region was established in 1998 and started its production for the first time in 2000 with a capacity of about (1) MW of electricity. This project is owned, operated and maintained by the Jordan Biogas Company (JBCO), and is expanded to (3.5) MW in the year 2010. The biogas plant in Jordan receives daily 60 tons of pure organic waste consists mainly of: slaughter house waste, food waste from restaurants & hotels, the residue of the central market for vegetables, yeast waste water, dairy industry waste water (Abu-Hamatteh *et al*. 2010). The main resources of organic waste in Jordan that can be potentially used to produce biogas are as follows: municipal waste from cities (1.5 million tons per year) mainly from slaughterhouse, vegetable market, hotels and restaurants, organic waste from agricultural and industrial waste including meat-processing industries, animal manure, mainly from cows and chickens, sewage sludge and septic.

In the last few years the interest to cultivate special crops to produce biofuel in Jordan was increased. The National Centre for Research and Extension in Jordan has implemented experiments to plant Jatropha in Jordan. The planting of Jatropha has been started in marginal areas (in Al-Mafreq in which the rainfall is less than 250mm); by planting 10 dunums in this area. The initial results reflect the high potential of planting Jatropha in the marginal areas of Jordan. The economic study of planting and manufacturing the Jatropha is still lacking, in this paper the economic study will be covered (NCARE, 2009).

5- Cultivation and manufacturing of Jatropha

The Jatropha industry is covering a global area estimated at some 900 000 ha; more than 85 percent of Jatropha plantings are in Asia, chiefly Myanmar, India, China and Indonesia. Indonesia is expected to be the largest producer in Asia with 5.2 million ha. Africa accounts for around 12 percent, mostly in Ghana, Madagascar and Zambia, but also in Tanzania and Mozambique. Ghana and Madagascar together will have the largest area in Africa with 1.1 million ha Latin America has approximately 20000 ha of Jatropha, mostly in Brazil. The area planted to Jatropha is projected to grow to 12.8 million ha by 2015 (Gexsi, 2008).

Jatropha, a perennial shrub or small tree, can attain heights of more than 5 metres, depending on the growing conditions. Seedlings generally form a central taproot, four lateral roots and many secondary roots. Thus, they are able to extract minerals that have leached down through the soil profile and return them to the surface through leaf fall, fruit debris and other organic remains. In this way, Jatropha acts as a nutrient pump which helps rehabilitate degraded land (FAO, 2010).

The leaves, arranged alternately on the stem, their size and shape can differ from one variety to another. Jatropha is monoecious, meaning it carries separate male and female flowers on the same plant (Raju and Ezradanum, 2002).Vegetative growth occurs during the rainy season. The plant may reach one meter and flower within five months under good conditions (Heller,1996). It generally takes four to five years to reach maturity eventually reaching a height of 3 to 5 metres under good conditions. The wood of Jatropha is soft and hollow. (Henning, 2008a).

During the dry season, there is little growth and the plant will drop its leaves. Flowering is activated by rainfall and seed will be produced at the end of the rainy season. Seeds are produced in the first or second year of growth. Jatropha trees are believed to have a lifespan of 30 to 50 years or more.

In many tropical and subtropical countries, Jatropha cuttings are planted to protect gardens and fields from wandering animals. Livestock will not eat the mature leaves and even goats will die of starvation if there is only Jatropha to browse (Henning, 2004a).

Jatropha grows in tropical and sub-tropical regions. It also grows in lower altitudes of 0-500 meters above sea level. Jatropha is not sensitive to day length and may flower at any time of the year (Heller, 1996). Jatropha can survive with as little as 250 to 300 mm of annual rainfall, at least 600 mm are needed to flower and set fruit (FACT,2007)

Jatropha trees capable of producing more than 2 tonnes of dry seed per ha in the first year of production with 30 percent seed oil content should be selected as source material. Yield per tree is likely to increase with wider spacing but with a decline in yield per ha.Jatropha is planted at ranging from 1 100 to 2 500 plants per ha (Achten, 2008). Oil quality and consistency are important for producing biodiesel, it is also important when producing Jatropha oil for direct use as a fuel. The physical and chemical content of Jatropha oil can be extremely variable.

Crude Jatropha oil characteristically low in free fatty acids, which improves its storability. The presence of unsaturated fatty acid allows it to remain fluid at lower temperatures. Jatropha oil also has a high cetane (ignition quality) rating. The low sulphur content indicates less harmful sulphur dioxide (S02) exhaust emissions when the oil is used as a fuel. These characteristics make the oil highly suitable for producing biodiesel (FAO, 2010).

6- Negative Impact of planting Jatropha - Economic and environment

The harvesting costs of Jatropha, may prove excessive. The level of economic returns that would attract and retain investment by the private sector may not be attainable on degraded lands. Comparing the returns to labour for Jatropha to other biofuel feedstocks, shows that Jatropha compares poorly to sugarcane and oil palm, but much depends on the level of yield. There is an urgent need to improve Jatropha yields through breeding and by addressing the knowledge gaps in Jatropha feedstock production. Measures should be considered to ensure that value chains of Bioenergy from Jatropha have the means and resources to adapt to emerging opportunities as these new technologies come on stream.

In another side the negative impacts of planting Jatropha on biodiversity are to be expected; where Jatropha cultivation replaces natural ecosystems. To some extent, this may be mitigated by mixed species cropping with other biofuel crops, food or fodder crops, or timber species. Where Jatropha is planted in degraded land, the risk to biodiversity is likely to be small.

Conservation agriculture practices under both extensive and intensive systems can help to optimize input use and offer higher productivities and returns with minimal environmental risks. Nevertheless GHG emissions from Jatropha biofuel will be lower if there are less intensive production systems on marginal lands and if use of nitrogen fertilizer is avoided or kept to a minimum.

Treated wastewater could be used to irrigate this plant. This means the low quality of water which is not suitable to be used for eaten crops will be used to irrigate Jatropha in degraded landed, as a sequence the fresh water and high quality water and not degraded landed will be conserved and used for other crops.

7- Cost –benefit analysis of planting and manufacturing Jatropha- case study Jordan

The National Centre of Agricultural researches and Extension in Jordan has started to plant Jatropha in north-east areas of Jordan (Al-mefraqarea in which the average rainfall is 250-300 mm). The results showed that the potential is very high to produce jatropha in these areas. This paper assesses the producing and manufacturing Jatropha in Jordan depending on the results of experiments in Jordan and other countries such as Egypt. It is still a need to assess the economics of cultivating Jatropha in Jordan. This part of the study assesses the financial analysis of planting Jatropha and using its oil as a bio-fuel. It assumes that the size of the project is 50dunums in Al-Mafreq near a treatment plant –in this case the treated wastewater will be used from this plant. The land of the project is owned by government.

A. Investment and operational Costs

The detail of the investment and operational costs are as follows; (Table.1 summarizes these costs):

1- Investment cost:

- Constructions cost (stores, guard room and rooms for machines) about 20000JD.
- Water Tanks cost (2*100m^3*20) about 4000JD.
- Oil Production Line-Fotma 204-3 costs 21500JD.

2- Operational cost:

- Plants of Jatropha (150 plant per dunum*50 dunum*0.4 JD) cost 3000JD.
- Salaries:
  - Permanent workers (1*3000JDper year) 3000JD.
  - Temporary workers (100 man/ day *12JD per day) 1200 JD.
- Fertilizer 500JD
- Maintenance costs 500 JD.
- Bottling of the oil (in the third and fourth year) 9800 *0.1 = 980, after the fourth year 24450* 0.1) costs 2445 JD.

B. Total revenue

The detail of the expected revenue is as follows:

- The expected production of dry seed and the pruning residuals per tree is 4kg in the third and fourth year and after that it reaches 10Kg(Foreign trade Ministry, 2011).
- The expected production of seed oil per dunum is 600*30%(percent of seed oil in dry seed)/0.92kg/L (density of the Jatropha oil)= 196 L in third and fourth year then it reaches 2000*0.3*/0.92=489L.
- The total production in the third and fourth year= 196*50= 9800L.
- The total revenue for the third and fourth year=9800*0.6JD/L= 5880JD.
- The total production after the fourth year= 489*50= 24450L.
- The total revenue after the fourth year=24450*0.6JD/L= 14670 JD.

Table 1: the Investment and Operational cost and Total and net Return

	Investment cost	Operational cost	Total cost	Total Return	Net Return
First year	45500	8200	53700	0	-53700
Second year		6180	6180	5880	-300
Third year		6180	6180	5880	-300
5th -24th year		7645	7645	14670	7025
25th year		7645	7645	34670	27025

C. The results of the analysis

The Benefit -Cost ratio, Net present worth and Internal Rate of Return (IRR) have been estimated in this analysis.

Benefit –Cost ratio measure is rarely used in the financial analysis of projects, but it is often used in the economic analysis. This measure represents the present value of total benefits divided by the present value of total costs at a discount rate, which is fixed in this research at 8%. This discount rate reflects the opportunity costs for capital investment by government in the society.

The net present worth can be found by subtracting the present value of the total costs from the present value of the total benefits at a specified discount rate which usually represents the opportunity costs for capital investments. The same discount rate of Benefit –Cost ratio is used-which is fixed at 8%.

IRR represents the discount rate at which the net present worth is equal to zero or it is the discount rate at which the present worth of total benefits is equal to the present worth of total costs in the all period of the project.

The results show that

- The Benefit -Cost ratio is 1.08 which is more than one; it means that the present value of the total return is more than the present value of the cost at 8% discount rate.
- The Net present worth (NPW) is positive and its value is 9589 JD at 8% discount rate.
- IRR is 10% which is more than the opportunity cost.

All the previous results show that the project of planting Jatropha is profitable and the net return of the project is more than the opportunity cost.

The other benefits of this project are the opportunities of jobs and saving the energy from other sources. The benefit will be greater if the government apply this project in other areas near the treatment plants in Jordan which are 29 plants. In this case; If the government establish the same project with the same area -only 50 dunums- then the government will provide more than 50 opportunities of permanent job and more than 2500 working days per year as a temporary work. In addition to the social benefit the project will produce about 750000 L of oil yearly; it means saving the quantity of oil from other sources especially that Jordan is not an oil production country. Economically, as the size of the project increases as the economic benefits increase (economies of scale), in case of establishing the same project in other areas, the profitability of the project will be more.

The low of quality of water will be used in this project and there is no need to use the high quality. It means the project will reduce the cost of treating wastewater and at the same time it will reduce the negative impact of using this water for other crops (especially the illegal use).

Conclusions and Recommendations

As a conclusion the project of planting Jatropha is acceptable from the economic point of view, producing oil from Jatropha has high potential to be profitable; the results of the financial analysis of the case study of planting Jatropha in Jordan show the project is profitable.

Socially and environmentally of producing biofuel has advantages and disadvantages. The advantage of planting Jatropha is mainly that Jatropha will not be on competition in using the resources with other crops, because It could be planted in marginal land and using low quality water. At the same time the using of the marginal land could affect the rangeland area which is an important resource in most Arab countries in view of its social.

The growing global demand for liquid biofuels has been seen as a way to create new employment opportunities through the work in the farms or in the biofuel factories, thus leading to increase in income generation and rural development, in addition to saving the energy from other sources.

Different suggestions have been obtained from the analysis of producing biofuel from Jatropha, the most important suggestions are:

1. Research programs are needed to evaluate alternative crops for their suitability such as Jojoba, which economically could be better than the

   Jatropha and it consumes less quantity of water.
2. Establishing units for oil production from Jatropha or other alternative will encourage people to feel the advantages of biofuel production and they will establish their own units.
3. Establishing and extending the planting of Jatropha in marginal land and desert areas.
4. Implementing training courses in the field of biofuel production.
5. Conducting research to determine the best economic alternatives to produce biofuel and establishing markets for biofuel production and trading.
6. Conducting research to determine the other benefit or cost of produce biofuel from the environment and social point of view.

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