ISSN 2229-5518

Economic and Energy Balances of Jatropha Production in Tanzania: A Case of Monduli and Mpanda Districts

Leonard Kiwelu (Corresponding author)

Abstract

The increase in the use of fossil fuels has led to an increase in Green House Gas (GHG) emissions which are believed to be the main reason for global warming. The world is now encouraged to use bioenergy as a solution in reducing GHG emission from fossil fuels. Jatropha has received much interest as a feedstock for biofuel production because of its minimal adverse effects on the environment and food supply. This crop is now cultivated and processed at both Engaruka and Mpanda study sites as alternative source of energy and income. Jatropha cultivation has economic and environmental impact due to its various products such as seeds and its effects on land use change. Despite the production of the crop in the country, there are no studies which have examined in details its economic and environmental impacts. This makes the assessment of the economic and environmental impact of jatropha production in Tanzania using Life Cycle Assessment approach necessary. The objectives under study include describing jatropha based products, to assess economic benefit of jatropha production to small scale farmers. The findings show that farmers get profit for high yield scenario 135 TZS/kg per metre. Also oil processing using hand press and oil expeller show positive economic return of 1 200 and 1 421 TZS/litre respectively. The environmental performance of jatropha is high due to low input application in the cultivation stage.

Keywords: Jatropha, Bio fuel, Life cycle, Economic, Environment

1. Introduction

The increase in the use of fossil fuels has led to an increase in Green House Gases (GHG) emissions which are believed to be the main reason for global warming. In addition to increased GHG emission, the increased use of fossil fuel and the fact that the stock for such fuels is limited has led to rapid increase in their prices. High prices for fossil fuels, affect the performance of the economies of countries such as Tanzania which depend entirely on imports for their oil needs. Literature shows that Tanzania is among the countries with no known oil reserves (CIA, 2008). In 2007 about 1.5 billion US$ which was an increase of over 30% compared to 2006 was spent by the country to import oil (BoT, 2008). The 2007 spending on oil imports was equal to 40% of the country total export earnings. This share was likely to increase in 2008 due to continuous hikes of world oil prices. The ever-aggravating situation made the Tanzanian government think about the possibility of displacing fossil fuels with liquid biofuels (Philip, 2007).

The dependence on imported fossil fuel affect national gross domestic Product (GDP) and hence pull down government strategy on eradicating poverty in rural area. Biodiesel was the alternative source of energy emphasized by Intergovernmental Panel on Climate Change (IPCC) presented in 2007 as cited by Philip (2007) that has less negative environmental impact and has positive economic contribution to small scale farmers. Among the important renewable or biofuels is bioethanol which is produced from conversion of starch or sugar-rich biomass like sugar cane, maize and other cereals feedstocks. Also biodiesel which is extracted vegetable plant oils (jatropha, oil palm and rapeseed) after a process of esterification.

Jatropha *curcas L.* as a feedstock for biodiesel production has received much attention in recent years due to its potential to contribute to the reduction of greenhouse gases (GHG). Ndong *et al.* (2009) undertook an LCA with West African conditions that shows that the use of biodiesel leads to 72% savings in GHG emissions compared with conventional diesel fuel. Also jatropha plant has ability to grow in areas with low moisture means it can be produced in semi-arid and arid regions (Francis *et al.*, 2005, Jongschaap *et al.*, 2007). Due to its ability to grow on marginal lands and degraded soils jatropha is often thought of as not competing for land with food crops (CRFA, 2006 and Philip, 2007).

Jatropha plant products (oil and press cake) save as alternative source of energy like electricity generation using strait jatropha oil (SJO) instead of using fossil energy to run the generator. The oil can also be used for lighting while press cake can be used as charcoal for cooking, raw material for biogas production or as fertilizer. Reinhardt, (2007) comment that for jatropha to have positive impact to the environment, press cake should be used effectively. From 2008, Tanzania Ministry of Agriculture Food Security and Cooperatives started to create awareness at all levels (farmers, private sector and government institutions) and identifying potential crops for biodiesel production. Jatropha is one of the crops that have been earmarked for promotion by the Ministry (TGPB, 2009).

Monduli and Mpanda are among the districts growing jatropha in plots and hedge farming systems respectively. Also the market of jatropha seeds and its related products as different companies working in these area buy them. Although the market is available and the use of the crop as a source of energy is generally known to reduce GHGs, it is important to estimate the economic and environmental impacts of producing and using the crop in the country as they differ from one country to another due to differences in cots for utilities and the production technology. Therefore, the scope of this study is to assess the economic benefits, and Green House Gas (GHG) emissions in the value chain of jatropha cultivation to end uses

1.1 ***M**ethodology*

This study uses primary data drawn from a sample of 260 household in Monduli and Mpanda districts. The two districts are the main grower of jatropha crop in different farming system (Fence and Plot) and propagation method such as cutting and seedling. The study compares different farming systems (plot and fence) based on land use change and use of husk material as manure or fertilizer. Also the study compare different processing technology found in the study area based on the use of main product (jatropha oil) produced and co-product (press cake) obtained. Likewise the study compares electricity production using jatropha oil by considering diesel engine and alternator. Energy input and output was measured based on jatropha oil where with fossil fuel as a reference point. Jatropha soap production was also compared with medicated soap production.

Descriptive statistical analysis was used to describe the socio economic characteristic such as age, sex, marital status, education level and household size in the study area. The study also assessed the economic impact of Jatropha cultivation to small scale farmers. Data were collected on the cost factors for the cultivation and on the returns from selling the seeds. These data were entered into a MS Excel sheet to sum up the discounted costs and benefits for every single year up to the tenth year where the study assume constant yield to its lifespan 45 years. This data then built the foundation for the calculation of four economic indicators parameters used included net benefit (NB) which is calculated as the remaining profit after subtracting all costs that incurred within one period from the value of all products produced within the same period. Net present value (NPV) presents today's value of the whole investment summing up. Also internal rate of return (IRR) was assessed as an indicator of the efficiency of an investment.

3. Results and Discussion

3.1 Socio-economic Characteristics of the Household Heads

The results in Table 1 show that average age of jatropha farmers were 41 years while non jatropha farmers were 39 years with total average of 40 years at both study sites. Total sample size of interviewed farmers was 240 of which 60% are males and 40% are females. The study found that, 88.8% of respondent were married while 9.2% and 1.9% were single and widowed respectively. The average household size was 8 with Engaruka having 7 and Mpanda 7 which is closely related to the data presented in URT (2002). Majority 68.5% of respondent had primary education while 1.9% had secondary level and 2.3% had adult education level followed by 27.3% of respondent that had no formal education. These findings are similar to those of the assessment of agricultural marketing information needs study URT (2005) which found that there was large numbers of farmers with primary education and above which implies that introduction of new technologies including jatropha crop as alternative source of income was easy because majority of respondents have formal education.

3.1.1 Agricultural activities in the study area

For most rural households animal keeping and crop farming are the dominant economic activities. Results provided in Table 2 show that 20% of respondents deal with crop production only while 80% deals with crop farming and animal keeping. It was reported (by respondents) that jatropha farmers grow this new crop to increase their incomes. Results provided in Table 3 show that 89.2 % of jatropha farmers do both crop and livestock keeping compared to 70.8 % of respondent who do not grow the crop.

3.1.2 Main crop grown at Mpanda and Engaruka

Table 3 describes types of crops cultivated by households in the study area. Majority of households cultivate more than one crop. Maize is the dominant crop at both study sites. Jatropha as a new crop is intercropped with food crops such as maize similar observation was reported by Loos (2008) and Wahl *et al.* (2009).

3.1.3 Type of livestock kept by respondents

Results in Table 4 show different types of livestock kept in the study area. The results show that at Engaruka the average number of cattle was 10 heads per household. On the other hand in Mpanda there was an average of 25 herds of cattle kept per household. The average number of cattle at Engaruka was small due to long drought of 2007 to 2009 that led massive death of cattle due to lack of grasses. Other types of livestock kept include goat, sheep and poultry. There are also other important animal kept in both study sites.

3.2 Description of Jatropha Based Products at Monduli and Mpanda

3.2.1 Jatropha cultivation in Tanzania

The results show that, jatropha is cultivated in two main farming systems that is fence and plot at Engaruka and Mpanda respectively. The propagation method used to plant this crop differed at the study sites. It was observed that, at Engaruka they use cuttings which are obtained from the older trees while at Mpanda they use seedlings which are distributed by PROKON. Planting space used in fence was not clearly known but at Mpanda a spacing of 3m x 3m is used. Messemaker (2008) report a plant space of 2.5m x 3m at Kikuletwa farm in Moshi. Also the study observes that cultivation of jatropha in the study area use both family labour and hired labour. Apart from long drought that occur at Engaruka since 2007 and affect other types of food crops and animal, jatropha crop produce fruit all the years while no irrigation is used in this crop.

3.2.2 Land use change due to jatropha cultivation in Tanzania

Table 5 indicates that land at Mpanda was transformed from crop land, non-cropland and bush land to give a chance for jatropha cultivation. About 88.6% of land used for jatropha production was previously used for crop production while 5.8% was formerly bush land, 4.3% and 1.4% of farmers use land that was previously grass land and forest respectively. These findings support the result reported by Loos (2008) on the level in which the new crop "jatropha" influence land use change in the area. Due to these results the study focuses on the CO_2 impact due to land use change as comparing with the potential natural vegetation as a baseline. That areas getting transformed by man (land transformations) as well as areas forced to maintain their current non-natural state (land occupations) may store reduced amounts of carbon in soil and vegetation, whereby the mobilized carbon is essentially transferred to the atmosphere in form of CO_2, contributing to global warming. Results Table 6 show that on average per hectare basis, no impact that are observed at Engaruka due to land use change because there is no any impact on land use while at Mpanda results obtained after the calculation using GWP500a and GWP100a show a total of 0.1 and 0.2 CO_2 kg/kg DJS as impact due to land transformation respectively. Likewise the result show that land occupation has positive impact in case of Engaruka where a total of 0.1 and 0.3 CO_2 kg/ kg DJS was obtained using GWP500a and GWP100a respectively. But in case of Mpanda only at GWP100a where a positive 0.1 CO_2 kg/kg DJS impact was observed due to land occupation by jatropha crop.

3.2.3 Jatropha farming systems in Tanzania

The study also assesses farming systems used by farmers for jatropha cultivation. The results show that all farmers in Engaruka cultivate jatropha in fence. Also in case of Mpanda the farmers use different farming systems for jatropha cultivation. Result provided in Table 7 show that majority of farmer intercrop jatropha with other perennial crops. These findings are similar to those of Wahl (2009) where the study observed that jatropha was almost always intercropped with other crops and due to this the cost of farming activities including land preparation and weeding decrease.

3.2.4 Type of crop intercropped with jatropha

The study also tried to identify the crops which are intercropped with jatropha in the study area so as to project the impact on food security if intercropping will end after jatropha canopy increase and hence hinder the production of other crops. The results in Table 8 show that majority of farmers 82% intercrop jatropha with maize. Mpanda is among the main maize producing area in Tanzania. Maize is sometimes considered as cash crop and also food crop to majority of farmers in the study area. The situation of food security to majority of farmers who intercrop maize with jatropha after five years will be in a problem if there is no other alternative land for food crop production.

3.2.5 Pesticide application in jatropha cultivation

Pests and diseases was the main problem that farmers at both study sites face. About 95% and 92.9% of the farmers interviewed at Engaruka and Mpanda report a problem of pests that affect, similar problem was reported by Loos (2008) at Mpanda where about 75% of farmers claim retain jatropha was affected by diseases such as red beetle and leaf spotting. The type of pesticide applied by farmer includes Deltra 600 liters and 187 liters of Bayfidan (*Triadimenol)* which are applied in total land of 187.21 ha. The cost of Deltra was 17 500 TZS/L Bayfidan (*Triadimenol)* cost 22 500 TZS/L (personal communication with PROKON agricultural office). Public transport (passenger bus) and motorcycle of PROKON extension officers were used to transport farming inputs from store to farmers at Mpanda as indicated in Table 9.

3.2.6 Fertilizer application in jatropha cultivation

The results show that none of jatropha farmers use chemical fertilizer or manure, apply irrigation and use of machine such as tractor in jatropha farm or fence. Results show that about 33.3%

of farmers use plough and 66.7% use hand hoe in farming activities at Engaruka while at Mpanda only 7% of farmer use plough and 93% use hand hoe in farming activities. In the focus group discussion conducted in the study area reported that jatropha grow well in the study area without the application of fertilizer or the need of irrigating the crop. It is well documented that the application of chemical fertilizer and use of machine like tractor in farming activities contributes much in GHG emission Whitaker (2009).

3.2.7 Labour cost for jatropha cultivation

Labour is the most important variable under economic analysis for jatropha cultivation. The results show that majority of farmers 90.8% use family labour in farming activities including land preparation, planting, weeding also pruning and harvesting. Only 9.2% of reported to use hired labour. The average variable cost for different farming activities in Table 10 were collected directly from farmers. Wiskerke (2008) in his study on assessing the labour used in different jatropha farming activities founds that jatropha harvesting and marketing consume more labour than other activities. In case of Tanzania since farmers not yet take jatropha farming to be a serious economic activity the cost of production are still low because the crop is mainly used to intercrop with other crop.

3.2.8 Yield from jatropha plant

The results Table 11 show that base on questionnaire the average yield of jatropha tree from Engaruka with 1, 2 to 3 years old were 0.43, 0.46 and 0.5 kg/ meter fence respectively while the yield of matured jatropha tree with 4, 5 and 6 years old yield were 0.51, 0.56 and 0.67 kg/ meter fence respectively. Results reported by FAO (2010) on yield of jatropha per tree range from 0.2 to 2 kg/metre, also the findings reported by Byiringiro (1995) on jatropha yield was 0.8 to 1 kg of seed per metre of hedge per year and Jongschaap *et al.* (2007) report a yield of 1.5 to 7.8 t/ha. All these findings (Byiringiro, 1995, Jongschaap *et al.*, 2007 and FAO, 2010) show that the yield obtained in the study area is low.

Results at Mpanda show that, the yield from tree with 1 to 3 years old was 0.006 kg/m^2 which were similar to average yield data of jatropha of tree with 4 to 5 years old. These give the average yield of 0.006 kg/m^2 which are all yield figures harvested by farmers and not potential yields since the plants produce more than shown in Table 11. The low yield in the study area can be attributed to the fact that companies which buy the seeds pay very low price which discourage farmers from harvesting all seeds and hence leading to underestimation of the yield.

3.2.9Jatropha yield scenario

In order to account for the high uncertainty of yield figures and to assess optimization potentials, three yield scenarios are used within this study. *Low yield scenario***:** The low yield figures considered in this section is the average yield over the whole lifespan of 20 years resulting from the house hold survey. *High yield scenario***:** This is another scenario considered in this study. The high medium yield is obtained from studies conducted different similar climatic condition. With this respect the study conducted Messemaker (2008) and Achten (2008) documented a yield of 1 kg/ tree in case of Mpanda. *Medium yield***:** This study considers the average yield of low and high yield scenario as presented in Table 12.

3.3 Processing of jatropha oil using different technologies

After farmer harvest jatropha seeds they sell the seed to the processing companies for further value addition. The function unit (FU) of oil pressing used in this study was 1 kg of Straight jatropha Oil (SJO) at the plant. Two main types of technologies are used in the study site for jatropha oil processing. These are oil press using oil expeller and oil press using hand press machine. These technologies were also reported by Beeren (2007).

3.3.1 Processing jatropha oil using oil expelling or screw press machine

Oil pressing using oil expeller was used by DILIGENT Company. The capacity of this technology used by this company is 75 kg of jatropha oil per hour. This machine have a life span of 10 years equivalent to 29 200 h of operation. The efficiency of oil expeller technology is 86% where 1 kg of jatropha oil and 3 kg of press cake is obtained from pressing 4 kg of dry jatropha seeds. The oil content of jatropha seed is 35% which has a density of 0.918 kg/l. After oil being produced is then cleared before further uses by using different technologies including press filter and candle filter. The clean jatropha oil is transported by truck from Arusha to Mombasa and shipped to Europe. Oil cleaning is another important process used to ensure oil quality. Press filter and candle filter are the main types of filter used by DILIGENT Company to clean raw jatropha oil. Press filter composes with multiple filter plates that are sheathed with filter cloth. From 30 litre of raw oil give 25 litre of clean oil after filtering

3.3.2 Jatropha processing using hand press machine

Hand press machine and gravity filter are the most appropriate technologies used by small scale jatropha oil processors because they are cheap and simple to operate. According to data collected from JPTL, KAKUTE and DISAT, efficiency of hand press technology is 71.4% and its capacity is to press 3 kg/h. five kilogramme of jatropha seeds produce 1 kg of Jatropha oil and 4 kg of press cake. After oil settle for 4 to 7 days, the oil is filtered by using cloth (cotton) filter with capacity of filtering 20 l/h and efficiency 80%. The filtration system composes plastic material (Bucket and plastic pipe) and cotton cloth material. The lifespan of the hand press machine is 14 600 hrs where 43 800 kg of oil from 219 000 kg of seeds is produced. KAKUTE (2006) and Jatropha Handbook (2009) reported similar findings on oil pressing using hand press machine.

3.3.3 Cost for jatropha oil pressing and equipment used

3.3.3.1 Labour cost for jatropha oil processing

The data collected at DILIGENT and JPTL company indicate that, the average wage paid for hand press machine operator is 5 000 TZS/day where 1 person is employed to run the machine and 1 watchman who paid 25 00TZS/day. Under oil expeller 2 persons are employed to operate the machine where each is paid 10 000 TZS/day and 4 casual labourers are used to carry different activities in the industry where the average wage for each is 3 500 TZS/day. In both processing technologies the average working hour was 8 where 24 kg/day and 600 kg/day of jatropha oil is produced using hand press machine and oil expeller respectively.

3.3.3.2 Seed transportation

The seed are transported from the study site to processing plant using passenger bus. The study considers Engaruka as a case study because the data on seed transportation were obtained from this area. The distance from Engaruka to Arusha town is 150 km. The bus fare charged in transporting 1 bag of jatropha seed with 65 kg was TZS 3 500 where the cost of loading and off-loading was 200 TZS each.

3.3.3.3 Cost of equipment or machine in TZS with capacity

In the interview carried by this study with DILIGENT Company in 2010 find that, the cost of press machine TZS 3.5 Million, cost of press filter is TZS 1.5 Million and cost of candle filter is TZS 1 Million. These costs are closely similar to the cost presented by Ferchau (2000) on different equipment required in oil pressing. Oil expeller use 22 kWh of electricity and 1 kWh cost TZS 129 equivalent to TZS 8 286 960 per year. Likewise data collected from KAKUTE, JPTL and DISART indicate that cost of hand press machine was TZS 250 000, cost of gravity filter 10 000 TZS which need to be renewed frequently at least once per month so the cost per year was TZS 120 000. Other equipment including oil container cost TZS 10 000 per year, dry wood where the machine is fixed cost TZS 20 000.

3.3.3.4 Jatropha soap production using jatropha oil

The study considers a function unit (FU) of 1 kg of jatropha soap, at the market. The data collected from KAKUTE, JPTL, and DISAT show that 1 litre of jatropha oil yield 1.08 kg of jatropha soap equivalent to 12 pieces of jatropha soap with 90 gm. The price of one piece of soap is TZS 1 000 which is three times higher compared to most medicated soaps in the market. The inputs required to produce 12 pieces of soap includes 1 kg of jatropha oil, mixed with water 0.5 litre (tap water) and 0.4 litre of pure NaOH (sodium hydroxide). The soap processors company also report that 1 person whose wage is 5 000 TZS/day make jatropha soap using 20 litres of jatropha oil per day. This implies that in processing 1 kg of jatropha soap require 0.4 man-days. Soap is transported to the market using passenger buses in average distance of 800 km from Arusha to Dar es Salaam or Mpanda to Mbeya. Jatropha soap substitutes other medicated soap in the market

3.3.3.5 Electricity generation using jatropha oil at Engaruka

The function unit defined in this section is 1 kWh electrical energy at Engaruka. The study find that, MFP Engine with capacity of 7.35 kWh and efficiency of 34% runs using 0.8 kg SVO per MJ of energy consumption equivalent to 6.4% efficiency. Also the alternator with 79% efficiency and capacity of 7.5 KVA produce 50 megawatts electricity which is enough for 50 households. The alternator has lifespan of 50 years with capacity of operating 73 000 h/lifespan. The cost of the MFP technology TZS 3.2 Million for press machine, TZS 1.8 million filter press and TZS 1 million for adoption engine while the cost of oil storage was TZS 0.12 million and TZS 2.5 Million for seed storage. These cost were also presented by Wijgerse (2007) in his study on jatropha for rural electrification in Tanzania; a case of Engaruka. Machine alternator and all other facilities were transported using truck from Morogoro to Engaruka with assumed distance 800 km. An average 1 person can manage to run MFP where the average wage paid was 100 000TZS per month where the average working hours were 7 hour per day.

3.3.3.6 Charcoal production from jatropha press cake

The press cake contains still 25 MJ/kg and thus is suitable for use as a source of energy. In the briquetting machine the cake is pressed in order to increase the density. Due to the lack of information, the same energy consumption (68 kWh/t of produced briquettes) for briquetting was assumed as reported in Thailand where similar technology is used (http://www.retsasia.ait.ac.th/Publications). The cost of this technology figure 7 according to DILIGENT Company is TZS 2.5 Million. Retort technology used by DILIGENT Company has an efficiency of 60% for press cake after the briquetting process as compared to 35% to 45% for wood residuals because of less compatibility of the residual. Also the result shows that 1.67 kg of briquette yield 1 kg of charcoal and 3.6 kg of wood yield 1 kg of charcoal. Similar findings were reported by Reumerman (2002). The price of charcoal from press cake was

400 TZS/kg which was similar to wood charcoal 400 TZS/kg. The optimization of press cake as source of energy increase economic value of Jatropha products and save the environment. Figure 8 shows the charcoal obtained from press cake and wood material respectively. In average 1 person is enough to make charcoal using retort technology. Since this type of technology is not yet adopted in the country the cost for labour was not captured in this study.

3.3.3.7 Press cake from jatropha seed used as fertilizer

Jatropha press cake as a source of fertilizer was assessed based on a function unit (FU) which was 1 kg of press cake. The study found that jatropha press cake materials are used as fertilizer at the processing companies (JPTL, KAKUTE DILIGENT) in their surrounding flower gardening. The nutrient content of jatropha press cake per kilogramme includes N 0.022 kg, P is 0.083 kg and K is 0.1 kg where cow manure contains N 0.038 kg, P is 0.051 kg and K is 0.015 kg (Jongshaap *et al.*, 2007). Therefore press cake can be used as a substitute for cow manure.

3.4 Economic Benefit of Jatropha Production to Small Scale Farmers and Jatropha oil Processors in Tanzania

3.4.1 Net benefit obtained from jatropha cultivation per kg of seed produced

The average price of jatropha seed in the study area was 200 TZS/kg. The results in Table 13 indicate that the net benefit obtained by farmers from jatropha cultivation were positive for high yield scenario and negative for low yield scenario at both study sites. Only Engaruka show positive net income at medium yield scenario. The results are similar to those obtained by the study conducted by Wahl (2009) in jatropha production in north Tanzania, the low yield scenario found to have negative net income under plot cultivation while the medium and high yield scenario reported to have positive net income. These results prove that if good farming management will be practiced by farmers they will earn more than the current situation. The average cost of producing 1 kg of jatropha seeds was 55 TZS/kg at Engaruka while at Mpanda the cost was 94 TZS/kg. The different in cost was due to different farming system. At Mpanda farmers cultivate in plot while at Engaruka farmers cultivate in fence which is less cost.

3.4.2 Net present value and internal rate of return of jatropha cultivation in different farming systems

Also the study assesses economic viability of jatropha cultivation for different farming systems in Tanzania by focusing on net present value and internal rate of return. Table 14 shows that, under fence cultivation low and medium yield scenarios give negative net present value (NPV) at Engaruka and Mpanda while positive NPV was obtained in high yield scenario. In comparing the efficiency of the two farming system internal rate of return (IRR) was considered. The results show that, at both study sites IRR under high yield scenario is greater than the discounting rate of 13.1% while the remaining scenarios IRR were less than the discounting rate mentioned above. This implies that the investment of jatropha is economically viable for high yield scenario only in both farming systems.

3.4.3 Economic analysis of oil pressing using oil expeller and hand press

3.4.3.1 Net income obtained from oil pressing using different technologies

The results for oil pressing using hand press and oil expeller technology show a positive net income of 1 200 TZS/litre and 1 421 TZS/litre of jatropha oil produced using hand press machine and oil expeller respectively from the second year after investment. The average cost of producing 1 litre of jatropha oil was TZS 1 300 and 1079 TZS for hand press and oil expeller respectively. In Tanzania the market price of jatropha oil is 2 500 TZS/litre which is high compared with the price of fossil diesel 1 600 TZS/l at Arusha filling station.

3.4.3.2 Net present value and internal rate of return of oil pressing

Results in Table 4.18 show the net present value (NPV) and internal rate of return (IRR) obtained as a result of processing and selling of jatropha oil using hand press machine and oil expeller. This analysis base on lifespan of the technology used (five years for hand press machine and ten years for oil expeller). The results indicate that, both technologies are economically viable for investment because NPV are positive for both technologies and IRR are greater than the discount rate used in this study of 13.1% for both technologies

4. Conclusion and Recommendations

In principle, jatropha has a significant environmental and economic potential to all players in the production chain. Regardless of the type of farming system applied in jatropha cultivation the economic benefit will be realized to farmers under high yield scenario. There was poor performance of jatropha in the country compared to other countries which grow the crop; this is mainly caused by low input application. Cultivation of jatropha diversifies sources of income to small scale farmers and creating jobs and income in the study area. Thus it is plausible to conclude that with proper management the yield for the crop can increase significantly. But the most important thing for investing in jatropha cultivation and processing is the financial sustainability to all players in the jatropha value chain. Small scale farmers are usually paid per kilogram of delivered seed, the result in the yield chapter indicate that farmer get low yield which reflect less return from selling seeds. Therefore, instead of farmers depend on selling seeds, they can make a profit out of pressing jatropha oil and make different jatropha based products such as jatropha soap and use for electricity production via MFP. Likewise, the cultivation of jatropha as living fence shows high economic return than plot cultivation. Therefore, there is possibility of increase income hence contributes into poverty alleviation under fence cultivation because there will be no competition with food crops as compared with intercrop and monoculture farming system. In case of Mpanda the study recommends that evaluation should be given to farmers so as they can use this crop for generating enough income by pressing and making different jatropha based products. Finally, large investors that encourage monoculture cultivation should be discouraged by the government by developing strong policy that guide the investment in this sector so as to reduce risk associated with social (food security and household livelihood) or environmental impact.

References

Achten, W., Muys, B., Mathijs, E., Singh, E. and Verchot, V.P.L. (2008). Life Cycle Assessment of Bioenergy from jatropha *curcas L*. Energy Balance, Impact on Global Warming, Land Use Impact, International Conference on LCA in Foods Edition. 5th Location, Götheborg, Sweden. 25-26th April, Division Forest, Nature and Landscape Research and Division Agricultural and Food Economics. 283-291pp.

Beerens, P. (2007). Screw-pressing of Jatropha seeds for Energyling Purposes in Less Developed Countries. Sustainable Energy Technology. Eindhoven, Netherlands. 11-50pp.

BoT (2008). Monetary Policy Statement – The Midterm Review. [http://www.bottz. org/Publications/MonetaryPolicyStatements/2008_Jan_MPS.pdf] site visited on 2/11/ 2009.

Byiringiro, F.U. (1995). Determinants of Farm Productivity and the Size Productivity Relationship Under Land Constraints: The case of Rwanda, Michigan State University in Partial Fulfillment of the Requirements for the Degree of Master of Science. 50pp. [http://ageconsearch.umn.edu/bitstream] site visited 17/5/2010.

CIA (2008). *The 2008 World Factbook*. Tanzania. [https://www.cia.gov/library/publications/the-world-factbook/geos/tz.html] site visited on 2/11/2009.

CRFA (2006). Biodiesels Around the World. [http://www.greenenergys.org/Biodiesel] site visited 3/10/2009.

FAO (2010). Integrated Crop Management 8-2010. Jatropha. A Smallholder Bioenergy Crop. The Potential for Pro-Poor Development. Food and Agriculture Organization of the United Nations, Rome. 90pp.

Ferchau, E. (2000). Equipment for Decentralized Cold Pressing of Oil Seeds. Folkecenter for Renewable Energy. 11-59 pp.

Francis, G. E. R. and Becker, K. (2005). A Concept for Simultaneous Wasteland Reclamation, Energy Production, and Socio-economic Development in Degraded Areas in India. Need, Potential and Perspectives of *Jatropha* Plantations. Natural Resources Forum.12–24pp.

Jatropha Handbook (2009). Oil Pressing and Purification 2nd Edition. 4-23pp.

Jongschaap, R.E.E, Corre W.J., Bindaraban P.S., and Brandenburg, W.A. (2007). Claims and Facts on Jatropha curcas L. Global Jatropha curcas Evaluation, Breeding and Propagation Programme. Plant Research International Wageninen UR. Stichting Het Groene Woudt, Laren Report 158. 16pp.

KAKUTE (2006). Jatropha Project in Monduli District, Arusha Region. [http://xborderbiodiversity. tripod.com/kakute.htm] site visited 17/6/2010.

Loos, T. (2008). Socio-economic Impact of a Jatropha-Project on Smallholder Farmers in Mpanda, Tanzania. Master thesis at University of Hohenheim, Institute for Agricultural Economics and Social Sciences. Stuttgart, Germany. 10-35pp.

Messemaker, L. (2008). The Green Myth? Assessment of the Jatropha Value Chain and its Potential for Pro-poor Biodiesel Development in Northern Tanzania. MSc Thesis at Utrecht University, the Netherlands. 63-83pp.

Ndong, R. (2009). Life Cycle Assessment of Biodiesels from Jatropha curcas in West Africa. A field study, Blackwell Publishing Ltd.1-14pp. [www.ias.unu.edu/.../UNU-IAS%20Report%20Biofuel%20e-ver.pdf] site visited on 7/8/2009.

Philip, D. (2007). An Exploration of the Potential of Producing Biodiesels and the Prospective Influence of Biodiesels Production on Poverty Alleviation among Small-Scale Farmers in Tanzania. Inaugural-Dissertation. Hohe Landwirtschaftliche Fakultät der Rheinischen Friedrich-Wilhelms- Universität zu Bonn. 25-66pp.

Reinhardt, G., Ga¨rtner, S., Rettenmaier, N., Mu¨nch, J. and Falkenstein, E. (2007). Screening Life Cycle Assessment of Jatropha Biodiesel. Final Report, Institute for Energy and Environmental Research Heidelberg. 26pp.

Reumerman, P.J. and Fredericks, B. (2002). *Charcoal Production with Reduced Emissions* 12th European Conference on Biomass for Energy, Industry and Climate Protection, Amsterdam, Netherlands. 1-4pp.

TGPB (2009). Tanzania Government Perspective on Biofuels. 6-30pp. [www.fao.org/docrep/012/i1544e/i1544e03.pdf] site visited on 21/7/2009.

UNCHS (1993). Application of Biomass-Energy Technologies Nairobi. Kenya. 6pp. [http://www.fao.org/docrep/013/i1756e/i1756e13.pdf] site visited on 12/4/2010.

URT (2005). National Strategy for Growth and Reducation of Poverty, Government Printer, Dar es Salaam. 72pp.

van der Land, H. (2007). *The Jatropha sub sector.* With Emphasis on Jatropha Soap Value Chain. Arusha: Match Maker Associates Ltd. 12pp.

von Lampe, M. (2007). Agricultural Markets Impacts of Future Growth in the Production of Biodiesels. Working Paper on Agricultural Policies and Markets, Directorate for Food, Agriculture and Fisheries, OECD. 34pp.

Wahl, N., Jamnadass, R., Baur, H., Munster, C. and Liyama, M. (2009). Economic viability of *Jatropha curcas* L. Plantations in Northern Tanzania Assessing Farmers Prospects via Cost-benefit Analysis. ICRAF Working Paper no.97. World Agroforestry Centre, Nairobi. 71pp.

Wijgerse, I. (2007). Jatropha for Rural Electrification in Tanzania: A Case of Engaruka. Eindhoven. Technische Universiteit Eindhoven University of Technology. 8pp.

Whitaker, M. and Heath, G. (2008). 'Life Cycle Assessment of the Use of Jatropha Biodiesel in Indian Locomotives', Technical Report NREL/TP-6A2-44428, National Renewable Energy Laboratory, US Department of Energy, Golden, Colorado. 1-58 pp.[http://www.osti.gov/bridge] site visited on 4/4/2010.

Table 1. Distribution of respondents by household characteristics

Variable name		Adopters (N=130)		Non-adopters (N=130)		All farmers (N=260)	
		F	%	F	%	F	%
Age	18 - 35	46	35.4	54	41.5	100	38.5
	36 - 45	43	33.1	42	32.3	85	32.7
	46 -60	29	22.3	23	17.7	52	20.0
	>60	12	9.2	11	8.5	23	8.8
Sex	Male	88	67.7	68	52.3	156	60.0
	Female	42	32.3	62	47.7	104	40.0
Marital status	Married	117	90.0	114	87.7	231	88.8
	Single	12	9.2	12	9.2	24	9.2
	Widow	1	0.8	4	3.1	5	1.9
Years of school	Primary	88	67.7	90	69.2	178	68.5
	Secondary	3	2.3	2	1.5	5	1.9
	Adult education	39	30.0	6	4.6	6	2.3
	No formal education	88	67.7	32	24.6	71	27.3
Household size	<3	3	2.3	16	12.3	19	7.3
	3 - 4	24	18.5	30	23.1	54	20.8
	5 - 6	27	20.8	53	40.8	80	30.8
	7 - 8	34	26.2	15	11.5	49	18.8
	>8	42	32.3	16	12.3	58	22.3

Table 2: Distribution of respondent by crop and animal keeping

Activity	Adopters N=130		Non adopters N= 130		All farmers N= 260	
	F %		F %		F %	
Crops	14	10.8	38	29.2	52	20.0
Crop and Livestock	116	89.2	92	70.8	208	80.0

Table 3: Distribution of respondents by main crop cultivated in the study area

Type of Crop cultivated	Monduli N=120		Mpanda N= 140		All study area N= 260	
	F	%	F	%	F	%
Maize	8	6.7	47	33.6	55	21.2
Maize & Black beans	112	93.3	0	0	112	43.1
Maize & Groundnuts	0	0	53	37.9	53	20.4
Maize & Beans	0	0	21	15.0	21	8.1
Maize, Groundnuts & Beans	0	0	19	13.6	19	7.3

Table 4: Distribution of types of livestock kept by respondent in the study area

	Monduli			Mpanda		
Type of livestock	**N**	**Average**	**Total**	**N**	**Average**	**Total**
Local cows	75	10	709	12	25	300
Exotic cows	2	2	4	6	2	9
Local goats	111	16	1807	55	6	328
Exotic goats	0	0	0	13	2	27
Sheep	86	13	1075	3	9	26
Pigs	0		0	16	3	54
Poultry	25	9	232	76	12	895

Table 5: Former land use before jatropha cultivation at the study sites

	Mpanda		Engaruka	
Land use	**Frequency**	**Percent**	**Frequency**	**Percent**
Food crop	62	88.6	0	0
Grassland	3	4.3	0	0
Bush land	4	5.8	0	0
Forest	1	1.4	0	0
Dry acacia fence	0	0.0	60	100
Total	**70**	**100**	**60**	**100**

Table 6: CO2 emissions from Land use change at both study sites

Land use change	Name	Engaruka	Mpanda
		Tropical savannas and grassland	Tropical savannas and grassland
Transformation			
	land with no impact	1.00	0.89
From	PNV	0.00	0.11
	Carbon loss	0.00	6.64

	duration factor (GWP 500a)	0.30	0.30
	Fossil combustion equivalent -	-	2.10
GWP 500a	CO2 (t / ha)	-	7.50
	CO2 kg / kg DJS	**-**	**0.10**
	total (t/ha)	65.98	65.98
	duration factor (GWP 100a)	1.00	1.00
GWP 100a	Fossil combustion- equivalent	-	6.60
	CO2 (t / ha)	-	24.10
	CO2 kg / kg DJS	**-**	**0.20**
Occupation			
Carbon of Jatropha plantation	Plot (t C /ha)		
	Fence (t C / ha)	11.48	
	duration factor (GWP 500a)	0.00	0.00
GWP 500a	Fossil combustion- equivalent	0.10	0.10
	CO2 (t / ha)	0.40	0.20
	CO2 kg / kg DJS	**0.10**	**0.00**
	duration factor (GWP 100a)	0.00	0.00
GWP 100a	Fossil combustion equivalent -	0.40	0.20
	CO2 (t / ha)	1.30	0.70
	CO2 kg / kg DJS	**0.30**	**0.10**
Total			
GWP 500a	***CO2 kg / kg DJS***	***0.10***	***0.10***
GWP 100a	***CO2 kg / kg DJS***	***0.30***	***0.30***

Table 7: Farming systems for jatropha cultivation

	Mpanda		**Engaruka**	
Farming system	**Frequency**	**Percent**	**Frequency**	**Percent**
Monoculture	26	37	0	0
Intercropping	44	63	0	0
Fence	0	0	60	100
Total	**70**	**100**	**60**	**100**

Table 8: Crop intercropped with jatropha in Mpanda

Type of crop	**Frequency**	**Percent**
Maize	36	82
Sesame	3	7
Groundnuts	5	11
Total	**44**	**100**

Table 9: Description of transportation chain of jatropha seeds and inputs in km

Material	Bus/Truck (km)	Motorcycle (km)
Seed from PROKON to Usevya	260	0
Seed from PROKON to Katumba	0	60
Input from PROKON to Usevya farmers	260	0
Input from PROKON to Katumba farmers	0	60

Table 10: Labour cost in jatropha cultivation per hectare in TZS

Farming activity	Cost under fence cultivation TZS/ha	Cost under plot cultivation TZS/ha
Preparation	35 000	75 000
Planting	5 000	15 000
Weeding		50 000
Pruning	10 000	
Pesticides		20 834
Harvesting	15 000	
Total cost	**65 000**	**160 834**

Table 11: Jatropha yield scenario at the study site

Year	Engaruka (kg/metre)	Mpanda (kg/metre squire)
1	0.43	0.0054
2	0.46	0.0046
3	0.50	0.0075
4	0.51	0.0043
5	0.56	0.0074
6	0.67	
Average	**0.52**	**0.006**

Table 12: Jatropha yield scenario at the study site

Yield Scenario	Engaruka Kg/m	Mpanda Kg/m2
Low	0.52	0.03
Medium	0.76	0.75
High	1.00	1.00

Table 13: Net income obtained from jatropha cultivation TZS/kg of seed produced

Yield scenario	Fence cultivation TZS/kg	Plot cultivation TZS /kg

Low	41	4
Medium	87	70
High	135	134

Table 14: Net present value and internal rate of return for different farming system

Yield scenario	**Fence cultivation/metre**		**Plot cultivation/metre squire**	
	NPV in TZS	**IRR (%)**	**NPV in TZS**	**IRR (%)**
Low	-495	-	-850	-
Medium	-171	5	-392	-
High	160	20	59	17