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Integration of Non-Food Biofuel Feedstock Enterprise in Smallholder Farms in Nyeri, Laikipia and Lamu Counties, Kenya

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Abstract
Agricultural farming is a predominant enterprise in developing countries and mainly Africa. This is attributed to land availability, abundant labour from its vast population, favourable climatic conditions and food demand among other factors. Most of the rural households depend on subsistence farming to meet their food requirements with minimal commercialization which mainly target the export market. There is thus need for caution on introduction of another enterprise in the smallholder farms so as not to distort the vulnerable food production enterprise. There is however evidence that most farms are not optimally being utilized. Hence increasing on the portfolio of the farm enterprises on the household level need not necessarily hinder or reduce their food production capabilities. One such additional enterprise could be non-food biofuel feedstock farming which has a dual potential of generating income and as a source of energy in the households. In Kenya, biofuel potential production areas have been zoned taking cognizance of the food production requirements, climatic conditions and biodiversity requirements in the midst of the energy demand and supply situations prevailing in the country. There is however ample evidence that the taking up of biofuel feedstock farming by the smallholder farmers is slow even though the government and a number of non-governmental organizations are deeply involved in its promotion. The study thus seeks to identify the factors within the smallholder farms that hinder the adoption of the Jatropha and Croton biofuel feedstock. A survey was conducted in three agro-ecological zones being Laikipia, Nyeri and Lamu of which a representative random sample of 273 was selected for the study with 136 having the crop in their farms and 137 being the control group. The study used a logistic regression econometric model sorted by crop type to take care of the uniqueness of each crop in terms of their agro-ecological requirements. The factors that influence the integration of croton in the smallholder farms are household size and proximity to the urban centre. Gender of the household head, land size and access to off-farm farm income were the main determinants of farmers' decision to adoption of Jathropa.
Keywords: biodiesel, biofuel, feedstock, integration

Introduction

Agricultural farming activities dominate most of the enterprises in developing countries and mainly Africa. This is attributed to land availability (Maltitz *et al*, 2009), abundant labour from its vast population, favourable climatic conditions and food demand among other factors. The local markets are however not fully developed and at best mainly targeted to export; making most of the rural households depend on subsistence farming to meet their food requirements. Smallholder households' farming is thus mainly engaged in meeting their food needs with minimal surplus for sale. It's then arguable that there is need for caution on introduction of another enterprise in the smallholder farms so as not to distort the vulnerable food enterprise.

There is however evidence that most farms are not optimally being utilized. Hence increasing on the portfolio of the enterprises on the household level need not necessarily hinder or reduce their food production capabilities. One such additional enterprise could be biofuel feedstock farming which has the potential of generating income and as a source of energy in the households. This would also have the most significant impact on food security and poverty reduction as the establishment of biofuel processing plants and other agro-industries can generate employment opportunities and other livelihood activities for the rural population (Malik *et al*, 2009).The global outlook for biofuels rests on a number of interrelated factors.The future price of oil, the availability of low-cost feedstock, technological breakthroughs that could reduce the cost of second generation biofuels, competition from unconventional fossil fuel alternatives and sustained commitment to supportive policies by governments (Sombilla *et al*, 2009), are the factors that need consideration. The recent increases in fossil oil prices have made oil imports a major component of the current account deficits of most developing countries (Malik, 2009). There is thus a need to explore the potential in biofuel as a source of energy. While there is the potential to provide more energy self-sufficiency for many tropical countries through the production of biofuels, the costs of large-scale production are high in both monetary and social terms (Van Wey, 2009). Large scale production will also necessitate the coming up of large scale plantations which will distort the social settings of the local communities and transfer most of the land to large scale producers hence making them more

vulnerable. Van Wey (2009) further pointed out that if development programs target small communities for the local production of electricity using biofuels, intra-country inequalities in lived experience can be reduced and can improve intra-community equality as well. National governments can also formulate new policies that promote the sustained development of biofuels and create an environment in which biofuel businesses—whether large or small in scale—can flourish without compromising food production and inflating food prices (Sombilla *et al*, 2009). Hence making smallholder farm production of the feedstock feasible in terms of the gains and costs involved. This in agreement with the assertion that within the developing world, and especially Africa, biofuels, are regarded as a potential mechanism to stimulate agricultural development, create jobs and save foreign exchange (Maltitz *et al*, 2009).

Although a good number of biofuel feedstock is food products e.g. corn and sugar, there are also non-food feedstock. Croton and Jatropa are some of such plants with capabilities of growing in marginal areas which could otherwise not be used in rain-fed food production. Most studies have cautioned against the global drive towards a biofuels economy, highlighting the potential impacts on food security (Maltitz *et al*, 2009) and hence care should be exercised in integrating the feedstock in the farms so as not to crowd out the food crops and for optimal energy output to be realized. The biofuel should also be carefully integrated into the energy distribution system while taking into account the already existing infrastructure. Biofuel blends can however use the same pumping infrastructure and equipment as the traditional petroleum based fuels and no modifications are necessary for petrol or diesel vehicles using low level blends (Malik *et al*, 2009). The storage potentiality of biofuel also makes it more viable as compared to the liquefied petroleum gas (LPG) and the compressed natural gas (CNG). It is also alluded that greenhouse gas (GHG) reduction estimates for the non-food feedstock like Jatropa are highest besides its ability to reduce other harmful air pollutants generated with the use of fuelwood and other biomass (Malik *et al*, 2009; Sombilla *et al*, 2009). Such pollution could result to wide negative health impacts especially those related to respiratory diseases that can impair one's ability to work fully and effectively. In Kenya, biofuel potential production areas have been zoned taking cognizance of the food production requirements, climatic conditions and biodiversity requirements in the midst of the energy demand and supply situations prevailing in the country. In the light of the success of integration of biofuel feedstock in most countries, there is need to identify the constraints of the same not to be replicated in Kenya. It should be investigated in the context of potential in biofuel production to attract the needed investment and new technologies to invigorate the neglected agriculture sector and promote further reduction in poverty especially when the small farmers are closely integrated in the whole biofuel supply chain (Malik *et al*, 2009; Sombilla *et al*, 2009). It can further be deduced that the diversification of agriculture and the establishment of processing plants create job opportunities which translate into increased household income and improved welfare.

Materials and Methods

The study was conducted in Laikipia, Nyeri and Lamu regions of Kenya beingpart of the areas identified by the mapping team as potential areas for biofuel feedstock production (Muok *et al*., 2010).

The study employed a logistic regression model as specified in equation 1 below,

$$\mathbf{Logit(Y)} = \left[\frac{\pi}{1-\pi}\right] = \boldsymbol{\alpha} + \sum_i^n \boldsymbol{\beta_i X_i} \quad \text{.....Equation 1}$$

Therefore,

π=Probability (Y=outcome of interest|$X_1=x_1$, $X_2=x_2$... $X_n=x_n$)

$$= \frac{e^{\propto+\sum_i^n \beta_i x_i}}{1+e^{\propto+\sum_i^n \beta_i x_i}} \text{.....Equation 1}$$

Where π is the probability of the event, α is the Y intercept, β_s are regression coefficients, and X_s are a set of predictors being age, education and gender of the household head, membership to group, access to off-farm income, value of output from farming, size of land available to household, and distance to the nearest urban market. The parameters α and β_s are typically estimated by the maximum likelihood (ML) method (eqn 3).

$$\mathbf{Log-likelihood} = \sum_{i=1}^{n}\{\boldsymbol{Y_i}\mathbf{ln}(\boldsymbol{P(Y_i)} + (\mathbf{1}-\boldsymbol{Y_i})\boldsymbol{ln}[\mathbf{1}-\boldsymbol{P(Y_i)}]\} \text{ ….…..Equation 1}$$

Results and Discussion

The factors that are significant in influencing the household decision to integrate the biofuel feedstock plants in their farms as estimated by logistic regression vary by region and on the type of plant. The study area was mainly divided in two regions with Lamu being along the coastal part of Kenya whereas Nyeri and Laikipia representing the highland and lowland areas respectively of which they are both marked out as potential arrears for the biofuel enterprises.

Along the coastal region, the main biofuel crop that was predominant was Jathropa and hence the factors that affects the growing of the biofuel crops in the region could as well be taken to be the factors that influences the cultivation of Jathropa. It is thus noteworthy to point out that the two crops, that is, Jathropa and Croton have significant differences in terms of time to produce nuts, size of plant and cropping system employed in their farming. Jathropa does well under intercropping system since the short height of the crop does form a canopy for the other crops mainly being legumes and cereals.Croton on the other hand is a tall plant that can only be grown along the fence and on areas where crop production is not being undertaken because of its canopy effect.

The study thus analyzed the data from the two regions differently to take care of the regional effects and the variations in the biofuel crop enterprises undertaken in the regions. In the Nyeri and Laikipia region, the factors that were significant in determining the integration of biofuel feedstock (Croton) in the smallholder farm was mainly the household size and the proximity of the household to the nearest urban market centre (Table 1). The larger the household size the lesser the odds ratio in favour of integration of biofuel feedstock plants in the household's farm. Large household size indicate more demand for food and given the failure of the markets in most developing countries, the households will need more land space for subsistence food production. This will thus necessitate that the likelihood of the household to incorporate another farming enterprise that demands on land space is adversely affected the larger the household size.

The probability of the household to integrate the biofuel crop also reduces the more near a household is to the urban centre. This could be explained by a number of effects that faces the household as its proximity to an urban market centre improves. The value of food products increases and makes them more profitable given the ease of access to high value market in the urban. Access to good road infrastructure also links up the households to other high value markets within the country. Hence households located near to urban centre will not engage in the biofuel feedstock production given the competition from production of food crops and pasture for livestock given the high prices for both the food crop output and livestock products.

Table 1: Logistic regression factors that influences integration of biofuel feedstock in household farms in Laikipia and Nyeri County.

Independent variables	Odds Ratio	Coef.	Std. Err.	z	P>|z|
Distance to urban	0.941	-0.061	0.028	-2.190	0.028
Off-Farm income	0.759	-0.276	0.395	-0.700	0.484
Group membership	1.005	0.005	0.386	0.010	0.989
Farm output	1.000	0.000	0.000	1.110	0.266
Household size	0.785	-0.243	0.094	-2.570	0.010
Education of household head	1.009	0.009	0.061	0.150	0.878
Age of household head	1.016	0.016	0.014	1.100	0.271
Log of household assets	1.027	1.027	0.165	0.160	0.874
Gender of household head	0.682	-0.382	0.397	-0.960	0.336
Log of household land size	0.960	0.960	0.067	-0.610	0.541
Constant	-	0.230	1.962	0.120	0.907
Number of Observations	168				
LR of χ^2	27.230				
Probability > χ^2	0.002				
Pseudo R^2	0.121				
Log Likelihood ratio	-99.370				

Dependent variable is whether a household integrated the biofuel feedstock or not

Jathropa is the main biofuel crop in the coastal region. Besides its potential due to its intercropping capabilities, its oil production potentiality is enhanced by the harsh semi-arid weather conditions prevailing in the coastal areas. The factors that are of significant influence in determining the probability of integration of Jathropa are access to off-farm income, gender of household head and household land size (Table 2). Access to off-farm income reduces the probability of incorporating biofuel feedstock production enterprise within household farms. It thus follows that most of the household will participate in biofuel enterprises only if they either do not have the capacity i.e. technical and/or capital to engage in off-farm activities.

The gender of the household head influence on the taking up of the biofuel enterprise in the farms is in favour of women. Given the fact that most household grow the crops under an intercropping system imply that the men often do not take much consideration about the enterprise. Most of the households in the farms where they grow Jathropa got those farms from the government as a settlement scheme and hence were issued to both males and females irrespective of their marital status. Hence most of the female headed households imply that they are single parents and hence have more economic challenges and would thus be more likely to diversify on farm enterprises than the male headed households.

The size of land available to the household influenced positively the probability of taking up the

biofuel enterprise in the smallholder farms. The larger the land size available for farming activities within a household, the higher the chance that the households will have excess capacity to take up an additional farm enterprise besides food production. The land sizes of the households in the study are for the households who had incorporated biofuel plants in their farms are larger, both the land available and land under crop production (Appendix A).

Table 2: Logistic regression factors that influences integration of biofuel feedstock in household farms in Lamu County.

Independent variables	Odds Ratio	Coef.	Std. Err.	z	P>|z|
Distance to urban	1.070	0.067	0.066	1.020	0.306
Off-Farm income	0.239	-1.431	0.543	-2.630	0.008
Group membership	0.777	-0.252	0.557	-0.450	0.651
Farm output	1.000	0.000	0.000	1.120	0.261
Household size	1.059	0.057	0.095	0.600	0.547
Education of household head	1.052	0.050	0.056	0.900	0.366
Age of household head	1.008	0.008	0.019	0.440	0.663
Log of household assets	0.869	0.869	0.132	-1.070	0.285
Gender of household head	3.407	1.226	0.577	2.120	0.034
Log of household land size	1.242	1.242	0.097	2.230	0.026
Constant	-	-1.652	1.904	-0.870	0.386
Number of Observations	105				
LR of χ^2	24.780				
Probability > χ^2	0.006				
Pseudo R^2	0.184				
Log Likelihood ratio	-55.118				

Conclusion

It is subsequently noteworthy that though the default thinking among development agents is that development of biofuel industry is synonymous with food insecurity, there are non-food raw materials that can be used for bioenergy production. Jathropa and Croton are two such non-food products which besides them not posing any threat for food production, they do well in marginal areas that cannot support the cultivation of the main stable food crops.The challenge of food insecurity besides being correlated to diversion of food crops for biofuel production has its own other unique causes. The markets for food products should as a way to address food supply problems be strengthened and be pro-poor so as to smoothen regional imbalances in access to food.

Energy is also a major driver of economic development for any country and thus should be sourced in a cost effective and sustainable manner. The local rural dwellers could meet their own energy needs through biofuels. Kerosene can be extracted for lighting and cooking which besides the cost; its supply could be free from the uncertainties prevalent in the fossil fuel markets. There is also a clear indication that most of the farmers are not employing the full capacity of their farms and hence integrating the biofuel feedstock crops in their farms could save their limited incomes both in sourcing for their energy needs and the byproducts being used as animal feeds besides as source of manure when the sector is fully developed.

At the country level, some of the marginal areas could be opened up for the biofuel crop production while taking care of environmental degradation. This could be a means of diversification from the pastoral enterprises which are demanding in terms of both the grazing land and water. The sector has more potential in production of biodiesel for transport industry which when fully developed will be a major source of employment besides addressing the country's balance of payment deficits which is mainly attributable to importation of fossil fuel.

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Appendix A: t-test of mean difference between biofuel feedstock integrated farms and the no-integrated ones.

	Levene's Test for Equality of Variances		t-test for Equality of Means				
Variables	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Diff
distance to nearest urban centre	0.833	0.362	1.46	271	0.146	1.35689	0.92964
			1.458	254.686	0.146	1.35689	0.93048
distance to centre	4.981	0.026	1.697	271	0.091	0.49371	0.29089
			1.699	246.9	0.091	0.49371	0.29055
Distance to urban	0.02	0.887	1.137	271	0.257	3.873	3.40623
			1.137	270.498	0.257	3.873	3.40667
Total value of household assets	1.668	0.198	-0.526	271	0.599	-19756.09409	37543.86171
			-0.526	245.413	0.6	-19756.09409	37587.4927
Schooling years	4.063	0.045	-0.021	271	0.984	-0.01014	0.49197
			-0.021	259.829	0.984	-0.01014	0.49234
Age of Household head	1.145	0.285	-2.71	271	0.007	-4.723	1.743
			-2.709	268.218	0.007	-4.723	1.743
Household size	2.963	0.086	1.533	271	0.127	0.45529	0.29705
			1.532	266.926	0.127	0.45529	0.29717
Land available to household	15.207	0	-3.85	271	0	-2.0429	0.53068
			-3.846	250.29	0	-2.0429	0.53123
Proportion of land on food crops	5.4	0.021	1.096	271	0.274	0.03072	0.02803
			1.097	266.2	0.274	0.03072	0.02801
Value of crop output	5.558	0.019	-1.431	271	0.154	-46306.51535	32363.49616
			-1.426	137.074	0.156	-46306.51535	32480.86861
Household expenditure per capita	1.46	0.228	0.073	271	0.942	187.80127	2589.67752
			0.072	256.226	0.942	187.80127	2591.89661
Land under crops	7.375	0.007	-2.477	271	0.014	-0.97734	0.39454
			-2.473	229.552	0.014	-0.97734	0.39515
Annual other income	0.225	0.636	0.295	271	0.768	2915.23884	9866.53308
			0.296	187.413	0.767	2915.23884	9842.13154

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