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SMALLHOLDER FARMERS' WILLINGNESS TO INCORPORATE BIOFUEL CROPS INTO CROPPING SYSTEMS IN MALAWI

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Abstract

Using cross-sectional data, this study analysed the critical and significant socioeconomic factors with high likelihood to determine smallholder farmers' decision and willingness to adopt jatropha into cropping systems in Malawi. Employing desk study and multi-stage random sampling technique a sample of 592 households was drawn from across the country for analysis. A probit model was used for the analysis of determinants of jatropha adoption by smallholder farmers. Empirical findings show that education, access to loan, bicycle ownership and farmers' expectation of raising socioeconomic status are major significant factors that would positively determine probability of smallholder farmers' willingness to adopt jatropha as a biofuel crop on the farm. Furthermore, keeping of ruminant herds of livestock, long distance to market and fears of market unavailability have been revealed to have significant negative influence on farmers' decision and willingness to adopt jatropha. Policy implications for sustainable crop diversification drive are drawn and discussed.

Keywords*: Adoption; Jatropha; Smallholder farmer;* Malawi

1. Introduction

The world economy depends heavily on fossil fuels for its energy supply which unfortunately is highly exhaustible. Fossil fuels are also a major contributor to the challenges of climate change the world is grappling with today. More than two billion of the world's poorest people depend on coal and biomass such as wood, charcoal, crop residues and dung to meet their daily energy needs (International Energy Agency, 2002). Estimates indicate that between 80% and 90% of the people in Sub-Saharan Africa (SSA) depend on biomass fuels, of which fuel wood accounts for more than 75% of the household energy balance (World Health Organization, 2002). The large scale land degradation and the loss of biodiversity encountered by SSA today can, to a great extent, be attributed to biomass fuel production through deforestation.

Overwhelmed by these challenges, efforts are now being concentrated on finding alternative sources of renewable energy. Many SSA governments are in the process of diversifying their sources of energy due to rising costs of imported energy and persistent problems with current energy production systems. For instance, Malawi is trying to diversify from hydro-electricity because siltation problems cause damage of equipment at power stations and result in regular power outages and black-outs. It is universally accepted that bio-based energy will be very important in the world's sustainable supply of clean energy. Biofuels are seen as one of the biggest economic opportunities for sub-Saharan Africa especially for job creation, income generation and domestic energy supply, mainly in rural areas. For many African countries such as Malawi, biofuels serve as excellent alternatives to firewood which together with charcoal provides 93% of energy needs for domestic use but unfortunately also tends to be the principal contributor to massive deforestation (Energy Bulletin, 2006 in Proceedings of the National Seminar on Bioenergy, 2012), Heavy use of firewood has resulted in increased soil erosion, siltation of rivers, and loss of biodiversity and acute shortage of fuel wood energy.

Very many crops that are suitable for energy production grow best in the tropics. Sub-Saharan Africa is well endowed with suitable land and climate giving the region an enormous comparative advantage in the production of biofuels. A wide variety of crops have potential as energy crops. *Bioethanol* can be produced from sugar cane, maize, wheat, cassava, and sweet sorghum and in the future even from cellulosic material such as wood chips. *Biodiesel* can be produced from soybeans, canola, peanuts, jatropha, sunflower seeds, castor beans, cotton plants and palm oil. Potential biofuel crops that are best suited for rural smallholder farmers in Malawi include sugarcane (because of its high efficiency in ethanol production), and shrubs and trees such as jatropha and moringa because of their ease of production.

A number of organizations including United Nations Development Programme (UNDP), Bio Energy Resources Limited, and D1 Oils Africa (Pty) are encouraging farmers to grow biofuel plants especially jatropha (*Jatropha curcas L.).* As far back as 2002 the Malawi Agroforestry Extension (MAFE) Project operating under a cooperative agreement between the Government of Malawi, USAID and the Washington State University promoted *Jatropha curcas* and *Moringa oleifera* (Bagani, 2003). In 2005 Biodiesel Agriculture Association of Malawi embarked on a nationwide campaign, urging farmers to plant jatropha to produce biodiesel. Despite the recognition and several initiatives to encourage jatropha production, full-scale cultivation has not started in Malawi.

Recognizing the escalation of the prices of inorganic fertilizers for farming and environmental problems associated with over dependency on unsustainable use of fossil fuels in trying to meet socioeconomic needs at household and national levels, it was imperative for Malawi to exploit the benefits of biofuel crop production in household food security and social welfare. However, in Malawi's agricultural sector very little is known about biofuel crops. Drawing on the Agricultural Research and Development Program (ARDEP) funded research project titled "*Investigation of the potential of small-scale biofuel production in employment and income generation, environmental rehabilitation and socioeconomic development in Malawi",* Nalivata and Maonga (2011) observes that "from among the identified actual and potential biofuel crops such as jatropha, moringa, castor oil tree, sugarcane, soybean, cotton, maize and sunflower, 50% of the field-level crop specialists in the agro-ecological zones in the country singled out jatropha as the crop that is currently being grown and promoted for biofuel production." The same cross sectional study by Nalivata and Maonga (2011) found that out of the 596 smallholder farming households interviewed during a field survey, only a third (33.4%) knew about biofuel crop production. The commonest biofuel crops known to smallholder farmers in Malawi included jatropha, moringa and sunflower. Coupled with knowledge gaps, uncertainty over availability of

markets for biofuel crops and products, culminating from poor pricing of most smallholder cash crops such as cotton and soya bean, has been one of the major reasons explaining low involvement of smallholder farmers in biofuel crop production in Malawi. This is further propelled by non-involvement of government agricultural institutions and structures in the biofuels discourse advocated by the private sector organizations *vis-à-vis* promotion of biofuel production in Malawi.

The above study involved farmers and farmer organizations, cooperative non-governmental organizations (NGOs), researchers and policymakers in the quest for a sustainable biofuel industry for the Malawi economy. The main thrust of the study was the exploration of possibility to incorporate biofuel crops into mainstream smallholder cropping systems. On the agricultural front, the Government of Malawi would improve smallholder agriculture by supporting the establishment of a biofuels industry for export promotion and rural development. Spurred by interest from international buyers and investors, the Malawi government may be attracted to large-scale biofuels plantations and processing facilities to maximize efficiency and achieve competitiveness in prices on the global market. As an agrarian economy, Malawi would also likely to seek ways of ensuring that the rural economy captures an increased share of the total value chain, and to incorporate and protect the interests of smallholder farmers and agro-processors. The most favorable trade-off might involve cooperative marketing, partnerships between small and large-scale businesses, as well as processing facilities owned and managed by smallholder farmers. Although with low levels of income the rural agrarian population in Malawi is spending substantial proportion of their incomes on energy, but not necessarily on the cheapest, healthiest or cleanest products and services. Thus, if well organized, the market potential for clean, affordable energy is huge across Malawi. The basic energy needs of the low income societies in Malawi include safe lighting, healthy cooking and heating fuel, communications, crop irrigation, enterprise operations (such as market kiosk lighting), and public services such as school computers or hospital equipment that can improve rural education and health, respectively.

The purpose of this paper is therefore to investigate critical socioeconomic factors with significant likelihood to determine smallholder farmers' decision and willingness to adopt jatropha into cropping systems in Malawi. Literature on biofuel production and adoption into smallholder cropping systems in the country is very scanty. As noted earlier, Nalivata and Maonga (2011) studied on *the potential of small-scale biofuel production in employment and income generation, environmental rehabilitation and socioeconomic development in Malawi, and found, among others,* that half of the crops officers under the Ministry of Agriculture across the country knew jatropha as a biofuel crop; and only a third of smallholder farm households covered in the study had knowledge about biofuel production. However, there was no significant finding on incorporation of jatropha or biofuel crops in general, into smallholder cropping systems in Malawi. This study therefore, goes a step further to improve understanding of some of the key factors, including household socioeconomic as well as farm level characteristics, affecting smallholder farmers' decision and willingness to consider incorporation of jatropha as a potential crop into their cropping systems. Such understanding is important for policy design aimed at establishing a vibrant crop diversification drive to enhance food security and farm income at household level. The study focuses on smallholder farmers, who although are characterized by small farms, tend to be in the majority and contribute significantly to national output and food security in Malawi.

The rest of the paper is organized as follows: the next section presents methodology, data and description of the variables used in the analysis. Results and discussion are presented in section 3, while section 4 draws conclusions and possible policy recommendations.

2. Methodology

2.1 Data source

The research employed desk study and field survey approaches in data collection. The desk study, which constituted the first phase of the study, involved a review and documentation of earlier and current studies and work done on biofuel production as well as on the biophysical environment necessary for biofuel crop production in Malawi to identify the missing literature in the knowledge archives. Using a checklist, discussions and interviews were done with key informants from relevant organizations such as Ministry of Agriculture and Food Security including Agricultural Development Divisions (ADD), Department of Energy, Department of Forestry; Farmers Union of Malawi (FUM), National Association of Smallholder Farmers in Malawi (NASFAM), Land Resource Centre, and biofuel organizations in the country. Two sets of checklists were administered to two different stakeholders: those organizations working with farmers on biofuel production and the Crops Officers at ADD level throughout the country. The first phase of the research inquiry took place in May and June 2009.

The second phase of the project's research component was done through a survey approach on smallholder farmers in Malawi. A field sample survey was conducted in October 2009 covering 11 districts from all the three administrative regions of Malawi. In the Southern Region of the country the study was conducted in Chikhwawa District in the Shire Valley Agricultural Development Division (SVADD), Neno and Thyolo Districts in Blantyre ADD and Machinga District in Machinga ADD - (an ADD is a demarcation of agro-ecological zones). In the Central Region, the survey covered Lilongwe and Dedza Districts both under Lilongwe ADD, Salima and Nkhotakota Districts in Salima ADD, and Kasungu District in Kasungu ADD. Finally, in the north of Malawi, the survey was conducted in Mzimba and Karonga districts under Mzuzu and Karonga ADDs, respectively. Primary data were collected at household level through oral interviews using semi-structured and open-ended questionnaire and by observation of relevant agricultural variables. Research on smallholder farmers was deemed necessary in order to provide a general but clear understanding of smallholder agriculture in Malawi and therefore lay a foundation upon which small scale biofuel crop production can be established. The study targeted a household because in the rural economic set-up it is considered as a decision-making unit. A sample of 596 households was drawn from across the districts using multi-stage (four stages) cluster sampling procedure. After cleaning and discarding the outliers the usable sample size for analysis was 592 households. The first three steps involved sampling of districts, Extension Planning Areas, traditional authorities and villages. All the selected sites were within the agricultural production zones. The final stage involved simple random sampling of households from the list of villages and employed proportional probability sampling. In this stage, households in villages with a larger population had a proportionately greater chance of being selected into the sample. The actual sample was drawn using simple random sampling based on random tables with village populations obtained from District Agriculture Offices. The household head and/or spouse were targeted for interviews using a semi-structured questionnaire. Focus group discussions were conducted at randomly selected sites with organized groups of farmers comprising between 8 and 15 in number to substantiate the quantitative semi-structured questionnaire. Stakeholder interviews were conducted with purposively selected representatives of organizations involved in smallholder agriculture, livelihood improvement as well as those in energy sector in the selected districts.

2.2 Data analysis

Factors that were hypothesized to influence farmers' willingness to adopt jatropha as a biofuel crop into their cropping systems on the farm are defined and described in this section. Choice of each of the variables used in the probit model is justified with explanations on how they relate to smallholder farmers decisions and willingness to adopt jatropha as a biofuel crop on the farm. Table 1 presents definitions of the variables used in the biofuel adoption model.

Table 1. Definition of Variables Used in the Biofuel Adoption Model

Variables	Definition and units of measurements
Dependent variable: Jatropha adopter	Farm household willing to adopt jatropha as biofuel crop on the farm; (1 = Yes, 0 = otherwise)
Explanatory variables	
AGE	Age of household head (years)
SEX	Sex of household head (1 = Female, 0 = Male)
HOUSEHOLD SIZE	Number of people in the household (persons)
EDUCATION	Level of household head's education (years)
LAND HOLDING SIZE	Size of household's landholding for agricultural production (acres)
RUMINANT	Household keeps ruminant herds of livestock (1 = Yes, 0 = otherwise)
CASH CROP	Household grows cash crops such as cotton, tobacco, tea (1 = Yes, 0 = otherwise)
EXTENSION	Household has regular access to relevant agricultural extension services (1 = Yes, 0 = otherwise)
LOAN	Household gets agricultural loans from formal money lending institutions (1 = Yes, 0 = otherwise)
CLUB MEMBER	Household is affiliated to farmers' club (1 = Yes, 0 = otherwise)
DISTANCE TO MARKET	Household is located more than 5 km (up to 2 hours walk) to farm produce market (1 = Yes, 0 = otherwise)
BICYCLE	Household owns a bicycle (1 = Yes, 0 = otherwise)
BIOFUEL KNOWLEDGE	Household has knowledge of biofuel crop farming (1 = Yes, 0 = otherwise)
MARKET FEAR	Household fears that markets for biofuel crop products will not be readily available (1 = Yes, 0 = otherwise)
SOCIOECONOMIC	Household's perception of improving socioeconomic status with biofuel crop farming (1 = Yes, 0 = otherwise)

AGE: In line with general literature, farmers' age on adoption of new technology or crop variety is found to have a negative effect, older farmers being more reluctant to change or the expected return being lower (Bocquého et al., 2011). In this analysis we hypothesized adoption of the new crop variety (jatropha) to increase among the youthful farmers and later to decrease among the older farmers considering the fact that the latter tend to be more risk averse than their youthful counterparts.

SEX: We analyzed the effect of sex on adoption of jatropha from the gender perspective in which women and men play different economic roles on the farm. From field observations, in Malawi, men are generally concerned with management of cash enterprises

on the farm while women take care of household food security. We therefore, expected that being a cash crop, jatropha would not be adopted by most female farmers unless household food security was achieved.

HOUSEHOLD SIZE: Household size is a proxy for labor availability on the farm. This becomes more important when the household mainly uses family labor. The new crop variety (jatropha) was classified as either labor intensive or extensive. We, therefore, could not determine the direction of influence that household size would have on farmers' decision to adopt jatropha.

EDUCATION: Education was hypothesized to positively affect adoption of jatropha into cropping systems on the farm. This is based on the fact that educated farmers have a better chance to acquire more information leading to improved understanding of the importance of crop diversification on the farm. Farmers with higher levels of education are relatively better informed about credit (loan) availability and practices and can shop around for better credit deals with regards to competitive interest rates and manage to diversify their crop enterprises.

LAND HOLDING SIZE: Landholding size was measured as the total land that farmers used to produce different types of crops. Like age, farm size is a usual factor explaining technology adoption, both in theoretical models and empirical models (Bocquého et al., 2011). "The size of landholding, and therefore farm size impacts on the household's land use decisions in terms of type and diversity of farm enterprises, as well as cropping systems and patterns" (Maonga, 2005). Large farm size was therefore expected to have positive effect on adoption of jatropha into cropping systems on smallholder farms.

RUMINANT: We could not determine the direction of influence that possession of ruminants would have on smallholder farmers' decision to incorporate jatropha into the cropping system. Nevertheless, considering the fact that jatropha is not edible by most livestock herds, farmers with an intention to grow jatropha for cash generation would likely be more willing to adopt it than otherwise.

CASH CROP: We hypothesized that farmers already growing cash crop would be more willing to add another on the list in order to boost their income. Therefore, the variable was deemed to have positive effect on farmers' decision to adopt jatropha on the farm.

EXTENSION: Access to agricultural extension messages is believed to have positive influence on adoption of new technologies and crop varieties by farmers. Extension services create awareness and enable farmers to get information about improved technologies or the new crop varieties. Such information is crucial for decision making by farmers in the process of new technology adoption. "Farmers must have access to information about improved technologies before they can consider adopting them" (Doss, 2003). We therefore, expected agricultural extension to play a positive role in influencing farmers' willingness to adopt jatropha into cropping systems on their farms.

LOAN: Access to credit was hypothesized to influence positively on smallholder farmers' decision to adopt jatropha as a biofuel crop into their cropping systems. "Agricultural loan facilities are necessary for expansion of capital base needed to start farm enterprises, improve management of current agricultural ventures or maintain current levels during difficult times in the agribusiness cycle" (Nalivata and Maonga, 2011). Elsewhere in India, agricultural credit has been found to exert significant and immediate positive impact on farm output (Abhiman et al., 2009). Increased access to credit can also help farmers overcome short-run liquidity challenges and potentially increase adoption of agricultural technology.

CLUB MEMBER: The importance of belonging to farmer's clubs sometimes tends to be similar to the role of agricultural cooperatives. Farmers in clubs can pool resources together and purchase them through loans under the club umbrella. The clubs also assist farmers with marketing of farm produce by finding better markets as well as in the management of

marketable agricultural commodities. We therefore, hypothesized membership to farmer's clubs to positively influence their decision to adopt jatropha into cropping systems on the farm.

DISTANCE TO MARKET: Long distance to agricultural market was thought to have negative effect on the adoption of jatropha as a cash crop by smallholder farmers.

BICYCLE: In Malawi's rural communities, a bicycle has fast become the most reliable mode of transport. Apart from being used to provide agricultural and other household transportation services, a bicycle has increasingly become a source of income through bicycle taxi operations. In this analysis, the bicycle was considered as one of the major household assets in the marketing of agricultural commodities. We therefore, hypothesized the variable to exert a positive effect on smallholder farmers' willingness and decision to adopt jatropha into mainstream cropping systems on the farm.

BIOFUEL KNOWLEDGE: Knowledge of a technology or new crop variety gives farmers an opportunity to make informed decisions regarding its adoption or otherwise. Therefore, farmers' knowledge of jatropha as a biofuel crop that can serve as a cash earner was thought to have positive influence on adoption decision by smallholder farmers in Malawi.

MARKET FEAR: In order to maximize utility, smallholder farmers make rational decisions when adopting new technologies or crop varieties based on their attributes. We considered jatropha as a pure cash crop and thus assumed that fears over unavailability of markets for the crop or its products would likely discourage smallholder farmers from adopting it.

SOCIOECONOMIC: Household perception of realizing positive socioeconomic benefits through incorporation of jatropha into the cropping system was thought to positively influence its adoption by smallholder farmers.

2.3 Theoretical Framework and the Empirical Model Used in Data Analysis

Famers make rational decisions and maximize their utility by adopting different agricultural technologies including new crop varieties. Comparison of the new crop cultivars and varieties with the existing traditional crop technologies tends to be the norm. They do so in order to see whether characteristics of the new technologies promise a higher utility than the traditional ones. In this study, we hypothesized that adoption of jatropha as a biofuel crop by smallholder farmers depends on different socioeconomic factors that tend to influence farmers' willingness and decision to take the new crop variety into their cropping systems. Therefore, a farmer's decision to adopt a new crop variety at farm level would be motivated by a random utility function which can be expressed as:

$$U_j = \beta_j x_i + e_j \qquad (1)$$

Where U_j is the utility to be obtained from growing jatropha as a biofuel crop on the smallholder farm, x_i is a vector of attributes of the new crop variety (jatropha) and the farm household characteristics, β_j is a parameter vector to be estimated, e_j is the disturbance term and assumed to be distributed normally, and j is the choice of farmer to adopt the new crop variety vis-à-vis maintaining the current status.

We assume that a farmer derives utility from adopting jatropha as a biofuel crop on the farm, given the resource endowment and farm household characteristics. Further, we assume that the farmer's decision to adopt or not to adopt the biofuel crop is represented by the utility function U_1 and, U_0, respectively; i.e.

$$U_1 = (1, z, y) \text{ and } U_0 = (0, z, y) \quad (2)$$

Where U_1 and U_0 are the farmer's utility obtained from making a decision to adopt the biofuel crop (jatropha) and non-adoption of the same, respectively. Therefore, the utility function of the farmer subject to the resource endowment at household level is constraint (z), and the other observable attributes (y) of the farm household can affect the farmer's willingness and decision to adopt the biofuel crop on the farm.

From the theoretical specification of the utility function, we assume an additively separable utility function in the deterministic and stochastic component that is hereby expressed as:

$$U_1 = U(1, z, y) = D_1(1, z, y) + e_1 \quad (3)$$

and

$$U_o = U(0, z, y) = D_0(0, z, y) + e_o$$

Where $U_j(.)$ represents the utility that is obtained from choosing to incorporate the biofuel crop on the farm, $D_j(.)$ is the deterministic part of the utility function and e_j is the stochastic component that is known to the farmer but unobservable by the researcher. The farmer's decision process to adopt the biofuel crop is modelled using a random utility framework. Theoretically, a farmer decides to incorporate the biofuel crop (jatropha) into the cropping system on the farm if the expected return with the new crop, minus its costs (c), is greater than the return obtained with the existing crop enterprises;

$$U_1(.) \geq U_0(.) \quad (4)$$
$$D_1(1, z - c; y) + e_1 \geq D_0(0, z, y) + e_0$$

Thus, c is the cost of adoption of jatropha into cropping systems on the smallholder farm and this includes both explicit and implicit costs to the farmer. The existence of the stochastic component allows us to apply a probabilistic distribution about a decision maker's behavior. The probability distribution of the willingness and unwillingness to adopt jatropha on the farm by smallholder farmers can be expressed as presented in equations (5) and (6), respectively:

$$P_1 = P(decision) = Pr(D_1(1, z - c; y) + e_1 \geq Pr(D_0(0, z, y) + e_0 \quad (5)$$

$$P_0 = Pr(D_0(0, z, y) + e_0 \geq Pr(D_1(1, z - c; y) + e_1 \quad (6)$$

In terms of the utility function of probability distribution, the decision of the farmer to adopt the new crop variety (jatropha) on the farm can be expressed as:

$$Pr(decision) = Pr(U_1) \geq Pr(U_0) \quad (7)$$

The dichotomous nature of the dependent variable in this study suggests that either a probit/normit or a logit model would be appropriate (Pindyck & Rubinfeld, 1981; Maddala, 1990; Gujarat, 2004; and Wooldridge, 2006). We choose to use probit model to analyse socioeconomic determinants of smallholder farmers' willingness to adopt the biofuel crop (jatropha) and incorporating it into the cropping systems on the farm. Due to lack of the cost data, (c), for the new technology (jatropha production), our model for this study only includes the other observable variables which are specified and presented in equation (8) below:

$$Y_i = \beta_0 + \beta_1 AGE + \beta_2 age^2 + \beta_3 SEX + \beta_4 HOUSEHOLDSIZE + \beta_5 EDUCATION + \beta_6 LANDHOLDINGSIZE + \beta_7 RUMINANT + \beta_8 CASHCROP + \beta_9 EXTENSION + \beta_{10} LOAN + \beta_{11} CLUBMEMBER + \beta_{12} DISTANCETOMARKET + \beta_{13} BICYCLE + \beta_{14} BIOFUELKNOWLEDGE + \beta_{15} MARKETFEAR + \beta_{16} SOCIOECONOMIC + e_j \quad (8)$$

The dependent variable (Y_i) of the model represents whether a smallholder farmer is willing to adopt and incorporate biofuel crops (jatropha) on the farm or not. We note that smallholder farmers' willingness to adopt jatropha into cropping systems may be influenced (positively or otherwise) by a number of independent socioeconomic variables which have been defined and presented in *Section 2.2* and summarized in Table 1.

In order to derive policy implications, marginal effects of the policy variables are used. The marginal effect indicates the effect of unit change in each independent variable on the dependent variable. In this study, the marginal effect of a variable is the effect of a unit change of this variable on the probability P(Y = 1|X = x), given that all other variables are constant. The marginal effect is expressed as indicated in (9):

$$\frac{\partial P(Y_i=1|x_i)}{\partial x_i} = \frac{\partial E(Y_i|x_i)}{\partial x_i} = \varphi(x_i'\beta)\beta \quad (9)$$

In this equation, Y_i is the outcome, and x_i the dependent variable in question.

3. Results and Discussion

The results and discussion section explores descriptive statistics of the variables followed by a detailed analysis of the factors that have been shown by the probit model to be statistically significant in influencing smallholder farmers' willingness to adopt biofuel crops (jatropha) into the cropping systems on their farms in Malawi.

3.1 Descriptive statistics of sampled households

In Table 2, summaries of descriptive statistics (means and standard deviations) are presented for each of the variables used in the probit model. In this table the means for the dummy variables also represent response frequencies as percentages. For instance, a mean of 0.926 for the dependent variable (Jatropha adopter) was found to represent 92.6% of the respondents who had shown positive willingness to incorporate jatropha as a biofuel crop into the main stream cropping systems on their farms. Similarly, a mean value of 0.39 for the EXTENSION variable represented 39% of the respondents who had revealed having regular access to relevant agricultural extension services on crop production

Standard deviations greater than the mean show that as a typical agricultural society, farmers tend to be highly heterogeneous in their socioeconomic status, display of social behavior and perceptions of things affecting their welfare.

3.2 Factors determining farmers' willingness to adopt biofuel crops

Table 3 presents the effects of the explanatory variables on the farmers' willingness and decision to adopt biofuel crops (jatropha) and incorporate them into main stream cropping systems. The probit model was estimated to identify the important and significant determinants of adoption of jatropha as a biofuel crop by smallholder farmers in Malawi. Overall, the model was found to be significant (p<0.01); this is an indication that the model satisfactorily passed the "goodness of fit" test.

Table 2. Descriptive Statistics of the Sampled Households

Variable	Observations (n)	Mean	Std. Dev.
Y (Dependent Var.)	592	0.926	0.263
AGE	592	41.230	15.923
SEX	592	0.512	0.500
HOUSEHOLD SIZE	592	5.218	2.253
EDUCATION	592	5.084	3.525
LAND HOLDING SIZE	592	2.670	2.449
RUMINANT	592	0.454	0.498
CASH CROP	592	0.216	0.412
EXTENSION	592	0.390	0.488
LOAN	592	0.046	0.217
CLUB MEMBER	592	0.348	0.477
DISTANCE TO MARKET	592	0.387	0.487
BICYCLE	592	0.590	0.492
BIOFUEL KNOWLEDGE	592	0.336	0.473
MARKET FEAR	592	0.117	0.321
SOCIOECONOMIC	592	0.791	0.407

The results show that seven variables (EDUCATION, RUMINANT, LOAN, DISTANCE TO MARKET, BICYCLE, MARKET FEAR and SOCIOECONOMIC) were significant determinants of smallholder farmers' willingness (or otherwise) to adopt and incorporate biofuel crops (jatropha) on the farm in Malawi. Education (EDUCATION) was found to be one of the major determinants of smallholder farmers' willingness to adopt jatropha and incorporate it in their cropping systems in Malawi. Significant at 5% level, EDUCATION would positively influence smallholder farmers' willingness and decision to adopt jatropha on the farm. This implies that higher education attainment by household head would increase the probability of smallholder farmers' willingness to adopt jatropha as a biofuel crop on their farms. Increasing the level of education by 1 unit (year) would likely increase the probability of jatropha adoption on the farm by a small margin of 0.55%. "Completing at least 6 years of schooling indicates being in the higher primary school" (Maonga et al., 2013). These results are consistent with those found by Uaiene et al. (2009) and the World Bank (2007) in Mozambique, which stated that "completion of at least lower primary school implied a much higher propensity to adopt new technology than lower or zero levels of education."

Keeping of ruminant herds of livestock on the farm (RUMINANT) was found to be a significant factor at less than 1% level of significance but with a negative influence on farmers' willingness to adopt jatropha into the cropping systems. Increasing the size of ruminant herds by one unit would negatively affect smallholder farmers' decision to incorporate jatropha into the current cropping systems by a margin of about 7.19%. Faced with poor pricing of smallholder cash crops such as cotton and tobacco, the negative effect may imply farmers' risk aversion in adopting jatropha as a cash crop on the farm. In addition, field observations have shown that the jatropha species commonly grown in Malawi are poisonous and not edible by livestock including the ruminants. Thus, smallholder farmers with intensions to improve livestock farming in a complementary manner with crop enterprises tend to be restricted from growing a new crop that cannot be used as feed for their livestock herds. In Malawi's agricultural sector, goats are the commonest type of ruminants kept by smallholder farmers. "Goats are usually tethered during the rainy season when most

of arable land is subjected to intensive cultivation and little area is available for grazing; they are herded during different times of the year;" (Ambali et al., 2001). With small farm landholdings, most farming communities in Malawi do not have adequate land for grazing livestock and therefore, would not prefer growing a crop whose products or by-products won't be used as forage, hence the negative effect on farmers' willingness and decision to adopt jatropha on the farm.

Table 3. Probit Model Results Showing Coefficients and Marginal Effects

Variable	Coefficients		Marginal effects			
	Coef.	Robust Std. Err.	(dy/dx)	Robust Std. Err.	z-values	Sig. [a]
AGE	0.031	0.026	0.0027	0.0023	1.17	
Age-squared	0.000	0.000	0.0000	0.0000	-0.69	
SEX	0.100	0.180	0.0085	0.0155	0.55	
HOUSEHOLD SIZE	0.014	0.047	0.0012	0.0040	0.29	
EDUCATION	0.064	0.029	0.0055	0.0026	2.1	**
LAND HOLDING SIZE	0.088	0.076	0.0075	0.0064	1.16	
RUMINANT	-0.844	0.235	-0.0719	0.0197	-3.65	***
CASHCROP	0.141	0.371	0.0120	0.0316	0.38	
EXTENSION	-0.244	0.192	-0.0208	0.0161	-1.29	
LOAN	1.443	0.502	0.1229	0.0441	2.79	***
CLUBMEMBER	-0.159	0.193	-0.0135	0.0161	-0.84	
DISTANCE TO MARKET	-0.461	0.216	-0.0392	0.0182	-2.16	**
BICYCLE	0.423	0.229	0.0360	0.0196	1.84	*
BIOFUEL KNOWLEDGE	0.050	0.263	0.0043	0.0223	0.19	
MARKET FEAR	-1.082	0.241	-0.0921	0.0195	-4.72	***
SOCIOECONOMIC	1.389	0.206	0.1183	0.0155	7.63	***
Constant	-0.096	0.709				**
No. of observations	592					
Wald Chi-square(16)	89.82					***

[a]**Note -** Statistical significance: *$p \leq 0.1$; **$p \leq 0.05$; ***$p \leq 0.01$.

As expected, access to agricultural loan (LOAN) had a positive effect on farmers' willingness to adopt jatropha as a biofuel crop on the farm. Significant at less than 1% level, access to agricultural loan was the most influential factor that would determine smallholder farmers' willingness to adopt biofuel crops (jatropha) in Malawi. Although only about 4.6% of the sampled smallholder households had access to agricultural loans, farmers believed that availability and accessibility of loan facilities would enable them to participate in the production of such cash crops as jatropha for biofuel purposes. The results have shown that the probability of smallholder farmers willing to adopt biofuel crops would be about 12.29% higher for those with access to agricultural loans than those without a chance to get a loan. Extending accessibility of loans to increased number of farmers would likely accelerate agricultural progress (Nalivata & Maonga, 2011).

Distance to farm produce market (DISTANCE TO MARKET) was another important factor that would significantly affect smallholder farmers' willingness to adopt biofuel crops in Malawi. The probit results have shown that at 5% level of significance, famers located more than 5 km from a farm produce market would have a probability of 3.92% less willing to adopt jatropha as a biofuel crop on their farms than their counterparts living within a radius of 5 km from the market. This may imply that construction of readily accessible rural road networks in the agricultural communities and availability of such support services as farm produce markets would likely improve agricultural production, marketing and development of the sector.

Ownership of a bicycle (BICYCLE) was also found to positively and significantly influence smallholder farmers' decision to adopt biofuel crops (jatropha). At 10% level of significance, a farm household with a bicycle would be 3.6% more willing to adopt jatropha as biofuel crop on the farm than another household without a bicycle. A bicycle was found to be one of the most important assets in 59% of the sampled smallholder households in Malawi. In rural farming communities bicycles are used to transport farm inputs and outputs between farms and markets; they have increasingly become the most reliable mode of transport through bicycle taxi services thereby serving as a source of income (Nalivata & Maonga, 2011). Thus, in the absence of farm produce markets within the farming communities, bicycles would play a significant positive role in influencing farmers' decisions to adopt marketable agricultural commodities especially the cash crops.

Another variable with negative influence on farmers' willingness to adopt jatropha as a biofuel crop in Malawi was the fear emanating from not being certain to find readily available markets for biofuel crop products (MARKET FEAR). This was cited by 11.7% of the sampled households that participated in the survey. The results show that at a highly significant level of less than 1%, a household with fears of not finding a market for the biofuel crop products would be 9.21% less likely to adopt jatropha into cropping systems on the farm. In the rural farming communities in Malawi sometimes it is not only the absence of reliable markets but also the non-existence of the selling points to serve farmers that discourage adoption of new crops even if such technologies promise the benefits of high potential productivity returns and an increase in farm income. This shows that properly functioning and well-coordinated markets are an important prerequisite and necessary condition in the development of smallholder farming and the agricultural sector in general.

Finally, household's perception of improving socioeconomic status with biofuel crop farming (SOCIOECONOMIC) was found to be one of the major determinants of smallholder farmers' willingness to adopt jatropha in Malawi. The variable was significant at less than 1% level; and showed that farmers with high positive expectation to improve socioeconomic status by incorporating biofuel crops into cropping systems on their farms would be 11.83% more willing to adopt jatropha for that purpose than those with negative perceptions. Indeed, any new crop technology perceived not to complement resource use maximization on smallholder farms and fail to promise improved socioeconomic status of farmers would likely be abandoned.

4. Conclusion and policy recommendations

This study attempted to highlight the socioeconomic determinants of farmers' willingness to adopt biofuel crops on their farms within the context of smallholder farming conditions with the case of jatropha in Malawi. The results showed that the most significant socioeconomic variables that would directly and positively influence smallholder farm household's willingness and decision to adopt jatropha into cropping systems include increased education, accessibility to formal loans, ownership of a bicycle, and farmers' expectation of improving socioeconomic status from the crop. On the other hand, possession

of ruminant herds of livestock, long distance to farm produce markets and uncertainty over availability of agricultural produce markets would negatively affect smallholder farmers' willingness and decision to adopt jatropha as a biofuel crop in their cropping systems.

From the discussion, we propose that improving education, information and communication flow would be crucial to enhancing farmers' awareness and understanding of available support services such as loans (accessibility and conditions), agricultural extension and availability of lucrative markets. Encouraging rural communities to construct all-weather feeder roads through public works programs would likely improve their travel and accessibility to agricultural input and output markets. These would, in principle, contribute towards achievement of a vibrant farm level crop diversification drive and realization of the national goal of improving food security and income at household level.

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