Community level production and utilization of jatropha feedstock in Malawi, Zambia and Zimbabwe

Enos Shumba, Peter Roberntz, Banarbas Mawire, Newton Moyo, Mxolisi Sibanda and Mufaro Masuka.

Published April 2011 by WWF-World Wide Fund For Nature (Formerly World Wildlife Fund) Harare, Zimbabwe.
07.08 (6K)

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

Environment Africa and Organization Development and Community Trust undertook shelf assessments of their community level jatropha feedstock production, processing and utilization projects. Candice Bate handled logistical issues related to the production of the document.

The Study was financially supported by WWF Sweden.

ACRONYMS

BAZ	Bio-fuels Association of Zambia
DAPP	Development Aid for People to People
GHG	Green House Gas
NGO	Non Governmental Organization
NOCZIM	National Oil Company of Zimbabwe
ODMCT	Organization Development and Community Management Trust
WWF	World Wide Fund for Nature

EXECUTIVE SUMMARY

The bio-fuel debate has largely focused on large feedstock plantations that produce products for the export market. It has not acknowledged and seriously considered the existence of considerable small scale feedstock production that is targeted at uses other than large scale bio-fuels. Such initiatives can make a difference to household economies through the use of jatropha as a live fence/hedge; a source of energy for cooking and lighting; to make soap, lotions and floor polish; and organic fertilizer (from seed cake). The nature and magnitude of such local level livelihood initiatives have, however, remained relatively un-investigated.

The objective of this Study was to document experiences of civil society organizations in promoting community level production and utilization of jatropha feedstock. Environment Africa has been doing this in Zimbabwe and Malawi; and Organization Development and Community Management Trust in Zambia. The Study was carried out in Mudzi district-Zimbabwe, Chikwawa district-Malawi and Chibombo district-Zambia. A survey questionnaire was administered to randomly selected jatropha feedstock growers in the three districts.

Key findings from the study were that:

- The jatropha plant is largely grown as a live fence or alley crop and receives very little management attention apart from annual pruning. This partly explains the low seed yields realized by the bulk of the growers. In these studies, yields ranged from 0.1-2.3 tons/per ha with the majority of growers achieving less than 0.8t/ha;
- At current low seed yields, jatropha feedstock production for community and large scale production is largely economically unattractive if the intended product is bio diesel alone;
-
- Growing jatropha feedstock for local level processing and utilization appears to be more economically attractive than selling seed for bio-fuel production. However, the situation might change if the relative price of fossil fuel increases relative to that of bio-diesel in future. Most of the value added products are used or sold within the community and are generally of low quality; and,
- Community jatropha feedstock production and utilization can create a range of products and may serve as a catalyst for local market development.

Key recommendations drawn from the Study are:

- The need to substantially raise jatropha feedstock seed yield through research and development in order to improve its economic appeal for community and large scale production for both bio-diesel production and other products;
- The need to broaden the jatropha feedstock product range, improve product quality and seek external markets for products produced at community level. A market study of value added jatropha based products is therefore necessary; and,
- The need to broaden community level energy sources beyond wood fuel which is a major cause for deforestation and contributor to Green House Gas emissions. A market study on current and potential cleaner energy sources and how they compare with jatropha feedstock is therefore recommended. It will involve the identification, economic assessment and demand projections for various renewable energy sources.

INTRODUCTION

Preamble

Fossil fuels are a major contributor to Green House Gas (GHG) emissions-the key drivers of global warming and climate change. Renewable energy sources such as bio-fuels are being touted as an effective mitigation strategy to reduce GHG emissions as well as address energy challenges for the poor in developing countries. The market for bio-fuels is further enhanced by the fact that some developed countries have committed themselves to measurable levels of bio-fuel use in response to the growing evidence of adverse impacts of climate change on ecosystem health and human wellbeing. However, bio-fuels can also be an emerging driver of habitat alteration, biodiversity loss, food insecurity and community displacement and disenfranchisement if not properly guided and implemented. For example, large scale feedstock plantations can create high GHG emissions and food insecurity if they lead to direct or indirect land use changes. This has given impetus to a focus on community level bio-fuel feedstock production and utilization in order to achieve local energy security, improve livelihoods and reduce GHG emissions in a non-competitive manner.

Climatic and soil conditions in Southern Africa are suitable for the production of a wide range of bio-fuel feedstocks. A study carried out by WWF in five countries of the region prioritized jatropha, sweet sorghum and sugarcane feedstocks for the following reasons:

- The crops were identified as potential feedstocks by at least two of the five study countries as follows: Botswana-jatropha and sweet sorghum; Malawi-jatropha and sugarcane; Mozambique-jatropha, sweet sorghum and sugarcane; Zambia-jatropha, sweet sorghum and sugarcane; and Zimbabwe-jatropha and sugarcane; and,
- There is a well established sugarcane industry in the region. Molasses from the crop has been used to produce bio-ethanol in Zimbabwe and Malawi since 1965 and 1972 respectively.

Jatropha is the most preferred feedstock across the five countries. This is largely because it has been portrayed as a”miracle crop” that can grow and produce on marginal soils with limited to no management. The crop is grown as a live fence/hedge by some smallholder farmers in countries such as Zimbabwe, Zambia and Malawi. However, it has a number of problems that include the following:

- Its commercial production is yet to take off in Southern Africa and very few large scale commercial plantings have been harvested and processed to date. In addition, its agronomic requirements, yield levels and economics are largely unknown;
- The crop takes 3-5 years to produce sizeable quantities of seed. This presents a challenge to smallholder farmers who have to tie up land for some time before they realize a return; and,
- The available germplasm has a long fruiting season and its fruits do not ripen at the same time. This makes mechanical harvesting difficult hence crop harvesting is labour intensive.

The bio-fuel debate has largely focused on large feedstock plantations that produce products for the export market. It has not acknowledged and seriously considered the existence of considerable small scale feedstock production targeted at uses other than large scale bio-fuels. Such initiatives can make a difference to household economies through the use of jatropha as a live fence/hedge; a source of energy for cooking and lighting; to make soap, lotions and floor polish; and organic fertilizer (from seed cake). The nature and magnitude of such local level livelihood initiatives have, however, remained relatively un-investigated.

Southern African countries such as Malawi, Zimbabwe and Zambia have some history of bio-fuel production from large scale plantations and smallholder farmers as illustrated in this section.

Zimbabwe

A significant proportion of Zimbabwe’s ethanol is exported since the country no longer produces petrol blends. However, a Cabinet decision of 2005 called for the re-introduction of fuel blending to address chronic fuel shortages experienced at the time. The following strategies were adopted:

- The resuscitation of bio-ethanol production for blending with fossil fuels and expanding on sugarcane feedstock cultivation; and,
- Increasing bio-diesel production by encouraging smallholder farmers to cultivate some 100 000ha of jatropha feedstock throughout the country. In this regard, government established processing plants with capacities of 10 000 litres per day in Mutoko and 60 000 litres per day at Mt Hampden. Farmers in various parts of the country are being mobilised to provide feedstock for the processing plants by the National Oil Company of Zimbabwe (NOCZIM) and Finealt Engineering-both government companies. Unfortunately, the "flexi" bio-diesel processing plants remain under utilized due to feedstock shortages.

The country's smallholder farmers are being encouraged to harvest jatropha seed from their live hedges and sell it to NOCZIM for feeding into bio-diesel processing plants. However, economic returns from this initiative have been very low. In an attempt to boost returns from community level jatropha production, Environment Africa (an environmental NGO) is promoting local level processing and utilisation of jatropha seed in the Mudzi district of Zimbabwe.

Malawi

Most of Malawi's bioethanol is exported as its local demand for blending with petrol is limited. The country is also promoting jatropha as a biodiesel feedstock through large scale plantations and smallholder out grower schemes. However, most of the plantations are still to be harvested. At the community level, jatropha has been established as a live hedge/fence for some time. Since 2007, Environment Africa in partnership with the Forestry Department has been promoting community level jatropha production in Chikwawa district of the Shire Valley. The original intention of the initiative was to produce biodiesel to operate local cereal grinding mills. However this has been hampered by inadequate jatropha seed supplies. The Forestry Department has also tried to facilitate the sale of some seed to outsiders but with limited success. Consequently, Environment Africa now seeks to enhance feedstock production and productivity; processing; and utilisation at the community level.

Zambia

Zambia's participation in bio-fuels production is recent. This has been largely influenced by the international debate on the need for cleaner energy, energy security and livelihood security. The bio-energy crusade has been championed by the private sector through the Biofuel Association of Zambia (BAZ). Focus has been on promoting jatropha feedstock production under large scale plantations and out-grower schemes and on establishing oil processing plants. For example, the Oval Bio Fuel company produced 1000 litres of diesel per week for sale to a mining company. Unfortunately, due to the world econmic recession, private sector interest in bio-fuels was waning due to a declining fossil fuel price and low jatropha feedstock productivity. Notwithstanding, NGOs such as Organization Development and Community Management Trust (ODMCT) and Development Aid for People to People (DAPP) are promoting community level jatropha feedstock production with the intention of adding value to at local level.

Objective of the Study

The objective of this Study was to document experiences of Environment Africa and ODCMT in promoting community level production and utilization of jatropha feedstock in Malawi, Zambia and Zimbabwe with emphasis on:

- Productivity of the feedstock; and,
- Economic returns to feedstock production when seed is sold for bio-fuel production compared to local level processing and utilization.

Jatropha grown as a live fence / hedge in Chikwawa district, Malawi

DESCRIPTION OF STUDY SITES

The study was carried out at the following sites: Chikwawa district in Malawi; Chibombo district in Zambia; and Mudzi district in Zimbabwe. The districts fall within WWF's priority focal landscapes of the Miombo Eco-region of Southern Africa. The districts are briefly described in this section.

Mudzi district

Mudzi district lies in the northern part of Zimbabwe. It receives low and erratic rainfall (300-500mm per annum). Inhabitants of the district are predominantly smallholder farmers who produce a wide range of crops such as maize, sorghum, millets and ground nuts and keep livestock. They however, realize low crop yields, suffer from food insecurity and are generally poor (live on less than $1 per day). Most farmers grow jatropha as a live fence around their homesteads and gardens to primarily keep out livestock. A few now sell the seed to NOCZIM for bio-diesel production. Since 2008, Environment Africa has been supporting local level value addition and utilization of jatropha seed through Environmental Action Groups. The groups were trained in various aspects of jatropha production, processing and marketing.

Chikwawa district

Chikwawa district is located in southern Malawi. It receives low and erratic rainfall that averages 600mm per annum. The district largely consists of small holder farmers who grow cotton, maize, sorghum, millets and ground nuts and keep livestock. The farmers achieve low yields and most of them live on less than $1 per day. Some farmers have started growing jatropha as a live fence and/or alley crop to broaden their livelihood options with support being provided through farmer groups by Environment Africa and the Forestry Department. The groups are trained in jatropha production and processing; and are given planting materials to establish hedges and alleys.

Chibombo district

Chibombo district is located in the Central Province of Zambia. It receives an average annual rainfall of 600mm. Smallholder farmers in the district grow maize, cow peas and cassava; and keep cattle and goats. Some farmers have started growing jatropha as a live fence/hedge and/or alley crop to broaden their income options. They received technical information on jatropha production from DAPP and the Conservation Farming Unit (both NGOs) through farmer cooperative clubs. DAPP bought the harvested seed and used it to train community members in oil pressing and soap making. However, the NGO has since wound up the initiative in the district.

METHODOLOGY USED

A survey questionnaire was administered to randomly selected jatropha feedstock growers in the three study districts. Sample size was 43 farmers in Chikwawa; 69 in Chibombo; and 76 in Mudzi.

RESULTS

Feedstock productivity

Jatropha production practices

Key management practices carried out on jatropha feedstock across study districts included the following:

- The plant is mostly grown as a live fence or alley crop;
- Most of the live fences and alleys are established from cuttings and truncheons except in Chibombo district- Zambia, where some growers plant seedlings;
- A major management practice carried out on live fences in Mudzi and Chikwawa districts is annual pruning, while weeding is an important activity in Chibombo district;
- The bulk of jatropha fruit is picked from the ground once a year, around April and July; and,
- The fruit is shelled and winnowed and the resultant seed sold or locally processed into various products.

Hedge pruning in Mudzi District

Specific jatropha feedstock production practices carried out at each study district are given in this section.

Mudzi district

Smallholder farmers in Mudzi district have a long history of jatropha cultivation with over 50% of respondents having done so for more than ten years. All respondents grow the plant as a live fence/hedge around homesteads and/or gardens for the sole purpose of keeping out livestock from destroying their annual crops. The length of hedge per homestead averaged 300 metres and ranged between 30 metres and 800 metres. All hedges are established from cuttings/trucheons secured from neighbours or from the farmer's own hedge in the case of extension plantings. The only major management practice carried out on the hedge is annual pruning.

From 2007, some farmers started collecting seed from the hedges for sale to NOCZIM for oil pressing and to other private buyers for local level processing. With respect to harvesting, 96% of survey farmers pick fruits

that fall to the ground and directly from standing plants. Although picking from the ground is the easiest and most popular method, its major drawback is that the drying process and seed quality cannot be controlled. Fortunately, seed quality is not an important consideration for farmers at the moment as it does not directly affect the price of seed or of locally processed products. Seventy nine per cent of respondents harvested or picked the fruit once a year between April and July while the remainder had an additional harvest around December and February. The latter harvest was not popular because of competition for labour with crop production. Once collected, the fruit is shelled and winnowed and the resultant seed is either sold or locally processed into various products. Forty two percent of the surveyed farmers did not sell any seed; 43% sold some to private buyers; and the remainder sold to NOCZIM. The majority of private buyers were from within the district. They processed the seed into products such as soap, oil for lighting, floor polish and body lotion.

Jatropha oil powered stove in Mudzi district

Chikwawa district

Ninety three per cent of jatropha growers in Chikwawa district establish their crop as a live fence/hedge and the remainder as an alley crop. The bulk of the hedges are established around homesteads whilst alleys are between annual crops (e.g. maize, sorghum and sunflower). The length of the hedge per homestead averaged 170 metres and ranged from 10 metres to 500 metres. Most of the plantings are established from cuttings/ truncheons and seedlings. However, the latter method has lower preference as it is more susceptible to termite attack than the former. The major management practice carried out on the feedstock is annual pruning.

With respect to harvesting, 42% of the respondents harvested seed from jatropha feedstock. Seventy two per cent of the growers collected fruits from the ground and from the tree. Most growers harvested the fruit once a year between April and August while the remainder had an additional harvest around December/January. Once collected, the fruit is shelled and the seed is prepared for sale.

Chibombo district

Farmers in the Chibombo district have limited experience with jatropha feedstock production. Some 77% of the growers had less than 5 years' experience; 17% had between 6 and 10years; and only 6% had more than 10 years. Seventy five per cent of the respondents established the feedstock as a live fence/hedge; and 25% as a mono crop. Most of the hedges are planted around homesteads and the remainder in the field and around gardens. Fifty three per cent of the plantings are from seedlings and the remainder from cuttings/truncheons. The major management practice carried out on the feedstock is weeding followed by annual pruning.

With respect to harvesting, 54% of the jatropha growers harvested seed. The majority of these picked the fruit from both the ground and tree. Most growers had one harvest between January and April. Once collected, the fruit was shelled, winnowed and the seed prepared for sale to DAPP. The later was the sole buyer of the seed during the lifespan of the project which has since come to an end.

Jatropha seedling nursery in Chikwawa District

Jatropha seed yields

There were large variations in the productivity of jatropha feedstock across Study districts. Estimated seed yields ranged from 0.1 tons/ha to 2.3 tons/ha based on farmer interviews. To facilitate across district comparisons, individual farm yields were grouped into the following categories: 0.1-0.5 tons/ha =0.3 tons/ha category; +0.5-1.0 tons/ha=0.8 tons/ha; +1.0-1.5 tons/ha=1.3 tons/ha; and, +1.5-+2.0 tons/ha=1.8 tons/ha (Table 1). Most growers fell within the 0.8 tons/ha or less yield categories while very few were in the 1.8 ton/ha category. This vindicates a general notion that current jatropha seed yields are low. An across district comparison showed that most growers in Mudzi fell within the 0.8 t/ha and 1.3 t/ha yield categories while those in Chibombo and Chikwawa districts were in the 0.3 t/ha and 0.8 t/ha categories. This is largely explained by the fact that Mudzi farmers have older hedges and more experience with managing the feedstock than their counterparts in the other two districts.

Table 1: Proportion of farmers falling within the various jatropha seed yield categories

Site/yield category	0.3t/ha	0.8t/ha	1.3t/ha	1.8t/ha
Mudzi district				
No. of farmers	14	25	22	15
% of farmers	18	33	29	12
Chikwana district				
No. of farmers	9	11	9	3
% of farmers	28	34	28	9
Chibombo district				
No. of farmers	10	12	3	1
% of farmers	38	46	12	4

Jatropha seed processing in Mudzi district

Economic returns from jatropha production

Gross margins from seed sales

The original objective for promoting jatropha feedstock in the Study districts was to produce bio-diesel. The extent to which this has been realized varied with Study district as follows:

- There were very limited jatropha seed sales in Chikwawa district-Malawi. The Forest Department linked some growers with buyers from urban centres. However, farmers complained about low prices offered by the buyers;
- In Chibombo district-Zambia, DAPP purchased seed produced by growers and used it to train communities in oil pressing and soap making. The NGO offered relatively attractive prices as an incentive for farmers to produce more feedstock. However, this incentive price was far above the long term sustainable purchasing price for the crop; and,
- In Mudzi district-Zimbabwe, NOCZIM bought seed to feed into government bio-diesel plants located outside the district. Farmers complained that prices offered for the seed were low.

The gross margin on jatropha seed sales for oil processing was generally low and varied with seed yield category and study district (Table 2). It was negative at 0.3 tons/ha in all districts. Thereafter, the response was district dependent. It remained negative for all yield categories at Chikwawa; was positive for subsequent yield categories at Chibombo; and was only positive at the 1.3 tons/ha and 1.8 tons/ha yield categories at Mudzi. The differential response was due to differences in the selling price. The prices were $95/ton, $100/ton and $130/ton at Chikwawa, Mudzi and Chibombo districts respectively.

Table 2: Gross margins on jatropha seed sales by seed yield category

Site/ Parameter	0.3t/ha	0.8t/ha	1.3t/ha	1.8t/ha
Mudzi district				
Income, $/ha	30.00	80.00	130.00	180.00
Variable costs, $/ha	54.74	81.74	126.74	171.74
Gross Margin, $/ha	**-24.74**	**-1.74**	**3.26**	**8.26**
Chibombo district				
Income, $/ha	39.00	104.00	169.00	234.00
Vairable costs, $/ha	40.80	86.40	131.40	176.40
Gross Margin, $/ha	**-1.80**	**17.60**	**37.60**	**57.60**
Chikwawa district				
Income, $/ha	28.50	76.00	123.50	171.00
Variable costs, $/ha	36.60	81.60	126.60	171.60
Gross Margin, $/ha	**-11.10**	**-5.60**	**-3.10**	**-0.60**

Based on Annex II

Gross margins on value added seed products

Environment Africa is promoting local level processing and utilization of jatropha seed in Mudzi district by providing manual oil pressers, value adding equipment and appropriate training to farmers. Value added products being promoted include: soap, oil lamps, floor polish and body lotion. Soap making was the most popular cottage industry among survey farmers. Consequently, it was used to demonstrate the economic viability of community level value addition to jatropha seed. Main processes involved in soap making included the following:

- Oil extraction from seed using manual oil pressers; and
- Mixing the resultant oil with caustic soda and water. The product was poured into trays for the production of soap bars.

Table 3 presents a gross margin analysis for community level soap production from jatroha oil. All margins were positive and much higher than those realized from direct seed sales across seed yield categories. The highest margins were $50/ha and $8/ha for soap making and direct seed sales respectively for the 1.8 t/ha yield category. It is, however, worth noting that the analysis did not include press cake. The cake is a major by-product used as an organic fertilizer in horticulture and cereal crop production by some growers and thus provides a direct link between community level jatropha processing and food security. There is also potential to pellet press cake as a high value organic fertilizer for vegetable gardens and as a feedstock for biogas plants. In addition, BP D1 Oils - a Zambian based company, is conducting research on the detoxification of press cake for use as a livestock feed. Such initiatives can further enhance the economic value of jatropha seed by-products and make the feedstock a more attractive livelihood enhancement option at community level.

Table 3: Gross margin comparisons from value addition to jatropha seed (soap making) and seed sales in Mudzi district

Parameter	0.3t/ha	0.8t/ha	1.3t/ha	1.8t/ha
Gross margin: Soap making				
Bars of soap produced	120	320	520	720
Income from soap sales, $/ha	90.00	240.00	390.00	540.00
Total variable costs, $/ha	89.84	223.34	356.84	490.34
Gross Margin, $/ha	**0.16**	**16.66**	**33.16**	**49.66**
Gross margin: Seed sales				
Income $/ha	30.00	80.00	130.00	180.00
Total variable costs $/ha	54.74	81.74	126.74	171.74
Gross Margin, $/ha	**-24.74**	**-1.74**	**3.26**	**8.26**

Based on Annex III

Soap making in Mudzi district

RECOMMENDATIONS

A number of conclusions and recommendations can be made from these studies. They include the following:

First, at current low seed yields, the profitability of jatropha feedstock production for both community and large scale production is greatly compromised if the intended product is bio-diesel alone. Furthermore, the amount of land required to produce a given quantity of bio-fuel under plantation conditions largely depends on the productivity of the feedstock. Consequently, substantial amounts of land will be required to support jatropha based bio-diesel production if seed yields remain low. The conversion of large tracts of land associated with this can adversely affect biodiversity, habitat and ecosystem integrity, climate change mitigation capacity, household food security and community land rights. There is therefore need to minimize such impacts by raising jatropha feedstock productivity through research and development.

Second, growing jatropha feedstock for local level processing and utilization appeared to be more economically attractive than selling seed for bio-fuel production. However, most of the current products are used or sold within the community and are generally of low quality. There is need to broaden the product range, improve product quality and seek external markets. A market study on value added jatropha based products is therefore recommended. The products include press cake pellets as a high value fertilizer or livestock feed (after detoxification); refined biodiesel to run stationery engines (e.g. Hammer mills and water pumps for small scale irrigation schemes) and to power lamps and cooking stoves; and high quality soap, lotion and floor polish. Some of these products are already being explored in Binga district, Zimbabwe (Fig1).

Figure 1 Some value added products from jatropha seed (soap, body lotion and floor polish)

Finally, the use of jatropha oil for cooking will broaden energy sources beyond wood fuel in the three districts. The current over reliance on wood energy is contributing to deforestation-a phenomenon that accounts for 20% of global GHG emissions. Furthermore, it reduces the capacity of forests to sequestrate carbon dioxide and thus to reduce GHG emissions. At the local level, households are travelling for long distances in search of wood. It is therefore recommended that a market study on current and potential cleaner energy sources be carried out. This will involve the identification, economic assessment and demand projections for various renewable energy sources such as jatropha feedstock, bio-gas (including use of jatropha press cake as a feedstock), solar & wind energy and micro-hydropower.

REFERENCES

DAPP, 2009. Jatropha "From soil to oil". Lusaka, Zambia.

Environment Africa, 2010. Bio-energy assessment report for Mudzi district in Zimbabwe. Harare. Zimbabwe.

FAO, 2008. Infocus Jatropha. Cleantech Margazine. London. United Kingdom.

Shumba, E. M., Allan Carlson, Harrison Kojwang, Mxolisi Sibanda and Mufaro 2009. Bio-fuel investments in Southern Africa: A situation analysis in Botswana, Malawi, Mozambique, Zambia and Zimbawe. Regional Synthesis Report, WWF SARPO. Harare, Zimbabwe

Swedish Cooperative Centre, 2008. Fuel for development? Facts from SCC. Nr 6, June 2008. Stockholm.

ODCMT, 2010. Assessment of community level production of bio-fuels in Zambia-The Chibombo district case study. Lusaka, Zimbia.

WWF and SADC, 2009. Key recommendations of a regional meeting "Assessing the status of bio-fuel investments in Southern Africa". Harare, Zimbabwe.

WWF SARPO. 2001. The Miombo Eco-region. Conservation for future generations. WWF. Harare, Zimbabwe.

Jatropha seedling nursery

ANNEXES

Annex I: Data used in the gross margin analyses

a. Jatropha production practices

i)Planting material and its establishment cost: Assumed to be zero as the live fences/hedges were already established.
ii) Pruning: 4.8 labour days are required to prune 1 ha of jatropha plants at a plant density of 1 000 plants/ha.
iii) Harvesting (including picking the fruit): 27 labour days are required to harvest 1 ton of seed.
iv) Shelling (including thrashing and winnowing): 18 labour days are required to shell 1 ton of seed.
v) Weeding: 7.2 labour days are needed to weed 1 ha of jatropha.

b. Jatropha processing into soap

i)Seed oil content: The oil content of jatropha seed is 33%. It was assumed that the available manual expressers can only extract the oil at 20%. 1 ton of seed will therefore produce 200 litres of oil.
ii) Oil expressing:
Soap making-step 1: Mix oil with Caustic Soda and water to produce a liquid soap mix. 1 litre of seed oil mixed with 150g of Caustic Soda and 750 ml of water will produce 2 bars of soap with a weight equivalent to 750g per bar.
Soap making-step 2: Involves the moulding/shaping and drying of the soap mix. 6 labour days are required to produce soap from 200 litres of oil or 1 ton of seed (steps 1 & 2).

Annex II: Details on gross margins on seed sales by yield category

a. Mudzi district

Parameter	**0.3t/ha**	**0.8t/ha**	**1.3t/ha**	**1.8t/ha**
Income ($)	30.00	80.00	130.00	180.00
Costs ($)				
Pruning	9.74	9.74	9.74	9.74
Harvesting	16.20	43.20	70.20	97.20
Shelling	10.80	28.80	46.80	64.80
Total variable costs	54.74	81.74	126.74	171.74
Gross Margin	**-24.74**	**-1.74**	**3.26**	**8.26**

Selling price: $100/ton; Labour cost: $2/labour day

b. Chibombo district

Parameter	**0.3t/ha**	**0.8t/ha**	**1.3t/ha**	**1.8t/ha**
Income ($)	39.00	104.00	169.00	234.00
Costs ($)				
Weeding	14.40	14.40	14.40	14.40
Harvesting	16.20	43.20	70.20	97.20
Shelling	10.80	28.80	46.80	64.80
Total variable costs	40.80	86.40	131.40	176.40
Gross Margin	**-1.80**	**17.6**	**37.60**	**57.6**

Selling price: $130/ton; Labour units =US$2/day

c. Chikwawa district

Parameter	0.3t/ha	0.8t/ha	1.3t/ha	1.8t/ha
Income ($)	28.50	76.00	123.50	171.00
Costs ($)				
Pruning	9.60	9.60	9.60	9.60
Harvesting	16.20	43.20	70.20	97.20
Shelling	10.80	28.80	46.80	64.80
Total variable costs	36.60	81.60	126.60	171.60
Gross Margin	**-11.10**	**-5.6**	**-3.1**	**-0.6**

Selling price: $95/ton; Labour units =US$2/day

Annex III: Gross margin for value addition to jatropha seed: soap making in Mudzi district

Seed yield, tons/ha	0.3	0.8	1.3	1.8
Oil yield, kg	60	160	260	360
Bars of soap produced, 750g each	120	320	520	720
Press-cake, tons	0.24	0.64	1.04	1.44
Income from soap sales, $	90.00	240.00	390	540.00
Costs, $				
Pruning	9.74	9.74	9.74	9.74
Harvesting	16.20	43.20	70.20	97.20
Shelling	10.80	28.80	46.80	64.80
Oil pressing	22.50	60.00	97.50	135.00
Caustic Soda	27.00	72.00	117.00	162.00
Soap making	3.60	9.60	15.60	21.60
Total variable costs	89.84	223.34	356.84	490.34
Gross Margin	**0.16**	**16.66**	**33.16**	**49.66**