Influence of Land Size on Adoption of *Jatropha Curcas* in Yatta District, Kenya

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Abstract
This study investigated how total land size owned influenced *Jatropha curcas* adoption in Yatta District. The study applied quantitative research method where questionnaires were administered to 240 respondents selected through multi-stage sampling technique. Data analysis was carried out using regression analysis and chi square test. It was found that farmers who had adopted *Jatropha curcas* cultivation were significantly low at 15.4%. It was also found that total land size owned was not a major factor influencing land size allocated to *Jatropha* cultivation since total land size owned accounted for only 28% variance of land size allocated to *Jatropha* cultivation and 78% of respondents were not willing to convert their pasture lands to *Jatropha* farms. An area of 248 acres was under *Jatropha* cultivation in the district which is equivalent to 0.038% of the total district area coverage. It was concluded that adoption of *Jatropha* in Yatta District was low. There was a negative correlation between total land size owned and land size allocated to *Jatropha* cultivation. Total land size owned did not have substantial influence on size of land allocated to *Jatropha* cultivation as willingness to convert pasture land to *Jatropha* farms, lack of alternative land for farming, land tenure and control and population density influenced on land size allocated to *Jatropha* cultivation.
Keywords: Adoption; ASALs; Biofuels; *Jatropha Curcas*; Yatta District.

1 Introduction

The current debate on climate change and rising oil prices has generated a great deal of interest in renewable energy resources such as biofuels. Currently the global economy is threatened by the finite nature and dwindling fossil fuel reserves, the volatility of petroleum fuel price and the possibility of supply disruption. The projected growth of the world economy which would result in an increase in petroleum fuel demand, in particular for the transport sector from 85million barrels/day to 330million barrels/day by 2020 is expected to amplify the problem and uncertainty (EU, 2006). All developing countries desire to be industrialized including Kenya which aspires to be industrialized by 2030 (GOK, 2010).

In Kenya the three main sources of energy which include wood fuel, petroleum and electricity account for 70%, 21%, and 9% of total energy use respectively. Wood fuels are used heavily by the household sector for domestic requirements (Kituyi, 2002). Not only have petroleum products remained 100% imported in the country in spite of recent discoveries in Northern Kenya, there is also the problem of rising and volatile prices of the crude oil (GOK, 2007). Over-reliance of fossil fuels in the country has increased air pollution by increasing emission of Green House Gases (GHGs) from these convectional fuels.

Liquid fuels derived from biomass also known to as biofuels are emerging as alternative fuels that could help manage the problem of the ever-increasing demand of oil thus providing energy security, mitigate the environmental problems arising from use of fossil fuels and stimulate rural development in Africa (Yamba, 2007). Biofuels can also revolutionize economies of agricultural farming communities, especially in Arid and Semi Arid Lands (ASALs). Due to the low population, the ASALs are considered to have large tracks of land with marginal agricultural activities. *Jatropha curcas* (referred herein as *Jatropha*) biodiesel crop is focused as the most suitable oil crop since it is non-food and can grow well in poor soils, hot and dry regions where food crops cannot thrive well (Jongschaap et al. 2007).

Despite the potentially important role *Jatropha* can play in Yatta District and notwithstanding the many agencies such as NGOs, private investors and churches involved in the promotion of *Jatropha curcas* cultivation in the country, its uptake remains low. This may perhaps be as a result of unavailability of land for *Jatropha curcas* cultivation. On that basis, this research work was undertaken to determine how total land size owned by farmers influence the adoption of *Jatropha curcas* cultivation.

2 Literature Review

Availability and access to land is an important factor to ensure successful adoption of a new cash crop and consequent agricultural development (Peters and Thielman, 2008). *J. curcas* cultivation is suitable in marginal land and in wastelands (Jongschaap *et al.,* 2007). Marginal land is defined as unsuitable for agricultural crop production due to low nutrient content in soil or climate constraints while wasteland is described as degraded land which can be brought under vegetative cover with reasonable effort and which is currently underutilized and/or land which is deteriorating for lack of appropriate water and soil management or on account of natural causes. Wastelands can result from inherent or imposed disabilities such as location, environment, chemical and physical properties of the soil or financial or management constraints (Jongschaap *et al.,* 2007).

Production of *J. curcas* plant for biodiesel production in Africa requires considerations on land availability. Unused potential agricultural land that can be converted for biomass energy supply in the continent is estimated to be 750Mha (Alexandratos, 1995). This land is potential and should be available for intensive cultivation of *Jatropha* leading to increased biodiesel production (Overend, 2007).

To increase *Jatropha* adoption in India, the government declared over 65 million hectares of land as wasteland in 2005 and another 174 million hectares declared as marginal land all which was committed for *J. curcas* cultivation the increased adoption of *Jatropha* cultivation (Sharma and Pradesh, 2006). According to Muller (2007), Tanzanian government planned to increase adoption by committing close to 20,000 hectares of land for *J. curcas* cultivation. This would be achieved through collaborations with private companies such as Sun Biofuels and GTZ and thus adoption is expected to go up.

Land is perceived as abundant for intensive cultivation of *Jatropha* in marginal areas which cover 83% of total area in Kenya (GOK, 2004). Yatta District which covers 246,700 hectares lies in the ASAL regions of the country therefore suitable for *J. curcas* cultivation. *Jatropha* requires extensive land for high yields to be realized and therefore marginal lands and wastelands are deemed appropriate to avoid competition with food.

3 Materials and Methods

3.1 Location and size

Yatta District covers an estimated area of 2497 Km^2 and is located within a latitude of -1.47 (1° 28' 0 S) and a longitude of 37.83 (37° 49' 60 E. The district borders Thika district to the North Western side, Kitui and Mwingi districts to the Eastern side, Machakos district to the Southern side, Maragwa district to the North and Mbeere district to the North Eastern side.

3.2 Agro-climatic conditions

Yatta District lies in Zone IV - V of the Agro-climatic classification of Kenya which refers to a marginal area that is highly risky but few types of crops growing, and with rainfall lying between 400mm-800mm (Braun *et al.,* 1982). Specifically, Yatta District is generally warm and dry during most part of the year except for some torrential and erratic rains experienced in the months of March and December. The mean monthly temperature ranges from 29 ^{0}C in the coldest months to 36 ^{0}C in the hottest months resulting in low or no yields in rain-fed agriculture. Despite these low yields, agriculture remains an important source of livelihood in the district currently.

The topography of the district is varied and rises from 500 m above sea level on the southern part of the district to 1200 m above sea level in the northern part. As indicated, a huge proportion of the district is semi-arid and receives very little and erratic rainfall. There are two rainy seasons: the long and the short rains. The annual average rainfall varies from 350-600 mm with high attitude areas receiving more rainfall than low attitude regions. However there has been gradual decline of rainfall since 1992 (GOK, 2004). The soils in the district are mainly sandy, rocky and acidic. Vegetation in the district varies with altitude although most of it has been depleted due to human activities like charcoal production.

3.3 Socio- economic activities

According to the 2009 census report, the district has a population of approximately 424,500 people consisting of 48.8% male and 51.2% female, with majority of the population being young with 56.7% ranging between 20 – 35 years. The total number of households in the district is 84,900, mainly settling around water sources and where soils are fertile (GOK, 2010). This leaves a big chunk of land in the district under-utilized.

There is a recurrent food shortage in the district because the soils are poor and the rains are not adequate to enhance good yields thus the population dependents on regular relief food. According to the welfare monitoring survey of 1997, Yatta District has 87.3 % of the population living below the poverty line (GOK, 2002). It is however clear that due to the high poverty levels in the district, most of people rely on traditional biomass as the major sources of energy and thus charcoal production is also a source of income leading to increased deforestation and indoor air pollution therefore extensive *Jatropha curcas* cultivation would play an important role in creating job opportunities and reclaiming degraded land.

3.4 Research design and data collection

This study is descriptive in nature and causal-comparative research design was employed. Both quantitative and qualitative research methods were applied. The quantitative research method entailed use of household (HH) questionnaires while the qualitative research method entailed in-depth interviews, Focus Group Discussions and observations.

Yatta District was selected purposively since it was one of the districts where pilot programs for *Jatropha* cultivation were undertaken by GAF. Two divisions in the district namely Masinga and Yatta were also selected purposively on the basis of their population and size. Cluster sampling method was used to choose four locations in the selected divisions. A multi-stage sampling technique was applied to select respondents 240 respondents as the sample population.

Data was collected by the investigator with the help of a well structured household questionnaire, and in-depth interviews employing personal contact with government officials, and NGO officials to collect information of land availability and land use issues in the district.

3.5 Hypothesis testing

Regression analysis was used to test whether total land size owned by the farmers determined the size of land allocated to *Jatropha curcas* cultivation. The R value was used to show the correlation of the two variables while the R square value showed how much variance of the dependent variable (land size allocated to *Jatropha* cultivation) can be explained by the independent variable (total land size owned).

The regression model below was applied in this study.

H_0: $\beta_1 = 0$ $\therefore$ $Y = \beta_0$
H_1: $\beta_1 \neq 0$ $\therefore Y = \beta_0 + \beta_1 X$

Where;

Y – Land size allocated to *Jatropha curcas* cultivation

X – Total land size owned

β_0 – Y intercept

β_1 – Slope

Both β_0 and β_1 values were obtained and t statistic done to qualify whether coefficients of beta values are different from zero. Parameter estimate table was given to present the results. Other factors influencing land size allocated for *Jatropha* such as lack of alternative land for farming, population density and lack of land access and control were identified, their frequencies given and bar graphs used to present results.

4 Results

4.1 Adoption of Jatropha curcas cultivation in Yatta District

Adoption in Yatta District was 15.4% significantly lower compared to 84.6% of farmers who did not engage in *J. curcas* cultivation ($\chi^2 = 105.92$, p = 0.000). Adoption in Yatta division was 20.4% wherelse in Masinga division adoption was found to be lower as shown in Figure 1. However, there was no significant difference in the adoption levels of the two divisions ($\chi^2 = 3.71$, p = 0.054).

4.2 Land use in Yatta District

Respondents were found to own mean land size of 11.8 acres which was apportioned in to different uses as shown in Table 1 Mean land allocation for *J. curcas* production was 0.24 acres per household accounting for 0.2% of total land owned. Livestock production and crop farming were allocated 50% and 40.7% of total land owned respectively implying that they were the main economic activities in the district. It was found that mean land allocated to *Jatropha* cultivation was significantly lower compared to mean land allocated to crop farming (t = 19.13, p = 0.000) and livestock production (t = 31.88, p = 0.000). Although it was expected that *J. curcas* production would be allocated substantial land size due to the high intensity of land degradation in the region and need to boost rural development, findings from this study were contrary.

4.3 Influence of land size on J. curcas cultivation

To compare total land size owned by farmers and the size of land allocated to *J. curcas* cultivation, regression analysis was done. It was found that total land size owned accounted for 28% (R square = 0.280) influence on land size allocated to *J. curcas* cultivation. Whereas, it was expected that farmers with bigger sizes of land are likely to allocate bigger land sizes for *J. curcas* cultivation, results showed that land size owned and land size allocated to *J. curcas* was negatively correlated (R = - 0.529). The simple linear regression equation was as illustrated in equation 1.

$$Y = 0.095 - 0.003X \quad \text{.......... Eqn 1}$$

Allocation of lesser land to *J. curcas* cultivation by farmers owning bigger sizes of land was to a great extent attributed to the high economic returns obtained from farm enterprises compared to their counterparts with lesser land.

4.4 Additional factors influencing land allocation to Jatropha curcas cultivation

Other factors identified influencing land allocation to *J. curcas* cultivation apart from land size owned were land access and control, population density and lack of suitable land for farming as shown in Figure 2. These factors differed among 95.5% of farmers who inherited land and the minority 4.1% of farmers who purchased land.

Land access and control was significantly the highest constraint to allocation of land for *J. curcas* cultivation amongst farmers who inherited their land at 71.8% (χ^2 = 15.60, p = 0.000) while lack of alternative land for farming was significantly the greatest constraint to land allocation for *J. curcas* cultivation among farmers who acquired land through purchase at 80% (χ^2 = 13.64, p = 0.000).

Lack of title deeds in the region inhibited most young farmers from acquiring credits from banks and other microfinance institutions for capital to intensify or engage in *J. curcas* production. Although government surveyors had done survey to farms in the district by 2009, title deeds had not been given out. Worse still, farmers who inherited their land highlighted that their land was under their parents' name because they were preventing any sale of the land by the younger generation.

Third constraint was population pressure reported in the two divisions, manifested through the ever growing population. Respondents in both divisions noted that land-holdings had decreased since migration to the district after independence and that there was less land available to pass on to offspring. While farmers in both divisions experienced the effects of population pressure on available land, farmers who purchased their land were significantly higher at 16.4% as compared to those who inherited at 5.2% (χ^2 = 4.53, p = 0.033).

4.5 Availability of pasturelands for Jatropha curcas cultivation

Ability of *J. curcas* to grow and be cultivated on marginal lands not used for crop production is one of the often highlighted benefits. Evaluating the land allocated for free grazing of inter-species composition was undertaken to identify if land was adequately utilized. Comparison of inter-species composition of different holdings is done in terms of the relative total live weight known as biomass of the different species, rather than in terms of their numbers. This is because relative biomass roughly parallels both relative output and relative pressure exerted on feed supplies. The unit used to measure animal biomass is kilograms of live weight referred to as Tropical Livestock Unit (TLU) which is the equivalent of 250 kg of biomass implying one mature zebu cow, 10 sheep, 12 goats or two donkeys (ILCA, 1990). It was reported that in Yatta District on average farmers owned 7 goats and 4 zebu cows and one donkey with a total live weight of 570kg calculated as shown in equation 2.

$$T = (N \times S) \times A \quad \text{.......... Eqn 2}$$

Where;

T = Total biomass

N = Number of animals

S = Species Weight

A = Average biomass equivalent

Species weights of selected animals and average biomass equivalent are provided in Table 2. Total live weight per livestock unit in Yatta district was found to be 570kg which is higher than the recommended 250 Kg of one Tropical Livestock Unit (TLU) implying mature zebu cow, 10 sheep, 12 goats or two donkeys.

On average farmers in Yatta district allocated 2.387 hectares per 570kg live weight equivalent to 1.05 ha/TLU against the recommended 2.1ha/TLU which is insufficient making the region prone to overgrazing. It is implied that any further reduction of the land for other activities like *J. curcas* cultivation would increase soil degradation through overgrazing.

It was clear that land in the district was not enough to expand *J. curcas* activities in pasture lands and still maintain the same number of livestock. Another key factor hindering that expansion was the unwillingness of the farmers to shift from livestock production to *J. curcas* production. As shown in Figure 3, 78% of all respondents were unwilling to convert their pasture land to *J. curcas* farms.

4.6 Estimating land size under Jatropha curcas cultivation in Yatta District

Average land size allocated for *J. curcas* cultivation was found to be 0.24 acres per household. Estimated total number of households in Yatta District was 84,900 with a mean household size of 5. At 15.4% adoption level, total number of households in the district growing *J. curcas* was 13,074 calculated as shown in equation 3.

$$e = G \times E \quad \text{Eqn 3}$$

Where;

e = Number of households engaged in *Jatropha* cultivation

G = Adoption level

E = Total households in the district

Consequently, total size of land allocated to *J. curcas* cultivation in Yatta District was 3,137 acres obtained by extrapolation from estimated land allocated to *Jatropha* cultivation per HH as indicated in equation 4.

$$L = l \times e \quad \text{Eqn 4}$$

Where;

L = Land allocated to *Jatropha* cultivation in Yatta District

l = Land allocated to *Jatropha* cultivation per HH in Yatta District

e = As defined in equation 3

On average 77 plants survived out of the average 97 *Jatropha* plants grown per HH implying that not all land allocated for *J. curcas* cultivation was actually under *J. curcas* because of high plant failure during early years of growth. To estimate total land size under *J. curcas* coverage, it was assumed that average *Jatropha* plants per HH were planted with spacing of 1 meter by 1 meter. Therefore acreage under *J. curcas* per household was found to be 0.019 acres determined as indicated in equation 5.

$$c = jp \times SP \quad \text{Eqn 5}$$

Where;

c = Land under *Jatropha* cultivation per HH

jp = Average *Jatropha* plants per HH in the district

SP = Acreage under one *Jatropha* plant

Consequently, total land under *J. curcas* cultivation in the district was 248.4 acres equivalent to 0.038% of total acreage obtained by extrapolation from estimated land under *Jatropha* cultivation per HH as illustrated in equation 6.

$$C = c \times e \quad \text{Eqn 6}$$

Where;

C = Total land under *Jatropha* cultivation in Yatta District

c = As defined in equation 5

e = As defined in equation 3

Presumed underutilized land allocated for *J. curcas* cultivation per household was 0.221acres calculated as illustrated in equation 7.

$$u = l - c \qquad \text{Eqn 7}$$

Where;

u = Underutilized land meant for *Jatropha* cultivation per HH

l = As defined in equation 4

c = As defined in equation 5

As a result overall underutilized land allocated to *J. curcas* cultivation in the district was 2,889.4 acres obtained by extrapolation from estimated underutilized land per HH as shown in equation 8.

$$U = u \times e \qquad \text{Eqn 8}$$

Where;

U = Total underutilized land allocated to *Jatropha* cultivation in Yatta district

e = As defined in equation 3

u = As defined in equation 7

5 Discussions

5.1 Jatropha curcas adoption in Yatta District

Cultivation of *J. curcas* in the ASALs in the country among them Yatta District has been suggested by NGOs, private investors and research organizations as an alternative activity in utilization of marginal land and revitalization of rural economies. However, despite the numerous programs promoting *J. curcas* cultivation in Yatta District, its adoption remained low.

Low adoption in the district was to a great extent attributed to numerous factors identified and analyzed as key drivers for sustainable adoption process. Some of the factors are inefficient strategies used in promotion, land unavailability, low profitability compared to main crops and a myriad of challenges identified such as lack of market and marketing facilities, inadequate knowledge on cultivation practices and attitude of farmers towards *J. curcas*. This finding concur with Mitchell (2008) that some of the key issues inhibiting take up of *J. curcas* are land unavailability, low profitability of *J. curcas* and market unavailability.

5.2 Influence of total land size owned on land allocated to Jatropha cultivation

Although land in marginal areas is perceived as abundant especially for activities like *Jatropha* cultivation, analysis from this study suggested otherwise. Mean land allocation for *J. curcas* production was very low at 0.2% of total land owned compared to 50% land size allocated to livestock and 40.7% land size allocated to crop production. Overall total land under *J. curcas* cultivation in the district was less than 0.038% of the total district acreage confirming that *J. curcas* cultivation is still marginalized in the ASALs contrary to GAF (2008) who indicated that the area under *J. curcas* in Yatta District is more than 0.2% of the total district coverage.

Total size of land owned had little influence on land size allocated to *Jatropha* cultivation. This was greatly attributed to the reality that expansion of land for *J. curcas* production, even if it is marginal land would mean farmers have to find other places for collecting firewood, herbs and fields for pasture. This finding was of the same opinion as Tanja *et al.*, (2009) that though land is marginal and under-utilized, it may not be available for *J. curcas* production due to economic and socio-cultural factors prevailing in those regions.

The study revealed that there was a strong negative correlation between the size of land a farmer owned and the size of land allocated for *J. curcas* cultivation implying the bigger the size of land a farmer has, the less likely for them to engage in *Jatropha* cultivation. Farmers with lesser land size were more likely to take up *J. curcas* cultivation because they mostly seek for a more economically rewarding enterprise to boost their low incomes as opposed to their counterparts with bigger land sizes. Size of land owned was not a key factor contributing to increase in adoption of *J. curcas*.

To enhance *J. curcas* cultivation, it is vital to ensure accessibility and availability of land. It was found that customary systems of land control limit options available for young interested farmers to engage in *J. curcas* cultivation. Lack of alternative land for cultivation was also a major factor inhibiting the availability of land for *J. curcas* cultivation. This finding agreed with Peters and Thielman (2008) that access to land is a key constraint to agricultural development and improved adoption of a new cash crop. This finding also confirmed that access to new land suitable for cultivation and capacity to intensify existing land determines whether small-scale farmers adopt a new crop.

Provision of land title deeds by the government would increase chances of *J. curcas* farmers to access credit from financial institution. Since land title deeds were not available in Yatta District, lack of finances was viewed by *J. curcas* farmers as a key impediment to adoption. This implied that it was difficult for farmers to intensify or commercialize *J. curcas* cultivation.

5.3 Availability of pasturelands for Jatropha curcas cultivation

Unwillingness of farmers to intensify *J. curcas* cultivation in pasturelands was one of the key impediments to increased take up of *Jatropha* cultivation. *J. curcas* cultivation could be a big threat to rural livelihood if not addressed in a holistic manner. Land allocated per livestock unit was not enough according to recommended carrying capacities for zone V in Kenya implying that further reduction of pasture land to *Jatropha* activities would increase overgrazing and subsequent soil degradation.

This finding agreed with Tanja *et al.*, (2009) that growing of *J. curcas* on scarce pastureland should not be regarded as any less of a threat to food security than the direct displacement of food crops. A shortage of fodder may result in poor livestock condition or depleted numbers and reduce the capacity of the household to cope with affected productivity.

6 Conclusions

There was a negative correlation between total land size owned and land size allocated to *Jatropha* cultivation. Total land size owned had no substantial influence on size of land allocated to *Jatropha* cultivation. Population density, willingness to convert pasture land to *Jatropha* farms, lack of alternative land for farming and land control and tenure had considerable influence on land size allocated to *Jatropha* cultivation.

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Figures and Tables

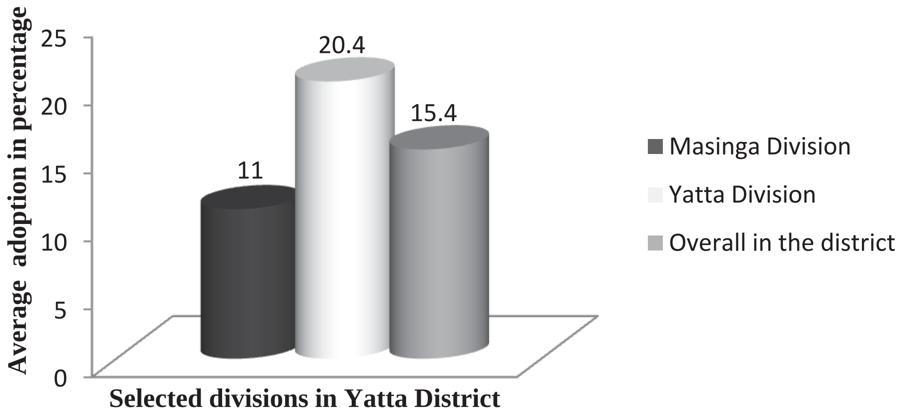

Figure 1: Adoption of *Jatropha curcas* cultivation in sample divisions

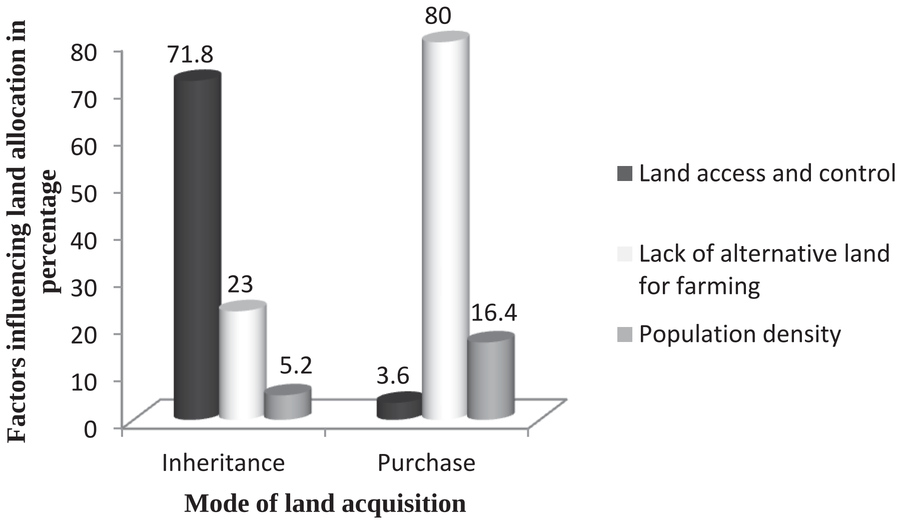

Figure 2: Factors influencing land availability for *Jatropha* cultivation in Yatta District

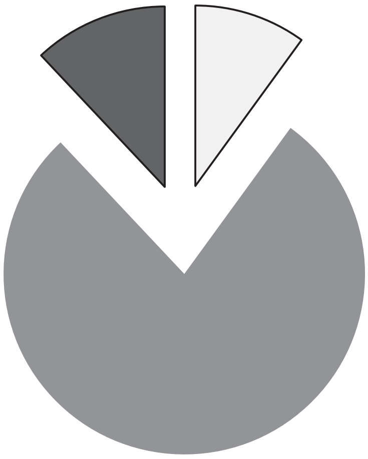

Figure 3: Willingness of farmers to intensify *Jatropha* cultivation in pasturelands

Table 1: Land allocation for various uses in Yatta District

Land use	**Mean Acres**	**Std. Dev**
Grazing of livestock	5.9	1.9
Crop production	4.8	1.9
Settlement	0.18	0.12
J. curcas cultivation	0.24	0.021

Table 2: Average body weights and biomass equivalent for selected animals in sub-Saharan Africa

	Species body weight (kg)	**Biomass equivalent**
Camels	250	1.0
Cattle	175	0.7
Sheep	25	0.1
Goats	25	0.1
Donkeys	125	0.5

Source: ILCA, 1990