

DSA PAPER
Food or *Jatropha curcas* for biodiesel production?
A Cost Benefit analysis in Kwale district.

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ABSTRACT

The paper reports on the Cost benefit analysis of *Jatropha curcas* oil seed production in relation to other food crops in Kwale district, Kenya. The plant is widely viewed as a potential biodiesel feedstock that is capable of growing in marginal areas where other crops cannot yield satisfactorily. However, wide adoption of the plant into farmers' fields by replacing existing food crops is perceived as a potential threat to food security. We employ an economic cost benefit analysis to compare the profitability of *Jatropha curcas* in relation to maize and oranges and assess the value chain: in order to evaluate the limitations and constraints of biodiesel production for smallholder farmers. Production of *Jatropha* was found to be unprofitable and not feasible as a biodiesel feedstock at the present while the assessment of the value chain showed limited markets for products. We conclude that *Jatropha curcas* is only feasible as a fence and should not be planted as a monocrop. We finally list policy recommendations for consideration by stakeholders.

Keywords: *Jatropha curcas*; cost benefit analysis, Kwale, Kenya

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1. INTRODUCTION

Energy supply and demand imbalances are current issues affecting the global economy. Without any natural fuel reserves, non-oil producing developing countries depend largely on fossil fuel importation for their supply. It is widely acknowledged that natural fossil fuel reserves are likely to be depleted in 100 years time from now. This calls for a search for more sustainable energy sources to substitute and consequently replace fossil fuel use. Renewable biofuels have gained popularity as potential sources of sustainable and clean energy globally. Renewable biofuel feedstocks are perceived to be essential contributors to the energy supply portfolio as they contribute to the world energy supply security, reducing dependency on fossil fuel resources and provide opportunity for mitigating greenhouse gases (IEA-2008). However for the fear to contribute to food insecurity, non-edible and drought tolerant plant species including castor, *Croton megalocarpus* and *Jatropha curcas* among others are preferred.

Among these *Jatropha curcas* (referred to as *Jatropha* throughout the text) has been widely promoted for the past several years across dry lands for the purpose of biodiesel production. *Jatropha* is a perennial plant whose origin is Central America and is reported to have the capacity to grow in marginal areas where other crops can barely grow (Van Eijck, 2006; Eijck, V. and Romijn, H., 2007 Wiskerke, 2008; Loos and Kagiso 2009). *Jatropha* has received attention for being inedible, however producing it does not necessarily mean food production remains unaffected. It may still compete with food crop production by taking away land, resources (including water) and labor if the economics are favorable. This justifies a comparison of the economic incentive to produce *Jatropha* vs. common food crops such as maize and oranges

While Kenya lags behind research on *Jatropha curcas* production, Extensive research has been carried out in Tanzania, India, Mali and Madagascar on agronomy and economic viability where *Jatropha* production activities are way ahead of Kenya. Research findings in these countries show that in order to yield well *Jatropha* like other plants require enough attention and good management. Infact Jongschaap et al, 2007 argue that, agronomy and management issues of production of *Jatropha* have not yet been properly researched for domestication as cash crops.

In Kenya, *Jatropha* has been planted as hedges for demarcation for their fields in some parts of the country. However, for the past few years, *Jatropha* has been widely promoted by NGOs or private companies to be adopted by smallholder farmers across diverse agro climatic conditions for the purpose of biodiesel production. Tomomatsu and Swallow (2007) made a preliminary assessment of market feasibility of *Jatropha* based biodiesel production chain and its profitability to small scale farmers in Kenyan context and concluded that *Jatropha* is not a viable feedstock at the present. Further, a comprehensive baseline survey was conducted recently to assess *Jatropha's* yield potentials and economic viability of exiting smallholder farms across Kenya (GTZ forthcoming). The major constraints identified are uncertainty over productivity due to lack of agronomy knowledge and lack of markets. If measures to enhance its productivity are taken, *Jatropha* could have a potential to serve as a biodiesel feedstock. At the same time, the

production of *Jatropha* should not compete with food production in Kenya where the majority of the populations are food insecure due to their poverty levels.

This paper presents some important recent results from a case study carried out in Shimba Hills, Kwale District, one of the Kenya's major *Jatropha* activity areas. The main issues discussed here are: Is *Jatropha* production a profitable enterprise for smallholder farmers in relation to important food crops? To what extent has the *Jatropha* value chain been developed and what are the constraints? Could contract farming significantly increase farmers' outputs from *Jatropha*? As a targeted biodiesel feedstock how feasible is it in kicking off biodiesel production in Kenya? A financial cost benefit analysis was used to compare the profitability between *Jatropha* and important food crops in the study area (Maize and oranges). Due to the limitations in the activities of the value chain our methodological approach (financial cost benefit analysis) captures only the costs of production and benefits up to the seed production level.

This paper is organized as follows. Description of *Jatropha* and its activities in Kenya is outlined in section 2. An outline of the cost benefit analysis as applied in the study is given in section 3. Section 4 presents the results while section 5 concludes the paper by discussing the results with policy recommendations.

2. DESCRIPTION OF JATROPHA

This section outlines the uses, characteristics, and *Jatropha* plantations and issues surrounding *Jatropha* activities in Kenya.

2.1 Characteristics and traditional uses of *Jatropha*

Jatropha curcas is a small tree or shrub of the family Euphorbiaceae. It is a perennial plant with a lifespan of 50 years and more when established from seed and 15 years or less when established from cuttings. It is believed to have originated from Central America, Caribbean or Mexico but has become naturalized in many tropical and subtropical areas e.g. India, Africa and North America (Heller, 1996; Nyamai D.O and Omuodo L.O 2007). It has been spread as a valuable hedge as well as a medicinal plant to Africa and Asian countries.

2.2 Estimated seed yields

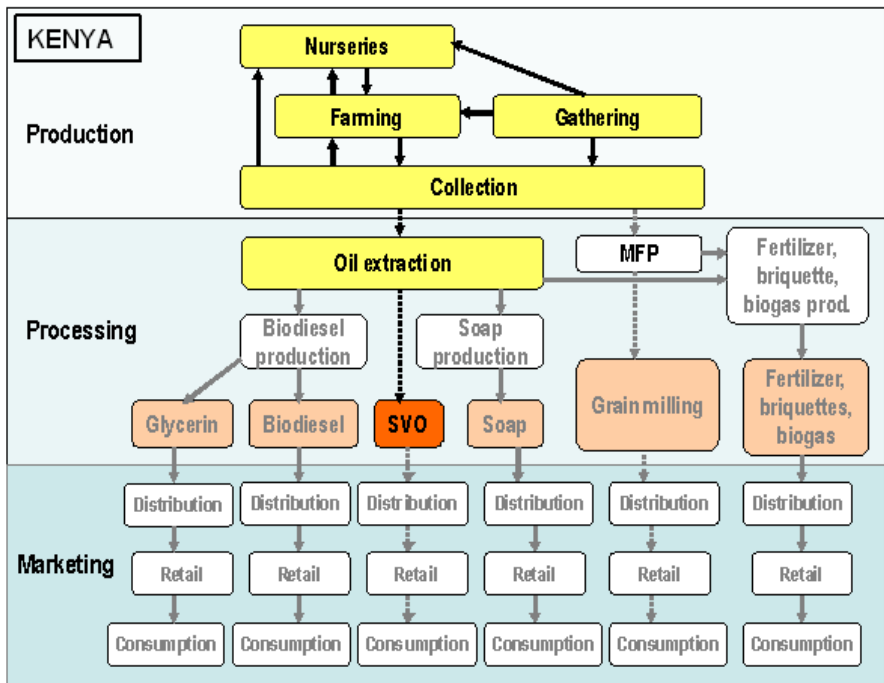
Yields depend on agro ecological conditions; soil conditions, altitude, temperature, water availability and management regimes. Although *Jatropha* is said to grow in marginal areas it is not nitrogen fixing and hence requires nitrogen rich soil for good seed production (Van Eijck 2008). Jones and Millers 1993 estimates yields ranging between 0.1 to 15tons/ha/yr (This is a maximum of 1.2 tons/acre) while Tewari et al in Tomamatsu and Swallow, 2007 estimates annual seed production of between 200grams to 2kg per plant depending on the conditions under which *Jatropha* is cultivated.

2.3 Jatropha activities in Kenya

In Kenya it is grown in Western, Central Eastern and Coastal parts of the country in attitudes of between 0-1650m (Maundu and Tengnus, 2005). Most farmers use seed and sometimes cuttings for propagation. Propagation by seed is encouraged because plants from propagated by seed have a longer lifespan of 50 years and more in relation to those propagated by cuttings which have a shorter lifespan of 15 years or less (Nyamai D.O and Omuodo L. O, 2007, Githunguri et al., 2008). The most common uses of Jatropha include; fencing, cows shelter, income generation and soil conservation. When planted as a cow shelter the plant does not require application of fertilizer or manure. The plants under such use are healthier and produce more seeds per tree in relation to those planted as fence or income generation.

Figure 1 shows Jatropha activities of the value chain in Kenya. The activities are concentrated at the production level where farmers are dedicated to development of nurseries producing planting material and cultivation of *Jatropha curcas* in their farms for seed production. Farmers then harvest seed from their farms or existing wild plants and store them for sometime. The contractor then collects the seeds from the farmers at a price of Ksh 50 per kilogram. At the processing level only a few organization carry out oil extraction for demonstration purposes (Energy Africa and Multi functional platform in Mpeketoni). The rest of the value chain is undeveloped with no stable market for seeds except for a few individuals who buy for propagation purposes. The only stable market in the research area is EA who buys seeds from the contracted farmers. Other preliminary buyers include individual farmers and NGOs who buy seed for establishment of their own nurseries.

Figure 1: Jatropha value chain in Kenya



Adapted from Messemaker (2007)

From the value chain it is theoretically possible to extract a variety of marketable products from *Jatropha* seeds, including straight vegetable oil (SVO), biodiesel and soap. Useful byproducts include glycerin (from the biodiesel production process), fertilizer, briquettes and biogas (from the seed cake) and energy services such as grain milling from multifunctional platforms (MFP) that provide all-in-one oil extraction and electricity production. However, at present most *Jatropha* related activities in Kenya focus on establishing the plant and producing seeds which are generally used as planting stock. Oil extraction is taking place only at a small (non-commercial) scale, and no market has yet emerged for any of the end products pictured here. The “business” of *Jatropha* in Kenya at this time is therefore based on propagating *Jatropha* rather than producing and marketing its end products. Instead of *Jatropha* acting as a means to produce energy or other commodities, for the time being *Jatropha* production is being treated as an end in itself. *Jatropha* is acting as the central commodity of a “sub-”value chain whose activities are confined to the production stage of a larger value chain which *Jatropha* is intended to support.

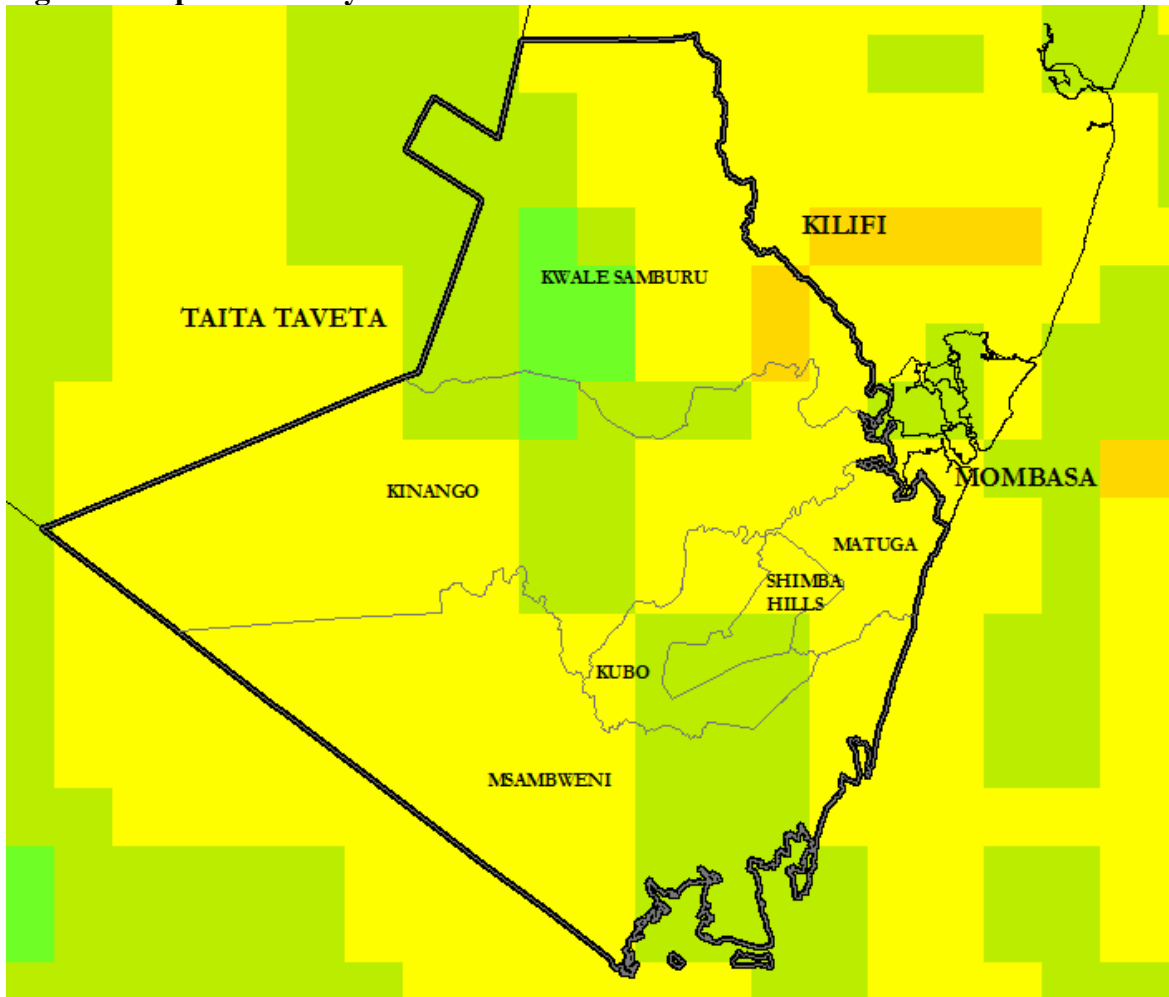
3. METHODOLOGY

The general methodology applied here is a cost benefit analysis (CBA). This method is appropriate for comparing different enterprises or a situation with or without an enterprise. In this study Maize and oranges were found to be the most important crops in the area with more than 95 percent interviewees having them on farm and were therefore chosen for comparison purposes. This section describes the study area, data collection methods and application of the CBA in the context of this research.

3.1. Study area

To empirically estimate the costs and benefits of producing *Jatropha* one of the major *Jatropha* growing area with an out grower scheme (Energy Africa) in Shimba hills was selected

Figure2. Map of the study area.



Kwale district is located in the Coast Province of Kenya and has an area of 8293 km² with a population of 583,330 persons. The annual growth rate is 2.625%. The mean household size is 6-8 people. Currently the district is divided into three districts namely: Kwale consisting of Matuga and Kubo divisions, Msambweni district consisting of Msambweni and Lunga lunga divisions and Kinango district consisting of Kinango, Samburu, Kasemeni and Ndavaya divisions. Contracted farmers were distributed throughout Matuga, Kubo, Msambweni and Kinango divisions.

3.12 Climate and rainfall

The area experiences a monsoon type of climate (Hot and dry between January and April and cool between July and August) and a bimodal rainfall pattern (Experiences short rains between October and December and Long rains between March and July and long rains) with an average rainfall range of 400mm and 1200mm. The area experiences high temperatures of between 25 to 26 degrees Celsius while the altitude ranges from 50 to 240 m above sea level. Soils are mainly sandy characterized by low structure stability.

The major economic activity in the area is farming with major crops being maize, cassava, and tree crops such as oranges, mangoes, coconuts, cashew nuts, and bixa. Indigenous people include the Digo and the Duruma; however other ethnic groups such as Kamba who immigrated after the independence in 1963 also reside in the area.

3.13 Activities of energy Africa (EA)

Energy Africa is a limited company with a vision to improve the environment through tree planting and renewable energy production in Africa. This organization was formed in 2004 and officially registered as a limited company in 2006

Figure 3



The focus of the company is to improve *Jatropha* agricultural practices by stabling optimal silvicultural regimes. Two hundred farmers have been contracted to cultivate *Jatropha curcas* in their farms. To achieve their goals EA has given them specifications for spacing, pit size, pruning method and provides important inputs such as pesticides, sprayers, manure and seeds/seedlings. The company has acquired an oil pressing machine and is ready to start pressing oil from the seeds collected from their contracted farmers and others. Before 2009 the company was purchasing seeds at Ksh 10 per kilogram but is now motivating their farmers by buying the seeds at a higher price of Ksh 50 per kilogram. However farmers are not satisfied by this price especially because management of *Jatropha* was found more demanding in relation to other crops. According to some of the farmers prices of Ksh 1000 and above have been identified in areas such as Kisumu district and the Rift valley and they are just wondering why they can not even get a half of these for their seeds.

3.2 Data collection

The research on which this paper is based involved fieldwork in Kwale district during February to April 2009. Field data used for the cost benefit analysis were gathered

through focus group discussions with key informants in the area and interviews with all farmers contracted to cultivate *Jatropha* in Shimba Hills. Existing literature was used as secondary source of information to complement the study. Only costs relating to production of *Jatropha* seed were accounted for because the cost of biodiesel production is greatly affected by the cost of production of the feedstock.

Limitations: it was difficult to account for other indirect costs such soil enhancement properties and environmental protection attributes of *Jatropha curcas*

3.3 A cost benefit analysis (CBA)

Cost benefit analysis can either be carried out from the farmers' perspective (financial CBA¹) or from the economy's point of view (economic CBA²). Since the value chain is only developed up to the production level our methodology approach is designed to capture costs of production up to the seed production level and benefits arising from the sale of seed. The motivation to estimate the potential seed yields was due to the fact that biodiesel production relies greatly on the cost of feedstock production estimated to be 6 percent of the total cost of production Tomamatsu and Swallow (2007). Energy Africa (EA) who buys seeds from their contracted farmers at Ksh 50 per kilogram provides the only reliable and available market.

3.31 Financial Cost benefit analysis (CBA)

Due to the limitations of the activities of the value a financial CBA was the most applicable method for this research. This is carried out from the farmers' perspective and considers costs incurred and benefits obtained from production of *Jatropha curcas* (Maina, G, 2009). In this case only costs of seed production were considered. These included costs of: land preparation, planting, weeding, pruning, harvesting, and disease and pest control. The only direct and measurable benefit was obtained from the sale of seed. These were valued at the prevailing market prices. Future flows of costs and benefits were inflated by percent and discounted at 18 percent to obtain their present values.

The formula below adopted from (Boardman et al., 2001) was used to calculate the Net present values.

$$NPV = \sum_{t=0}^n \frac{B_t - C_t}{(1 + r)^t}$$

Where:

NPV=Net present value

N=Life time of the contract

B_t=Total benefits from *Jatropha* production

C_t=Total costs of producing *Jatropha curcas*

R = real discount rate

T =Production Year

¹ In the financial benefit-cost analysis, the unit of analysis is the *project* and not the entire economy

²In economic CBA the unit of analysis is the entire economy

The Net present value is the difference between the present value of cash inflows and the present value of cash outflows. It compares the value of a project today to the value of that same project in the future. The current market rate of 18 percent has been used to discount both costs and the benefits.

4. DATA AND RESULTS

The research on which this paper is based involved fieldwork in Kwale district during February to April 2009. Field data used for the cost benefit analysis were gathered through focus group discussions with key informants in the area and interviews with all farmers contracted to cultivate *Jatropha* in Shimba Hills. Existing literature was used as secondary source of information to complement the study. Only costs relating to production of *Jatropha* seed were accounted for because the cost of biodiesel production is greatly affected by the cost of production of the feedstock.

Limitations: it was difficult to account for other indirect benefits such as soil enhancement properties and environmental protection attributes of *Jatropha curcas*.

The average yields obtained in Shimba hills are 0.5kg per plant and 100 kg per acre as shown in table 1. 1 USD = Ksh 76

Table1. A comparison of yields per acre and their prices in year 2009

	Yield per acre	Price	Total revenue
Crop	Kg	Ksh	Ksh
<i>Jatropha curcas</i>	100.00	50.00	5000.00
Oranges	2122.13	12.50	26526.62
Maize	681.92	35.00	23867.31

Source: Fieldwork

Average seed yields per acre were 100kg for *Jatropha*, 2122kg for oranges and 681.92 for Maize. Assuming a 20 kg bag of oranges costs KShs 250, the cost of oranges becomes Ksh12.5 per kilogram. The cost of *Jatropha curcas* is currently KShs 50 per kilogram. The average price for maize is KShs 35 per kilogram. Oranges were found to yield the highest revenue of Ksh 26526.6 annually followed by Maize with average revenue of Ksh 23867.3 per season. Revenue from maize could be double this amount when maize is planted twice in a year. However due to rainfall irregularities farmers plant once during the long rains. Revenue for *Jatropha* is the lowest in the category with revenue of Ksh 5000 per acre.

Table 2 shows the different categories of costs of production (Fixed costs, variable costs and total costs) for the three crops in question. Being a perennial crop establishment of *Jatropha curcas* exhibits the highest fixed costs. These are costs of land, farm implements, seeds land preparation, planting, and replanting. Farmers could not recall the costs of establishing Orange trees. Therefore fixed costs for oranges and maize refer to the cost of land and farm implements. Variable costs are highest for maize production (Ksh 6077.77) and lowest for *Jatropha curcas*. However due to the high fixed cost *Jatropha curcas* exhibits the highest total costs of Ksh 47494.11.

Table2. A comparison of costs of production per acre

	Costs of production (Ksh)		
	TFC	TVC	TC
<i>Jatropha curcas</i>	44494.32	3394.21	47494.11
Oranges	30250.00	4239.06	39489.06
Maize	30250.00	6077.77	36327.78

Source: estimated from fieldwork

Table 3 shows the average revenue for the three crops in year 2009. Oranges give the highest returns of Ksh 26527 followed by Maize of Ksh 23867 while *Jatropha* yields the lowest returns.

Table3. A comparison of average revenue in year 2009

	Revenues (Ksh)	Year earned	Life span (yrs)
<i>Jatropha</i>	5000	3	50
Oranges	26527	3	
Maize	23867	1	annual plant

Source: Fieldwork

Revenue for *Jatropha* and Oranges is obtained after the second year while maize being an annual crop yields output in the same year. Maize can yield double this revenue depending on the rainfall. Farmers are usually in apposition to plant twice a year when rainfall is sufficient.

Table 4 shows a breakdown of the gross margin (GM) for the three crops.

Table4.
Gross margin (GM) analysis for the year 2009

Crop	Cost	Revenue	GM
Maize	6077.78	23867.31	17789.53
Oranges	4239.06	26526.62	22287.56
<i>Jatropha</i>	47494.11	5000.00	(42494.11)

Source: Fieldwork

The cost of seed is assumed to be Ksh 50 for *Jatropha*; cost of oranges is Ksh12.5 per kilogram while that of maize is Ksh35 per kilogram. The GM is therefore highest for Oranges at Ksh 22287.56 and lowest for *Jatropha* at Ksh (42494.11).

Finally table 5 shows the Net present value (NPV) and the internal rate of return (IRR) for the three crops. Costs and benefits were inflated by 5 percent and discount at 18 percent to reflect their present values. Maize has the highest NPV as well as the highest IRR While *Jatropha* has a negative NPV of (14710.21) and the lowest IRR of 13%. Although this method is not justified because *Jatropha* is a perennial while maize is an annual crop, comparing Oranges and *Jatropha* (both perennial) shows the same trend with oranges exhibiting a higher NPV as well as higher IRR of 41 percent in relation to *Jatropha curcas* whose IRR is lower than the discount rate (18 percent) used here.

Table5.
A comparison of the Net present values (NPV) and IRR

	NPV	IRR	B/C
<i>Jatropha</i>	(14710.21)	13	
Oranges	81770.08	41	
Maize	115 583.74	155	

Discount Rate=18%

Inflation rate 5%

Source: Own calculations

5. DISCUSSION CONCLUSIONS AND RECOMMENDATIONS

The following constraints were found to be limiting development of *Jatropha* as a biodiesel feedstock: lack of policies to guide stakeholders and investors, conflicting interests among foreign investors, lack of knowledge about management of *Jatropha* trees, lack of seriousness among the contracted farmers and lack of a complete and working *Jatropha* Value chain. Total revenue earned from *Jatropha* is less than that from other crops because farmers have not accepted the plant as their own. The low yields and revenue from *Jatropha* is probably due to inadequate knowledge in the agronomics and management practices by the farmer.

Contract farming could a potential solution to accessing farm inputs by the farmers and hence a means of assuring them high inputs however farmers often feel like they are benefiting the contractor by planting *Jatropha* in their fields.

Jatropha is widely advocated for by women who lack land ownership unless they are widowed. This limits possible value addition that can be done with other *Jatropha* products such as soap production. Adoption of *Jatropha* as a fence is seen as a solution to existing human wildlife conflict in the research area. However this could not necessarily be so because wild animals such as elephants are too strong to be protected using *Jatropha* fence. They occasionally break into farmers' fields to destroy food crops.

From the results it is clear that although *Jatropha* can grow in marginal areas, seed yields are highly depend on soil fertility, moisture and other management practices. Due to the misguided conception that *Jatropha* is a magical plant seed yield are quite low in Kenya and therefore relying on *Jatropha* as the only biodiesel feedstock would delay the country's vision of becoming a major producer, user and exporter of biodiesel by 2020. From the yields obtained it is evident that *Jatropha* will take some time before it becomes a reliable biodiesel feed stock per se.

Jatropha is only interesting to the farmers because they can intercrop it with other food crops at the moment. However the question of what they will do after 5 years when *Jatropha* plants are big enough with shading effects to intercrops remains unanswered. Despite these *Jatropha* is feasible as a fence, as a shelter for cows and being non edible it is partly a solution to the human wildlife conflict in Kwale district. It is not completely a solution to wildlife conflicts because the plants can always be destroyed by the wild animals even though they are non edible.

The following recommendations are drawn from a careful analysis of the production situation on Shimba hills:

- To avoid the risks of large-scale production hence competition with food crops in terms of land and labor, the government should formulate policies that would ensure adequate supervision of all actors in the value chain.
- To enhance responsibility in caring for *Jatropha* plants, farmers have to accept *Jatropha* s one of their crops and stop being opportunistic about what is offered by the contractors.

- Seeds with tested and known provenances should be recommended to the farmers for easy establishment of potential yields in different agro ecological zones.
- All *Jatropha* stakeholders have to be motivated to become active in their respect channels of the value chain
- A complete value chain with working links and linkages need to be developed
- Markets have to be sought for all *Jatropha* products to motivate producers
- Harmonization of all research work by different organizations is required

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