Cultivation of *Jatropha Curcas L.* for Energy Purposes in Kibwezi, Shimba Hills and Bondo, Kenya

Atalitsa C. N.[1], Moturi N. W.[2], Mironga J.[3], Ogendi G. M.[4], Koech H. K[5]

[1, 2, 3, 4, 5]Egerton university, Department of Environmental Science, P.O. Box 536-20115, Egerton

Abstract: ***In most developing countries, plants remain the major source of energy especially in rural areas, although oil has assumed an importance as a source of energy for transport. The alternative solar, wind and geothermal energy sources can be significant but cannot provide liquid fuel. J. curcas has been identified as a way to meet the populations' increasing energy needs. J. curcas, also known as "physic nut" is a multipurpose and drought resistant tree that can be used in the production of bio-fuels, potentially reduce carbon dioxide emissions and make a country more self-reliant in its food needs. The seeds can be pressed to obtain oil, leaving a seedcake rich in nitrogen that can in turn be used as fertilizer. The seed oil can be used for soap production, as an insecticide or for medicinal purposes, animal feed or to produce biogas (Heller, 1996). The tree can be grown in a number of climatic zones in tropical and sub-tropical regions of the world, areas of low rainfall and poor soils as it is in the case of Kibwezi, Shimba Hills and Bondo. Its production could therefore, be an income generating opportunity for rural dwellers. As much as this could provide income to rural communities, the potential impact of the crop on the environment has to be considered. The plant can be used to reclaim waste lands and can be grown in many parts of Kenya. Cultivating J. curcas therefore, is an eco-friendly way of growing cash and energy. The aim of this study was to assess the cultivation of J. curcas for energy purposes in Kibwezi, Shimba Hills and Bondo, Kenya. Data collection was by the use of structured questionnaires and observation schedules. Results show that farmers in Kibwezi, Shimba Hills and Bondo cultivated J. curcas for energy needs at household level.***

Keywords: bio fuels, climate change, Jatropha curcas, impacts, energy

1. Introduction

The negative response of climate change in the world is as a result of the growth of green house gas emission due to burning of fossil fuels, resulting mainly from industrial activities and motor transportation. Rising energy consumption and environmental issues has now shifted the focus towards bio-fuel use, especially transportation. There is a large interest globally in finding renewable fuels to substitute petroleum based fuels with the purpose of enhancing energy security and mitigating climate change. The growing interest on bio-fuels is driven by escalating oil prices and the uncertainty about sustained oil supplies.

India for example is now actively promoting bio-diesel from *J. curcas* and their experience indicate that bio-fuels promotion results in improved energy security, economic gains, rural development and greater energy efficiency (Kumar & Kumari, 2007).

2. Materials and Methods

2.1. Descriptions of the Study Areas

Kibwezi (Figure 1) is a dry and hot area with little rainfall (550-670 mm) and high temperatures of 24°C. The district experiences high temperatures during the day and low temperatures at night. Most parts of the region are semi-arid although areas below 670 metres above sea level are generally arid. Soil types vary between sand, loam and clay. The major economic activity is mixed farming mainly for subsistence purposes. The area experiences crop failure due to drought (Drought Monitoring Bulletin, 2009). The major food crops grown are maize, beans, pigeon peas and cow peas. The main cash crops grown in the district are coffee and cotton. Horticultural crop farming is also undertaken but in small holdings on individual farmer basis though surplus may be exported. The major sources of energy in the district are diesel driven generators, wood-fuel, and charcoal. Solar energy and biogas sources of energy are not very common. *J. curcas* has been growing in the region mainly as hedges (GTZ, 2008).

2.2. Shimba Hills, Coastal Province

Shimba Hills (Figure 1) is a hot and dry area with medium to high agricultural potential. Most parts of Shimba Hills fall in the semi-humid zone with average rainfall of 400- 1300 mm. Soils vary with topography and geology of the area. The sandstone and grit on the coastal range yield a fairly good, that is well stated for cultivation. The average annual temperature range from 25°C to 26.6°C. Vegetation cover is sparse with overgrazing, being a major contributor to soil erosion. Most of the farming in the region is small scale. The major economic activity is farming, with maize, cassava and rice as the main food crops, while coconut, cashew nuts and cotton are the main cash crops (DSA, 2009). The most common source of energy in the district is fuel wood; however, it is becoming scarce as the existing bush lands are cleared for farming (Kwale District Development Plan, 1997-2001).

2.3. Bondo, Nyanza Province

Bondo region falls in agro-climatic zones ranging from humid in high altitude areas (1,400-2,000 metres), sub-humid (1,200 to 1,400 metres) and semi-humid (1,100 to 1,300 meters) (Figure 1). This region has diverse soil types, though mainly loamy and black cotton soils. Vegetation type is mostly bush land and dry woodland. The district experiences a bimodal rainfall with an average of 1100 to 1350mm and means temperatures of 22°C. Humidity is relatively high. The county is a mixed farming area; however farming is done mainly for subsistence. The major cash crops in the district are sugarcane, cotton and coffee. Most cultivated land is under food crops such as maize, sorghum, beans, cassava, finger millet and sweet potatoes. Groundnuts, beans, and soya beans are dual purpose crops which serve as cash crops and food crop. The most important source of household energy in Bondo is wood fuel while other sources of energy are paraffin and electricity. The other alternative forms of energy such as biogas, solar and wind power are not much used for lack of appropriate technology. Industrialization has not taken firm root despite the potential in agro-processing industries and fish processing. *J. curcas* has been grown in this region and has always been used as a medicinal plant (Bondo District Development Plan, 1997-2001 and District Environment Action Plan 2006-2011 for Bondo District).

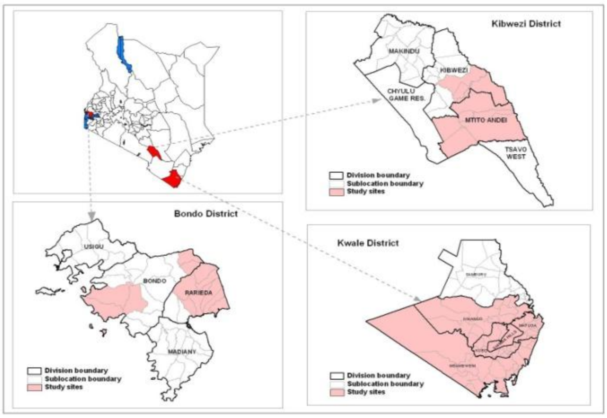

Figure 1: Map of Kenya showing the Study Sites (***Source:*** Centre for Training and Integrated Research for ASAL Development (CETRAD) office, 2009).

The research involved fieldwork in Bondo, Kibwezi and Shimba Hills districts. The research design was a cross-sectional survey while data collection was by the use of structured questionnaires. Field data were gathered through focus group discussions with key informants in the area and interviews with all farmers contracted who cultivate *Jatropha* in their farms. The sample was made up of *J. curcas* adopters and non *J. curcas* adopters. Existing literature was used as secondary source of information to complement the study. Information on energy security was also collected.

3. The Study Design, Sampling Design and Sample Size

The study design was a cross-sectional survey. The sampling unit for the farmers were households. Purposive non-probability sampling was used to select two *J. curcas* growing locations in each study sites and this involved selecting two divisions from each county i.e Bondo, Shimba Hilss and Kibwezi which were selected based on the population of *J. curcas* farms after which a list of the farmers were prepared. A stratified proportionate sampling was used to select proportional number of farmers from each of the two divisions. At household level, simple random sampling was used to select the households to be interviewed. For comparison purposes households were disintegrated into two, mainly; those that practise *J.curcas* cultivation and those that do not.

Proportionate to size sampling methodology was used to determine the sample size as specified by Anderson *et al.*, (2007) for an infinite population:

$n = z^2pq/e^2$

Where

n=sample size

p =proportion of the population containing the major interest (small holder *J. curcas* farmers)

q = the weighted variable computed as (1-p)

z = 1.96

e =acceptable error precision

For infinite population the sample (n) is as follows

$n = 1,96^2x0.5x0.5/(0.05)^2 = 385$

The exact population in this research was known. The total population of *J. curcas* farmers in all the three sites was 585. The proportionate to size sampling methodology ensured that all selected villages and households had an equal chance of being selected into the survey sample.

4. Results and Discussion

One of the main drivers for adoption of bio-diesel is energy security. Energy security in this study was looked at in terms of the energy sources consumed by the households, whether its cultivation would solve the households' energy needs and the reasons for adoption of *J. curcas.*

4.1. Energy consumed by the households

From figure 1, it can be deduced that biomass is an important source of energy. Generally, more than 68% of the people's energy needs in Kenya are met from biomass resources. Firewood was the most important source of energy with the highest use in Kibwezi (87%), 82% in Bondo and 66% Shimba Hills. This was followed by kerosene (10% in Bondo, 10% in Kibwezi and 1% in Shimba Hills), charcoal (4% in Bondo and 0% in both Kibwezi and Shimba Hills) and electricity (3% in Bondo and 0% in both Bondo and Shimba Hills) where kerosene, electricity and the use of batteries were the main types of lighting energy used. Despite the presence of power lines in the areas, few households could afford electricity for lighting; an indication of increased poverty levels. Only 6% of rural households in Kenya have access to electricity, and 95 % of the rural population depend on firewood or other biomass for cooking and heating (Afrol news, 2010). Battery for lighting purposes (torches) was mostly used in Shimba Hills at 33% and Kibwezi at 2%.

The use of kerosene for heating purposes was higher in Bondo and Kibwezi at 10% each than in Shimba Hills at 1%. The results hence, indicate a high dependency on wood as a source of energy especially used for daily food preparation at household level. Kerosene, like other petroleum products, despite its reliance by the low income households, has become less affordable for low income population in recent years (Tomomatsu and Swallow, 2007). The price for kerosene has gone up by 3.5 times from 1996 to 2005 and the average consumer retail price for kerosene went up 2.5 times from Kshs. 22.03 per litre in 1998 to Kshs. 56.16 per litre in 2006 (Kenya, 2006). The increase in price of kerosene in Kenya 2011, has witnessed the largest increase of 12 per cent with a litre now costing Kshs. 96. This compared favourably with the cost of producing *J. curcas* oil might be most competitive with kerosene when produced in rural areas close to the source of seed supply and far from the source of kerosene production (Tomomatsu and Swallow, 2007).

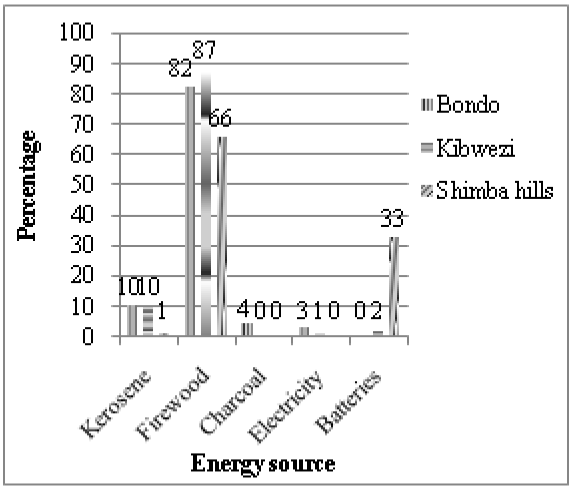

Figure 1: Energy sources consumed by the households' at the three sites

4.2. Cultivation of *J. curcas* for Household Energy Needs

In regard to whether cultivation of this crop would cover energy needs at household level, both adopters and non-adopters of *J. curcas* were interviewed and over 75% of the respondents felt that their energy needs would be solved. In Bondo 78.9%, Kibwezi 82.3% and Shimba Hills 82.5% agreed *J. curcas* oil would solve their energy needs (figure 2). The energy needs in this case for the households was that for cooking and lighting. The major reason the respondents gave out about the use of *J. curcas* oil as their preferred energy source was that it would be a substitute to kerosene and charcoal; therefore, production of *J. curcas* oil will transform the use of kerosene to clean energy since *J. curcas* oil produces clean fuel that lasts relatively longer than kerosene. In this respect, *J. curcas* oil can be used in cooking stoves, reducing dependence on unhealthy and environmentally destructive smoke from charcoal, wood and kerosene. Other respondents felt the use of *J. curcas* would be cheaper because they will harvest the seeds, press and use it immediately for lighting and cooking; especially in Kibwezi and Shimba Hills where there was the highest response due to the distances and nature of transportation.

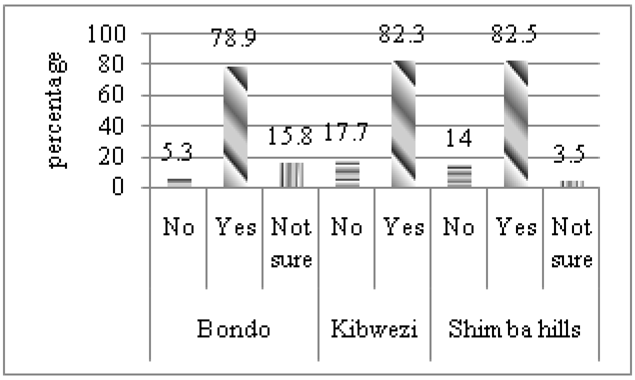

Figure 2: Response on whether *J. curcas* will solve the households' energy needs.

Some respondents said their energy needs would not be covered. Respondents who felt the use of *J. curcas* oil would not solve their energy needs were represented by 5.3% in Bondo, 17.7% in Kibwezi and 14% in Shimba Hills. The reason for relatively high percentage in Kibwezi and Shimba Hills is because there are still pockets of forests and scrublands where respondents would still want to harvest firewood unlike, in Bondo where there are no forests. Most of these respondents were non-*J. curcas* adopters who did not get enough information on the crop and were pessimistic it will survive in the harsh conditions because of the persistent crop failures. They were not in any farmers' association or community based organization leading to the lack of appropriate information on farming activities of *J. curcas*. When there is a new crop, it is sometimes hard for farmers to take in the new idea especially the small-scale farmers who have very small pieces of land. Among those who were not sure of the contribution of *J. curcas* to their energy needs at household level were 15.8% in Bondo and 3.5% in Shimba Hills respectively.

4.3. Reasons for adoption of *J. curcas*

Concerning the use of *J. curcas* oil in regard to energy security, respondents were asked why they chose to adopt this plant. From the survey, majority of the respondents' cultivated *J. curcas* to diversify income; 96.3% in Shimba Hills, 67.3% in Kibwezi and 100% in Bondo (figure 3). One of the income generating activities which is already taking place in Shimba Hills is soap making. *J. curcas* bio-diesel production is expected to contribute to the improvement of rural livelihood because the main production location is in semi-arid areas where poverty levels are high and land productivity is low. In Bondo for example, many farmers had abandoned farming and turned to sand harvesting as an alternative (DEAP, 2007). The introduction of *J. curcas* therefore presented an opportunity for the production of bio-fuel on the already degraded land and at the same time enable the households improve their income. In Shimba Hills 63.3%, 32.1% in Kibwezi and 54.5% in Bondo cultivate *J. curcas* for their own energy supply. The reason being the use of *J. curcas* oil will reduce the dependency on biomass. Cultivating *J. curcas* for own energy supply would hence be suitable for households. Energy security greatly influenced adoption of *J. curcas*.

Besides energy needs, few farmers planted *J. curcas* because neighbouring farmers had them; while others planted because they were encouraged by NGO's to plant the seeds. An example of an NGO which is Norwegian based that encouraged farmers to plant *J. curcas* in Shimba Hills is Energy for Africa Foundation. It helps the farmers press their *J. curcas* seeds for their local consumption. In Kibwezi, KENSOL (Kenya Solution on Energy) an NGO has a seed bank where farmers who have already harvested their proceeds put their seeds in this bank awaiting pressing process once they have attained enough produce. The direct use of oil in engines has not started in Kenya yet, due to the viscosity of *J. curcas* oil. For engine purposes, *J. curcas* oil needs to be transesterified (Gerpen *et al.,* 2004).

Plate 1: *J.curcas* as a hedgerow in Shimba Hills, Kenya

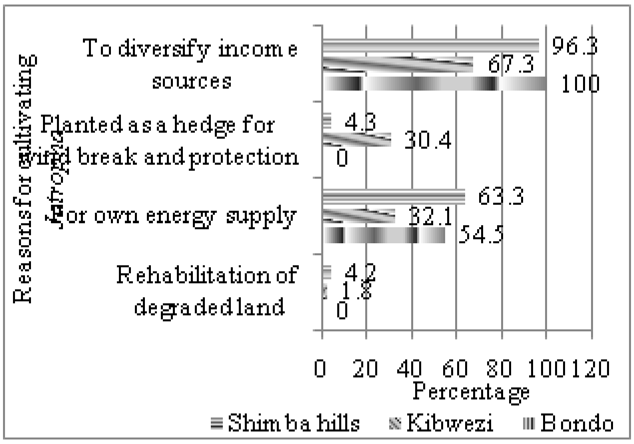

Figure 3: Reasons given by respondents for adoption of *J. curcas*

Other reasons for the adoption of *J. curcas* included planting as a hedge for windbreak and rehabilitation of degraded lands. Only 4.3% and 30.4% of the respondents in Shimba Hills and Kibwezi respectively, planted *J. curcas* as a hedge for wind break and protection from foraging livestock since it is not browsed by animals hence, can be raised as boundary fence or live hedge by a farmer. Heller (1996) and Jongschaap *et al.,* (2007), confirm from their studies that *J. curcas* is suitable for fencing and wind breaks and that it is also effective in combating soil erosion and desertification. While it is not possible to restore land to its original status, rehabilitation attempts to bring some degree of restoration. To illustrate the potential use of *J. curcas* to rehabilitate degraded lands, 4.2 % in Shimba Hills and 1.8% in Kibwezi of the interviewed households cultivated *J. curcas* for rehabilitation of their degraded lands. Therefore, depending on the reasons of the respondents on adopting *J. curcas*, its introduction to the farms will increase vegetation cover, reduce the independence on fossil fuel hence decreased deforestation and also combat soil erosion.

The limited supplies, uneven distribution, and rising costs of fossil fuels, create a need to change to more sustainable energy sources in the foreseeable future. Ensuring environmental sustainability and access to energy services is very key to achieving all the Millennium Development Goals (MDGs). Bio-energy systems if properly harnessed and planned; provide a number of environmental and socio-economic opportunities for Kenya as well as Africa. Bio-energy production can bring investments in land; infrastructure and human resources that could help unlock Kenya's idle potential and positively increase food production. Agricultural development is now viewed as crucial for achieving the Millennium Development Goals, especially for developing or low-income countries (World Bank, 2006). If Kenya can achieve energy security, it can not only free itself from over dependence on fossil fuels but also realize environmental security and a host of other central development and poverty alleviation goals in line with its vision 2030.

5. Conclusion and Recommendations

The findings of this study indicate that there is need to embrace *Jatropha curcas* cultivation for bio-energy production at diversifying income and as well as promoting energy security. More research should be carried out to analyze the cost benefits analysis of cultivating *Jatropha curcas* and reinforce effective strategies to curb energy insecurity.

6. Acknowledgements

We are grateful to Egerton University Graduate School and the Faculty of Environmental Science and Resource Development and the Department of Environmental Science for according us the opportunity to do this study. The reviewers of this manuscript who assisted in adding value to this paper are also appreciated.

References

[1] African News Agency (AFROL News), (2010). Science for a changing world.
[2] Anderson, C. N. K., U. Ramakrishnan., Y. L. Chan. & E.A. Hadly, (2007). Serial SimCoal: a population genetics model for data from multiple populations and points in time. *Bioinformatics*, 21, 1733–1734
[3] Bondo District Development Plan, 1997-2001 and District Environment Action Plan 2006-2011 for Bondo District).
[4] District Environment Action Plan (DEAP) - Bondo District 2006-2011. District Environment Office, Bondo, Kenya
[5] Drought Monitoring Bulletin, (2009). Report from the ministry of state for the development of Northern Kenya and other arid lands resource management project II. Available at www.aridland.go.ke.kajiado.pdf
[6] Gerpen, J.V., B. Shanks., R. Pruszko., D. Clements, & G. Knothe, (2004). Bio diesel Analytical Methods.

Report prepared for national Renewable Energy Laboratory. Colorado, USA

[7] Government of Kenya, (2002a). District Environment Action Plan (DEAP) Bondo District, 2006-2011. District Environment Office, Bondo, Kenya. Ministry of National Environment Management Authority, Nairobi.

[8] GTZ, (2008). A Roadmap for Bio-fuels in Kenya, opportunities and obstacles May 2008. Assessment Study. Beijing, German Technical Cooperation GTZ. (Available at http://www. jatropha.net/gtz-brochure-12.htm).

[9] Heller, J. (1996). Physic nut. *J. curcas L*. Promoting the conservation and use of underutilized and neglected crops. **1**. Institute of Plant Genetics and Crop Plant Research Gatersleban, International Plant Genetic Resources Institute, Rome.

[10] Jongschaap, R.E.E., W.J. Corre., P.S. Bindraban, & W.A. Bandeburg, (2007). Claims and Facts on *J. curcas L*: Global *J. curcas* evaluation, breeding and propagation programme. Plant research International B.V., Wageningen University & Research Centre, Wageningen, the Netherlands, report 158.

[11] Kumar, A., & A. Kumari, (2007). *J. curcas:* high yielding accessions and improvement. Expert seminar on *J. curcas* L. Agronomy and Genetics. Published by FACT Foundation. 26-28 March 2007, Wageningen, the Netherlands.

[12] Tomomatsu, Y., & B. Swallow, (2007). *J. curcas* biodiesel production in Kenya: Economics and potential value chain development for smallholder farmers. World Agro forestry Centre, Nairobi: Working paper No. 54.

[13] World Bank, (2006). Agriculture and Achieving the Millennium Development Goals. Agriculture and Rural Development Department, the World Bank Washington, DC <http://siteresources.worldbank.org/INTARD/Resources/Ag_MDGs_Commplete.pdf> (accessed on 7th May, 2011).

Author Profile

Atalitsa Caren Navalia has a Diploma in Analytical Chemistry from Kisumu Polytechic, B.sc. degree in Industrial Chemistry from Jomo Kenyatta University and M.Sc. degree in Environmental Science from Egerton University. She is currently an Assistant Lecturer in the Department of Environmental Science, Egerton University, Kenya.

Wilkister N. Moturi, Ph.D holds a Ph.D in Environmental Science. In addition, she has attended various professional courses in various parts of the world and won several awards. She is currently a Senior lecturer and chairperson of Environmental Science Department, Egerton University. She has wide knowledge and experience in the field of Environmental Science and has done research and presented papers in various for a. She has published widely in the field of Environmental Health. She is the Kenyan mentor of myclimate; a Swiss based NGO, a reviewer of several journals and the patron of Egerton University Students Association. She is a collaborator with the Family Planning and Environmental Sustainability Assessment (FPESA), a project of the Worldwatch Institute (USA).

Mironga, M. John, Ph.D is a senior lecturer in the Department of Geography, Egerton University. He holds a Ph.D in Geography, Egerton University, Master of Philosophy in Environmental Monitoring and Computerized Cartography, Moi University and Bs.c degree in Forest Resources and Wildlife Management, Moi University

Ogendi, M. George is a Senior lecturer in the Department of Environmental Science, Egerton University, Kenya. He holds a B.Sc in Natural Resources, Egerton University, a M.Sc. in Environmental Science, UNESCO-IHE in the Netherlands and Ph.D in Environmental Geochemistry and Toxicology, Arkansas State University, U.S.A. He is currently the Coordinator Chemeron Dryland Research Training & Ecotourism Centre Egerton University

Koech, K. Henry holds a Master of Science in Environmental Science, Bachelor of Science in Natural Resources Management. He is currently an Assistant Lecturer at the Department of Environmental Science, Egerton University. He has a professional training in Environmental Impact Assessment (Egerton University) and Mainstreaming Climate change in Development (Development Reality Institute.)