The Impact of Biofuels Crop and Land Rental Markets on Farm Household Incomes: Evidence from South Africa

Athur Mabiso[1]

Dave Weatherspoon[2]

1. International Food Policy Research Institute, Development Strategy and Governance Division, Washington, DC
2. Michigan State University, Department of Agricultural Food and Resource Economics, East Lansing, MI 48824

Selected paper prepared for presentation at the Agricultural & Applied Economics Association's 2011 AAEA & NAREA Joint Annual Meeting, Pittsburgh, Pennsylvania, July 24-26, 2011

I. Introduction

The participation of rural farm households in biofuels crop and land rental markets is a relatively new phenomenon in Sub-Saharan Africa that has generated much controversy (Rossi and Lambrou, 2009; Sulle and Nelson, 2009; Arndt, et al. 2008a; Arndt et al, 2008b; Cotula et al., 2008). There is still debate on the impacts of biofuels investments on rural farm households and whether these initiatives, often operated by foreign firms, have any real benefits for the poor. Can biofuels, through feedstock cropping contracts or through land rental markets improve the wellbeing of smallholder farmers, or are they simply exploitative, leaving smallholder farmers with less income or over their land and ultimately worse off?

These questions have generated much discussion about biofuels in many parts of Sub-Saharan Africa including South Africa, where foreign firms have invested in biofuels and engaged beneficiaries of the on-going land redistribution program to participate in biofuels markets. Many new farmers that are benefiting from the land redistribution program in South Africa have had to decide if they want to grow food crops for own consumption and or sale, or to participate in new biofuels markets either through the sale of feedstock crops or leasing their land to biofuels firms (Cartwright, 2010; Colin and Woodhouse, 2010). This has been further complicated by the government's ban on maize and jatropha production for biofuels feedstock use, citing potential problems of food-fuel tradeoffs, water scarcity and risk that jatropha may be an invasive species (Brent, Wise and Fortuin, 2009; Nieuwoudt, 2007 ; Visagie and Prasad, 2006).

While most of the literature on biofuels has focused on the food-fuel tradeoffs and more recently on the "land grab" and land governance issues (Cotula et al., 2008; von Braun and Meinzen-

Dick, 2009), microeconomic analysis of household-level effects of biofuels developments particularly on incomes and poverty have been rare; yet this is arguably central to understanding how biofuels developments affect the rural poor and how policies and strategies can be designed to make biofuels beneficial and pro-poor for poverty reduction.

There are generally two competing views on smallholder-farmer participation in biofuels-related markets. One hypothesis posits that smallholder farmers become food insecure when they allocate their land to biofuels crops because they divert land (and other factors of production) away from food production, resulting in the reduced availability of food locally. Under this hypothesis, any land previously left fallow or un-cleared is allocated to biofuels crops at an opportunity cost of expanded food production; or possibly the opportunity costs of providing beneficial environmental services and land conservation amenities associated with unfarmed land. Participation of farm households in biofuels crop markets is thus considered to have a negative effect on farm household food security, income and poverty and could also contribute to increased food prices, which make it more difficult for farm households to access food. Previous economy-wide and global-level studies have in fact shown that biofuels production contributed to increased world food prices (Headey and Fan, 2008; Rosegrant et al., 2008).

The antithesis to this view is that, by participating in biofuels crop markets, farm households may actually increase their incomes and as a result increase their purchasing power which would then mean improved food access[1] and escape from poverty. After all, most food insecure households in Sub-Saharan Africa are net buyers of food over the course of any given agricultural year and food access has been shown to be an important component of food security among rural farm households, not just food production (Weber, et al., 1988; Jayne, Zulu and Nijhoff, 2006). Therefore, it is plausible that alternative biofuels markets could increase farm

[1] This is assuming food markets are not missing and are easily accessible at relatively low transaction costs

incomes of farm households and in turn lift them out of poverty and improve their food security status. This of course would depend on the ability of biofuels markets to significantly increase farm households' incomes (i.e. after accounting for the potential increase in food prices that may simultaneously result). A separate argument is that farm households may benefit from biofuels developments through increased access to productive resources such as farm inputs, credit and technical extension services, which most biofuels firms often provide in the context of interlinked biofuels crop-marketing contracts. These resources could in turn induce positive spillover effects for food production, creating farm-level investment synergies and fostering productivity growth in both biofuels and non-biofuels crops (i.e. potentially increasing productivity of both food and cash crops). Similar results have been found in other interlinked non-food cash crop contracts in the past (Goetz, 1990; Govereh and Jayne, 2003). Moreover, the establishment of biofuels plants in rural areas would likely generate nonfarm rural employment opportunities. These too would have positive multiplier effects through linkages with household-level investments in smallholder agricultural production, which would then lead to increased farm incomes from crop sales and food production, and ultimately improved food security[2]. While these hypotheses and causality chains are all quite plausible, it is not clear if smallholder farm households participating in biofuels-related markets actually experience an increase in farm incomes in the first place, and whether the kind of participation in biofuels-related markets matters. Does participating in a land rental market for biofuels production result in better farm incomes compared to growing crops for sale as biofuels feedstock? And how do the resulting incomes compare to participation in traditional food, feed and fiber crop markets? The objective of this study is a first step in understanding these questions and the household dynamics

[2] There is a wealth of literature on rural non-farm employment and its relation to incomes and food security e.g. von Braun 1995; Reardon, et al., 2007, Davis et al, 2009; ILO, 2008.

associated with participating in biofuels crop and land markets. This paper analyzes the factors influencing farm-household participation in biofuels markets and estimates the impact of participation on farm household incomes.

Whether farm households actually increase their incomes through participation in biofuels markets may in fact depend on the type of biofuels market opportunities available to them and simultaneously the type of biofuels markets that they choose to participate in out of the set of opportunities available to them. Too often, farm household participation in biofuels-related markets has been oversimplified to mean the choice between growing and selling a biofuels crop versus growing a food crop for own consumption and may be sale of surplus crop. To the contrary, biofuels developments present a more complex choice set for rural farm households, consisting of a wider variety of market opportunities that include not only a variety of biofuels crop markets (i.e. feedstock crop choice) but biofuels-related labor and land rental contracts markets. The latter have recently surfaced across rural South Africa likely due to a combination of the increased amount of land that has been redistributed to previously-disadvantaged black farmers under the government's land redistribution program as well as the increase in foreign biofuels firms that the South African government has welcomed to invest in rural South Africa. Thus, smallholder farmers' decision to participate in biofuels has become an important part of the land use issue and its evolution in South Africa.

In this study we make use of a timely household survey to account for this new land-rental market development associated with biofuels and assess the determinants and outcomes of participating in either biofuels land-rental or biofuels crop markets. This affords us the novelty of distinguishing between the effects of different biofuels market opportunities presented to smallholder farmers by biofuels firms and the land redistribution program. This allows us to

draw conclusions regarding the determinants and outcomes of participating in specific biofuels-related markets. Previous studies have only managed to estimate the economy-wide impacts of biofuels production in general, usually at the national and/or regional levels based on microsimulations and scenario analyses (BFAP, 2007; Arndt, et al., 2008a; Arndt, et al., 2008b; Rosegrant et al., 2008; Elobeid and Hart, 2007; Takavarasha, et al., 2005; Pingali, et al, 2008). The remainder of this paper is organized as follows. Section II describes the nature of biofuels participation in South Africa and the kinds of crops and relevant considerations important for defining what is referred to as biofuels crop and land rental markets. Section III presents the theoretical and empirical models used to analyze participation in biofuels markets and the impacts of participation on household farm incomes. In section IV, the data collected and analyzed are described while section V presents the results of the analyses. Section VI concludes the study with policy implications and areas for future study.

II. Participation in biofuels-related markets in South Africa

When this study was initiated, farm-household participation in biofuels markets was expected to entail growing crops for sale to a biofuels firm. This notion, which is quite common in the media and literature, soon turned out to be very limited as was evinced by pilot data collection during interviews with biofuels firms. Preliminary findings showed that biofuels firms in South Africa were in fact offering a choice between land-rental contracts and feedstock supply contracts to smallholder farm households. Thus we accordingly expanded our definition of participation in biofuels-related markets to include these two broad options. While it would have been interesting to disaggregate participation in biofuels markets by the type of feedstock (crop), the sample size was not sufficient to perform such a disaggregated analysis. Additionally, it would have been

informative to include participation in biofuels-related labor markets (e.g. supply of non-farm labor to biofuels processing plants or supply of farm labor to farms operated by biofuels firms). Nevertheless, the biofuels firms in this study were not found to be hiring local labor in these ways. This in itself suggests that biofuels firms in the study area have not created significant farm and non-farm rural employment opportunities for locals and this may be an area to explore for future development strategies.

Nevertheless, the only biofuels-related labor activity that was found in this study is that of a few farmers who were selected by one biodiesel firm to receive an hourly wage for mentoring other less-experienced biofuels crop farmers who had recently joined the group of farmers growing crops for the biodiesel firm. To understand this form of limited labor activity in the non-farm biofuels market, it was useful to look at the characteristics of the biodiesel firm offering these opportunities. The biodiesel firm was identified as a not-for-profit organization with a philosophy and business model of empowering entrepreneurs in biodiesel crop markets. It provided free training in business management and farming skills to participating farmers and had been in operation for five years. The mentors, who were hired on an hourly basis to provide mentorship to new farmers, had initially been engaged to supply feedstock by the biodiesel firm four years earlier. These mentors were among the first batch of farmers that had received assistance and training to produce sunflower and soybean for sale to the biodiesel firm. Rather than treat this small group of mentors as participating in a separate biofuels-labor market we decided to treat them as participating in the biofuels crop markets since this was their main activity and mentoring activities were occasional and only recent.

An important feature of farm household participation in biofuels in South Africa was that several crops were being used as feedstock. For biodiesel firms sunflower, soybeans and canola were

being used while ethanol firms were using maize, sugar beets and sugarcane. However, smallholder farmers were not found to be participating in all feedstock markets because certain firms had chosen not to involve smallholder farmers. For instance, no smallholder farm household was involved in sugar beets-ethanol markets because the firm investing in sugar beets-ethanol production had chosen to work with large-scale commercial farmers instead (at least for the time being). However, the firm indicated having plans to involve smallholder farmers in the future, mostly in the production of sorghum, which would be used as a complementary feedstock for sugar beets. This is because sugar beets are relatively perishable and the production season in the area is limited by climatic conditions such that sugar beets can only meet the firm's feedstock demand ten months of the year; hence the plan to use an alternative feedstock such as sorghum to keep the ethanol plant in production for the whole year.

Overall, smallholder farmers who independently grew crops for sale to biodiesel firms were either growing sunflower or soybeans, while those involved with an ethanol firm grew and sold maize. The finding that some farmers were participating in biofuels by growing maize is interesting in that maize had been banned by the government for use as a biofuels feedstock. Interviews with the firm involved revealed that the firm had recently stopped using maize as a feedstock and had turned to sugar beets.

In addition, none of the smallholder farmers were producing canola as a feedstock for biodiesel production. Instead these farmers were leasing land to the canola-biodiesel firm which then produced the canola itself. This is because the canola-biodiesel firm had decided to focus on renting land from farm households for canola production rather than training farm households how to produce canola, since canola had never been grown in this area before.

Regarding participation in biofuels through labor supply, the canola- biodiesel firm did not hire local farm-labor even though it had rented land from the smallholder farmers who now had freed up labor. The biofuels firm had adopted a plantation-style configuration with external labor from an "expert-mentor" farmer that had previously owned land, which had been bought by the South African government as part of the land reform program.

It was established that previously, the canola-biodiesel firm had actually attempted to train the smallholder farmers in canola production during farm trials conducted prior to engaging the large scale farmers. Unfortunately the canola production farm trials were relatively unsuccessful. This lack of success may explain in part, why the firm resorted to renting land from the smallholder farm households as well as engaging the labor of experienced large-scale commercial farmers whose land had been purchased by the government for land redistribution purposes.

Although there were some smallholder farmers participating in sugarcane-ethanol out-grower schemes in KwaZulu Natal and Mpumalanga provinces, these areas were not included in this study due to budgetary constraints that limited the data collection to the Eastern Cape, Limpopo and North West provinces. Biofuels firms in these sample areas were not producing ethanol from sugarcane mainly because sugarcane is not suited for the climatic conditions in these areas.

While it is important to consider the different types of crops used as biofuels feedstock in South Africa to accurately define participation in biofuels-related markets in the context of this study, the distinction between crops may be less important than the distinction between the *uses* of the crops. This is because most crops generally have multiple potential uses—food, feed, fiber or biofuels. Moreover, a crop can be viewed by the farmer as a cash crop or own-consumption crop depending on whether it is eventually sold to the market or consumed by the household,

irrespective of its use. Given this complexity of defining what a biofuels crop was and ultimately what participation in a biofuels market was, it became important to keep in mind that all of the biofuels crops in South Africa are also used as food crops with the exception of sugar beets[3]. Also the timing of the participation decision could vary. For example crops could have initially been grown by farmers for own-food consumption crops only to be sold to food processing firms or biofuels firms or possibly both. Given these combinations and permutations, we decided to simplify the definition of participation in a biofuels-related crop market such that a farm household was considered to have participated in a biofuels-related crop market if any amount of any crop was sold to a biofuels firm irrespective of the biofuels type (ethanol or biodiesel). Participation in biofuels-related land-rental market was also defined similarly as leasing any amount of land to any biofuels firm for production of any crop used as a biofuels feedstock by the firm. This definition of participation in biofuels aggregates a number of different activites and potentially confounds the effects of various factors, nevertheless it provides useful information on the variety of biofuels investments in South Africa and the complex participation choice set farmers had to deal with. Table 1 shows the different choices that the smallholder farm households could have made to participate (or not participate) in biofuels-related markets.

III. Theoretical and empirical models

In this section, we present the theoretical underpinnings and empirical model used to analyze participation in biofuels related markets and the effects of participation on farm household earnings. We considered smallholder farm households to be rational utility-maximizing units that select, out of a set of market participation options (described in the previous section), to either

[3] Although sugar beets could potentially be used as a food crop in South Africa they are new and not used for this purpose.

participate in some biofuels-related market or not. This multinomial decision is based on the farm household's utility obtainable from participation subject to its reservation utility, resource constraints and farm household characteristics. It is assumed that a latent random utility model generates the observed multinomial participation variable. Let the underlying farm household's utility from participating in market *p* be $U_p^* = Z'\alpha_p + l_p'\delta_p + e_p$, where Z is a vector of observable independent variables i.e. market incentives, farmland and farm household characteristics (e.g. cash crop prices, land rental value, landholding size, household head's education and gender and dependency ratio). l_p is a vector of unobserved latent variables such as farming ability, that affect the biofuels market participation choice and the resultant household earnings. e_p is an error term which is assumed to be independent of l_p while α_p and δ_p are parameters associated with Z and l_p respectively. While U_p^* is not observed the farm household's choice to participate in a particular biofuels-related market *p* is observed. If we let *I* be the multinomial index denoting the specific market participation choice of a farm household, then we can write $I = p$ if and only if $U_p^* = \max(U_j^*) \vee j$ where U_j^* is the complete set of optimizing utility levels associated with each respective *j* participation decision that the farm household could possibly make. The expected household income resulting from each participation choice can be expressed as

$E(y) = \mu\ (x'\beta + I_p'\gamma_p + l'\lambda)$ where *x* is a set of exogenous variables with associated parameters β and γ_p, which denote the effects of participation in a biofuels-related market on household earnings relative to non-participation. Note, the expected earnings are also a function of the unobserved latent variables l_p with marginal effects parameters λ.

To empirically model this class of participation decision, we can use a multinomial probit model where the error terms are assumed to have a multivariate normal distribution with correlation between alternatives. This approach is advantageous over the multinomial logit model often applied in this context because it relaxes the independence of irrelevant alternatives (IIA) assumption. In estimating the multinomial probit model, we included household characteristics as independent variables as well as village level characteristics. However, because we were not just interested in the determinants of participation in biofuels related markets but also the effects of participation on farm household earnings, we proceeded by using the mixed multinomial logit treatment effects[4] model of Deb and Triverdi, 2006. While the mixed multinomial logit treatment effects model maintains the IIA property, it allows us to jointly estimate the determinants of participation in biofuels-related markets and the effects of participation on farm household earnings using the maximum simulated likelihood method, which employs the Halton sequence draws as an acceleration technique (Deb and Triverdi, 2006). We employed the mixed multinomial treatment effects model because a solution is econometrically feasible unlike with an analogous multinomial probit treatment effects model.

The use of a treatment-effects-type model was necessitated by the potential selection bias associated with smallholder farm households' participation in different biofuels-related markets, which is likely to result from the unobserved latent variables l_p. Self-selection may arise when participation in a particular biofuels market p is chosen by a distinct group of farm households that find it more beneficial than others to participate in that respective market. For example, it would be likely that farm households with agricultural land recently acquired through the land

[4] While estimating a multinomial probit treatment effects model would seem desirable for its relaxation of the independence of irrelevant alternatives assumption which is inherent in the mixed multinomial treatment effects, estimation is not feasible; identification of the covariance structure would require alternative specific exclusion restrictions. Moreover, the model is relatively fragile (Keane, 1992).

reform program but with low farming ability would be more inclined to participate in a land rental market than to grow the crops themselves for sale to a biofuels firm. In contrast, farmers who have high farming ability and the necessary land and farming implements may find it apposite to exercise their abilities and farm the crops for themselves then sell the crops to the highest bidder in the market (which may not necessarily be a biofuels firm). Therefore, if we were to directly compare the effects of leasing land to a biofuels firm versus growing crops and selling them to the biofuels firm, we would underestimate (or overestimate) the effects of participation on household earnings. Thus, we accounted for potential selection bias by way of the mixed multinomial treatment effects model. In estimating the mixed multinomial treatment effects model it was necessary that we imposed exclusion restrictions to identify the parameter estimates, such that some variables appearing in the probability distribution of the selection decision (participation in a biofuels-related market) were absent in the probability distribution of the outcome variable (household income). In our case we excluded membership in a cooperative or group, savings from the previous year available at the beginning of the planting season and distance to main market.

The joint distribution of the participation and income model can be obtained by multiplying the two probability distributions specified as follows,

Prob $(y, I = p \mid Z, x, I) = \mathbf{f}(x'\beta + I'\gamma + l'\lambda) \times \mathbf{g}(Z'\alpha + l'\delta)$

where **f** is the probability distribution of the household earnings and **g** is a multinomial probability distribution of the participation decision. By assuming the latent variables l_p are independently and identically distributed standard normal we can integrate out their joint probability distribution, **h**, so as to obtain a joint likelihood function that is solvable by simulated maximum likelihood estimation; since it does not have a closed form solution it is not directly

solvable by maximum likelihood estimation. Thus, following (Deb and Triverdi, 2006) the joint density is

$$\text{Prob}\,(y, I = p \mid Z, x, I) = \int [\,\mathbf{f}(\,x'\beta + I'\gamma + l'\lambda\,) \times \mathbf{g}(\,Z'\alpha + l'\delta\,)\,]\mathbf{h}(l)dl$$

In our analysis, two separate treatment effects models of this class were estimated for two outcome variables; (i) household cash earnings from a variety of productive sources (including crop sales, on-farm wages, off-farm wages and land rented out) and (ii) household expenditures on groceries. The latter was included in the analysis as a proxy for income and to draw inferences on food-fuel tradeoffs and how farm household participation in biofuels-related markets might affect household purchases of food and other non-durable consumption goods.

IV. Data

This study used data collected from a farm household survey that was administered in rural areas of the Eastern Cape, Limpopo and North West provinces of South Africa between September and December, 2009. A total of 247 farm households were randomly sampled from eight village areas in the Butterworth Eastern Cape, Brooksby-Lichtenburg North West and Monsterlus-Laersdrif, Limpopo enumeration areas. These village areas were selected purposively based on the presence of biofuels firms operating there to meet their feedstock supply needs. Prior to the farm household survey, key informant interviews were conducted with the managers of the biofuels firms as well as officers in the provincial government departments involved with biofuels initiatives in each area. This was primarily to delineate the sampling frame (the target population), which was defined as smallholder farm households located in village areas where biofuels firms were engaging smallholder farmers for feedstock supply. Based on the information gathered from the firms and the government departments farm households were

randomly sampled from each village area irrespective of whether they were engaged in biofuels initiatives or not. In the end a total of 93 farm households participating in some biofuels-related market and 154 farm households not participating in any biofuels market were sampled (see Table 2 for details).

In collecting the data, a 13-page questionnaire was used, which included questions on farm household characteristics (household composition, education, household cash income from various sources, age and marital status of household members), monthly grocery expenditures, types of crops produced, quantities of crops harvested, consumed, sold and stored, and whether the crops were sold as biofuels or food or non-food cash crops. The questionnaire also included questions on landholding size, land allocation among different crops farmed and land leased to biofuels firms. Summary statistics and details on relevant variables are shown in Tables 2 and 3. Village-level crop price data were also collected from the farm households and were corroborated by the local markets, biofuels firms and government department officers. The price data included average prices of maize, soy beans and sunflower (the main cash crops in the study areas). In addition, farm and non-farm wage rates for each village area were collected as were land rental rates. These village-level price/wage/rental data were included in the analysis to control for relative incentives associated with participating in different market opportunities.

V. Results

Table 3 presents descriptive statistics of the farm households sampled in this study. Included in the table are Pearson Chi-square and Fisher's exact Chi-square statistics computed to test for group differences between farm households that chose to participate in some biofuels-related market versus those that chose not to participate. In addition, ANOVA F-test statistics are

presented for continuous variables to test differences in means among the groups of farm households. The descriptive statistics show that the mean household size was 4.2 (standard deviation = 2.6) while the average household head's age was equal to 56.7 years (standard deviation = 13.1 years). Most household heads had relatively low levels of education (less than grade 10), however farm households that grew their own crops for sale to biofuels firms had relatively higher levels of education, e.g. 6.5% had a Bachelor's degree or higher compared to 0% for those who leased their land to biofuels firms and 2.6% for those who did not participate in any biofuels market. In general, farm households that chose to grow crops for the biofuels firms were significantly different from those that leased their land to the biofuels firms and from those that chose not to participate in biofuels-related markets. For example, farm households that grew crops for biofuels firms were younger in age (mean = 52.9 years compared to 58.3 years and 57.5 years for households that leased land to biofuels firms or did not participate, respectively), had larger areas of arable land and more household assets. This suggests self-selection on the basis of resource endowments, where farm households with more resources were more inclined to grow crops for biofuels firms. It appears that in many respects the group of farm households that leased their land to biofuels firms had fewer resources. For example 29.5% lived in a traditional hut dwelling compared to only 8.2% for those who grew crops for biofuels firms and only 6.8% owned vehicles compared to 10.2% for those who grew crops for biofuels firms. While these farm households had land, mostly acquired recently through the land reform program, they were relatively resource poor.

Mean household incomes, as measured by monthly cash earnings, differed in magnitude by group but not statistically. The incomes ranged from Rand 3650 for households that participated in biofuels crop markets to Rand 2735 for households that leased their land to biofuels firms. The

fact that we did not find any statistical difference in cash incomes suggests that participating in biofuels related markets did not have a significantly different impact on household incomes compared to non-participation. However, when we compared the household grocery expenditures, there was a statistical difference between the groups. Households that leased their land to biofuels firms had the highest consumption expenditure of Rand 647 per month followed by households that did not participate in any biofuels related market who spent on average, Rand 632 per month. It was those households that grew crops for biofuels firms that actually had the lowest consumption expenditure of Rand 579 per month. One possible explanation for this result is that most farmers that participated in growing crops for biofuels firms also grew their some of their own food crops. Thus, unlike the households that leased their land, they could still grow food crops which would supplement their food purchases. Nonetheless, multivariate econometric analysis is needful to adequately assess these differences in incomes.

Econometric Results and Discussion

To determine the factors influencing participation in each biofuels-related market we began by estimating a multinomial probit model where the dependent variable was the probability of participating in (i) a biofuels-crop market, (ii) a biofuels land rental market or (iii) not participating in any biofuels-related market. Table 4 presents the estimated coefficients and standard errors of the multinomial probit model estimation. The respective marginal effects are shown in Table 5.

The results of the multinomial probit model show that at 1% significance level, receipt of price information significantly influenced participation in both biofuels crop and land rental markets. Farm households that stated they had received price information were more likely to participate

in either biofuels-related market than those who said they did not receive any price information. The price of maize (the main crop farmed in the study areas) and the land rental rate were both significant predictors of participation in a biofuels cropping market. A higher maize price implied increased probability of participating in a biofuels crop market while increased rental rates implied reduced participation in a biofuels crop market. These results are not all that surprising given that maize was being grown as a biofuels feedstock for the maize-ethanol biofuels firms in some of the sample areas. Also, maize prices were highly correlated with prices of other biofuels feedstock crops, therefore higher prices maize would likely act as an incentive signal for farmers to grow crops. As for the rental rate, it is expected that a higher rental rate would attract farmers into the land rental market and away from own crop production; again an incentive signal this time in the form of returns to land. While only significant at the 10% level, distance to the main agricultural market was found to influence the decision to participate in a biofuels crop market. Being located an additional 1 km further away from a major agricultural market would decrease the likelihood of participation in a biofuels crop market by 0.07% compared to not participating in any biofuels market at all. In contrast, distance to a major market did not seem to influence the probability of leasing land to a biofuels firm, suggesting that biofuels land renatal markets in South Africa may be providing a useful alternative to farmers distant to crop markets. Thus biofuels firms, particularly those that lease land, potentially benefit farm households located further away from major agricultural markets.

Gender of household head was also found to influence the probability of participating in biofuels-related markets (both crop and land rental markets), at the 10% significance level. Female-headed households were 2% less likely to participate in biofuels crop markets and 9%

less likely to participate in a biofuels-related land rental market. This can be explained by the fact that fewer women own land or have access to factors of production in the areas studied. Thus, the inequitable distribution of factors of production and resources disfavors female-headed households' participation in biofuels-related market opportunities and even if new biofuels market opportunities present themselves in a village, women and female-headed households are likely to be left behind and excluded from any potential benefit from the biofuels opportunities compared to male-headed households. It is particularly worth noting that the gender difference is more pronounced for biofuels land rental markets. While it is possible that women are less likely to participate in land rental markets for fear of losing their recently gained land, it may also be the case that land reform program, while it has made efforts to include women and female-headed households as beneficiaries, has not done enough to achieve equitable land distribution in terms of gender. This finding may be particularly important in as far as the government's gender equity goals and land governance are concerned. If women and female-headed households are to effectively participate in biofuels-related markets, and other agricultural market, they will need access to a whole suite of productive resources (including land e.g. through the land redistribution program, adequate farming equipment and inputs and extension services).

As would be expected, landholding size was a significant determinant of participating in a land rental market, with households owning larger parcels of land being more likely to rent land to biofuels firms. Corroborating this finding was qualitative evidence obtained during personal interviews with managers of the biofuels firms. Managers of several biofuels firms indicated that they preferred renting larger areas of land as this allowed them to realize economies of scale in farm production. Moreover, the ability of biofuels firms to rent large areas of land from fewer

farmers allowed them to reduce the amount of coordination and transaction costs incurred in acquiring land for farm production. Thus, farm households with smaller areas of land often had to combine their pieces of land and rent their combined land as a group, if they wanted to participate in a biofuels-related land rental market. This often presented challenges of coordination and likely limited the ability of farm households to participate in biofuels land rental markets if they had small landholding sizes. One remedy which was observed during data collection is that of third party coordination, whereby farm households with small land areas were being coordinated by a local government entity (e.g. the provincial government department of agriculture, the local chiefs and/or the ASGISA program (Accelerated and Shared Growth Initiative of South Africa)). Nevertheless, given that the econometric results show that farm households with small land areas well less likely to participate in the land rental markets, it would seem that the coordination problem was not entirely solved by these local government initiatives. Improving how the coordination of land rentals takes place or finding other means of addressing this issue may be warranted.

An important finding, not readily revealed in the econometric results but obtained through qualitative information during data collection was that farm households that leased their land and cited lack of resources often mentioned the benefit of freeing up their labor for household chores, rural farm employment or non-farm rural employment. This important feature of the biofuels land rental markets was however not complemented by availability of remunerative employment opportunities in the study areas and presents an area that government could potentially explore to enhance the benefits that arise when biofuels firms engage communities through land rental markets. From the point of view some households that were constrained by labor, especially those with women with young children and multiple household chores, the land rental markets

presented such households with more than just money earned from leasing out land; mainly time which could then be used for other needs. Overall, a number of markets related incentives appear to have taken precedence in determining the kind of participation in biofuels markets. Thus, developing a variety of strong market institutions for biofuels in areas where there are biofuels investments would appear to be critical for farm households to effectively participate and gain from the new biofuels market developments. Developing complementary markets, in the form of farm and non-farm labor markets as well as the provision of necessary factors of production and farm inputs also appear to be important.

Regarding the effect of participation in biofuels markets on income, results of the mixed multinomial treatment effects model are presented in Table 6. In general it was found that participating in biofuels crop markets did not significantly increased household income, compared to non-participation. This result, while suggesting that cash incomes of participants are the same as incomes of non-participant possibly fails to capture the non-monetary gains such as those experiences by the land renters who gained by freeing up their labor.

Other factors that were found to significantly increase the level of household cash income were land area owned, highest level of education attained by the households head, the local price of maize and off-farm wage rate. In contrast, the dependency ratio was found to decrease the level of household cash income as was a low education level of between the first and ninth grade. The latter was negative relative to a higher education (the reference level), implying that schooling beyond the ninth grade had a positive impact on household cash incomes; a somewhat expected result. Findings suggest that gender of household head while it had an impact on the participation decision, did not have an impact on the income level. This result is a little counterintuitive since

once but may be a result of the fact that there was no significant difference in cash incomes between participating and non-participaing households. Therefore, while most female-headed households may experience barriers to participation in biofuels markets, the statistically insignificant differences in the returns to participation may mean gender does not have an effect on incomes in the areas studied.

Overall, it is important to bear in mind that while results show that incomes among biofuels participating farmers were not significantly greater than those of farm households that did not participate in any biofuels market, the data analyzed do not capture non-monetary gains which appear to have been experienced by some of the households. Thus, the differences in impact may not have been captured purely because there were non-monetary gains associated with the biofuels developments.

VI. Conclusions

This paper studied the determinants of farm household participation in biofuels crop and land rental markets and estimated the effects of participation on farm household cash income. Using a multinomial probit model, it was established that resource constraints such as land holding size and limited the participation of poorer farm households in biofuels crop and land rental markets. Market variables including the access to price information, price of maize and land rental rate were all found to influence the decision to participate in biofuels related markets. As expected a high land rental rate induces households to lease their land to biofuels firms, while a higher maize price induces them to grow crops on their land.

Gender of household head was also found to influence the participation decision, with women less likely to participate in biofuels markets. Qualitative findings also showed that poorer

households and particularly households with women and younger children were likely to participate in land rental markets, if they chose to participate as this freed up their labor for other income generating activities while earning income from land leased to the biofuels firms. Thus, land rental markets are seen as playing an important role in improving incomes of the resource-poor households. Moreover, this may in fact be equalizing incomes between the resource poor and the resource rich, implying that biofuels rental markets may be reducing income disparities and inequity in rural South Africa. However, this hypothesis requires more formal assessment as this was not addressed in this paper. The evidence that there were no significant income differences between households that participated in biofuels crop or land rental markets and those that did not participate in any biofuels market may potentially be a result of the income-equalizing nature of the biofuels markets studied in this paper. Results from a mixed multinomial treatment effects model found that participating in different biofuels markets (crop or land rental markets) did not significantly affect the household cash income. Farm households that chose to participate in biofuels crop markets or land rental markets were not significantly better off in terms of their household cash incomes. Additional analysis is needed, particularly to assess the differences in consumption expenditure of households participating in biofuels markets and thos not participating. This would potentially reveal food-fuel tradeoffs not shown by the analysis of cash income. In summary, it appears there are benefits accruing to farm households from participating in biofuels investments, some of which are non-monetary. Future analysis of these benefits would help improve our understanding of the total benefits and how biofuels policy might be designed to enhance the benefits for the poor.

References

Arndt, C., Benfica, R., Maximiano, N., Nucifora, A.M.D., and Thurlow, J.T. 2008. Higher Fuel and Food Prices: Impacts and Responses for Mozambique. *Agricultural Economics* 39(Supplement):497-511.

Arndt, C., Benfica, R., Tarp, F., Thurlow, J. and Uaiene, R. 2008. Biofuels, Poverty and Growth: A Computable General Equilibrium Analysis of Mozambique. IFPRI Discussion Paper 00803. Washington D.C.: International Food Polic Research Institute.

BFAP – Bureau for Food and Agricultural Policy. 2007, March. Modelling the Impacts of Macroeconomic variables on the South African Biofuels Industry. Pretoria, South Africa.

Brent, A.C., Wise, R., Fortuin, H. 2009. The viability of the South African biofuels industrial strategy. *International Journal of Environment and Pollution*, Volume 39, Numbers 1-2, 16 July 2009 , pp. 74-91(18)

Cartwright, A. 2010. Biofuels trade and sustainable development: the case of South African bioethanol. In Dufey, A. and Grieg-Gran, M. (eds) *Biofuels production, trade and sustainable development* London: International Institute for Environment and Development.

Colin, J. and P. Woodhouse. "Introduction: interpreting land markets in Africa." Africa: The Journal of the International African Institute 80.1 (2010): 1-13.

Cotula, L., Dyer, N., and Vermeulen, S., 2008. Fuelling exclusion? The biofuels boom and poor people's access to land: London, IIED.

Davis, B. Winters P. Reardon, T. and Stamoulis, K. 2009. Rural nonfarm employment and farming: household level linkages. *Agricultural Economics* 40: 119-123.

Deb, P. and Trivedi, P. K. 2006. Specification and simulated likelihood estimation of a non-normal treatment-outcome model with selection: Application to health care utilization. The Econometrics Journal, 9: 307–331.

Elobeid, A and Hart, C. 2007. Ethanol expansion in the food versus fuel debate: how will developing countries fare? *Journal of Agricultural and Food Industrial Organization* 5(2): Article 6 Available at: http://www.bepress.com/jafio/vol5/iss2/art6

Goetz, S.J. 1990. Market Reforms, Food Security, and the Cash-crop Food-crop Debate in Southeastern Senegal. Unpublished Ph.D. dissertation. Michigan State University, East Lansing, MI.

Govereh, J. and Jayne, T.S. 2003. Cash cropping and food crop productivity: synergies or trade-offs? *Agricultural Economics* 28(1): 39-50.

Headey, D. and Fan, S. 2008. Anatomy of a crisis: the causes and consequences of surging food prices. *Agricultural Economics* 39(supplement): 375-391.

Keane, M.P. 1992. A note on identification in the multinomial probit model. *Journal of Business and Economic Statistics* 10(2):193-200.

IFAD. 2003. Promoting Market Access for the Rural Poor in Order to Achieve the Millennium Development Goals. Discussion Paper. IFAD

ILO (International Labor Organization). 2008. Promotion of rural employment for poverty reduction. International Labour conference 97th session. Geneva. p46

Jayne, T.S., Zulu B and J.J. Nijhoff. 2006. Stabilizing food markets in eastern and southern Africa. *Food Policy* 31(4): 328-341

Meyer, F., Strauss, P.G., and Funke, T. 2008. Modelling the Impacts of Macro-economic Variables on the South African Biofuels Industry. *Agrekon* 47(3):327-345.

Nieuwoudt, S. (2007, December 24). Food security hobbles SA biofuel strategy. *Mail and Guardian*. Johannesburg, South Africa.

Pingali, P., Raney T. and K. Wiebe. 2008. Biofuels and Food Security: Missing the Point. *Review of Agricultural Economics* 30(3):506-516

Reardon, T., Berdegu´e, J.A., Barrett, C.B., Stamoulis, K., 2007. Household income diversification into rural nonfarm activities. In: Haggblade, S., Hazell, P.B.R.,Reardon,T. (Eds.),Transforming the Rural Nonfarm Economy, Johns Hopkins University Press, Baltimore.

Rosegrant, M.W., Zhu, T., Msangi, S. and Susler, T. 2008. Global Scenarios for Biofuels: Impacts and Implications. *Review of Agricultural Economics* 30(3):495-505

Rossi, A., and Lambrou, Y. 2009. Making sustainable biofuels work for smallholder farmers and rural households: issues and perspectives. Food and Agriculture Organization, Rome.

Sulle, E. and Nelson, F., 2009, Biofuels, Land Access and Rural Livelihoods in Tanzania, IIED, London, UK

Takavarasha, T., Uppal, J., and Hongo, H. 2005. Feasibility Study for the Production and Use of Biofuel in the SADC Region. Southern African Development Community (SADC). Gaborone, Botswana.

Vink, and Kirsten, J. 2000. *Deregulation of agricultural marketing in South Africa: Lessons learned*. The Free Market Foundation Monograph No. 25. Sandton, South Africa

Visagie, E. and Prasad, G.2006. Renewable energy technologies for poverty alleviation. South Africa: biodiesel and solar water heaters. Cape Town: Energy Research Center, University of Cape Town

von Braun, J., ed. 1995. Employment for poverty reduction and food security. International Food Policy Research Institute, Washington DC.

von Braun, J. and R. Meinzen-Dick. 2009. "Land Grabbing" by Foreign Investors in Developing Countries: Risks and Opportunities. International Food Policy Research Institute Policy brief 13. International Food Policy Research Institute, Washington, DC.

Weber, M.T., Staatz, J.M., Holtzman, J.S., et al. 1988. Informing food security decisions in Africa: empirical analysis and policy dialogue. *American Journal of Agricultural Economics* 70(5):1044-1052.

Table 1. Choices available to farm households for participation in biofuels-related markets

Biofuels-related market	*Participated in biofuels market*	*Did not participate*
Land-rental market	Rented land to biofuels firm (Biofuels crop produced: canola)	Rent land to non-biofuels firm/farmer or leave land unfarmed
Cash crop market	Produced biofuels feedstock crop for sale (maize, soy beans, sunflower)	Produce food/feed/fiber crop for own consumption Produce food/feed/fiber crop for sale
Labor market	Mentorship of newly enrolled biofuels crop farmers	Provide farm-labor Provide non-farm labor

Table 2. Description of Variables

Variable	Description and units of measurement	Sample mean or percentages
Dependent variable(s): y		
Participation in biofuels-related market	Participation in biofuels crop markets, measured as a multinomial categorical variable (grow crops for sale to biofuels firms (ii) entering into a land-rental contract to lease land to a biofuels firm and (iii) Not participating in biofuels-related market.)	Grow biofuels crops = 20.2% Lease land to biofuels firm = 17.8% did not participate in biofuels related market = 61.9%
Household cash income	Monthly cash income (in Rands)	Mean = R3170.07 (standard deviation=4834.86; minimum=R240 maximum=R28,900)
Household monthly grocery expenditures	Average monthly expenditure on groceries	Mean = R624.22 (standard deviation=113.40, minimum = R420 maximum = 986.
Explanatory variables: *x*		
Sex of household head	Binary variable, whether the household head is a male or female	Male = 64.1% Female 35.9%
Age of household head	Age group category (i) 21-40 years, (ii) 41-60 years, (iii) 61-89 years	Mean = 56.7 years (standard deviation = 13.1) minimum = 21 maximum = 89 21-40 years = 11.7% 41-60 years = 48.2% 61-89 years = 40.1%
Household size	Number of individuals in the family	4.2 members (standard deviation = 2.6, minimum = 1, maximum = 12)
Dependency ratio	A ratio obtained by dividing the sum of individuals younger than 15 years and older than 64 years by the total number of individuals in the household	Mean = 0.313 (standard deviation = 0.287, minimum = 0, maximum = 1)
Education of household head	The highest level of education attained by the household head (ordinal variable)	No schooling = 12.3% Grade 1-9 = 49.2% Grade 10 - not complete Grade 12 = 22.1% Complete Grade 12 – Diploma = 13.5%

		Bachelor's degree or higher = 2.9%
Marital status	Whether household head is married or not, (nominal variable)	Married civil/religious = 48.6% Married traditional/polygamous = 30.2% Not married/single/divorced/widow = 21.2%
Location – Province	Province where the farm is located (nominal variable)	Eastern Cape = 47.4% Limpopo = 36.0% North West = 16.6%
Land area available for crop farming	Land in hectares that the household has access to for crop farming	Mean = 8.83 ha (standard deviation = 14.61; minimum = 0 ha maximum =150 ha)
Remittances	Amount received as remittances last year	R761.21, standard deviation = 3680.00; minimum = 0 maximum = R50,000
Savings	Amount of savings at the beginning of the planting season	Mean = 1208.53 (standard deviation =
Distance to market	Distance to main market (measured in km)	38.3 km (standard deviation = 48.5) minimum = 0 km, maximum = 220 km
Cell phone	Access to cell phone; proxy variable to measure access to market information (binary variable – Yes/No)	Has cellphone = 94.0% Do not have cellphone = 6%
Radio	Access to radio; proxy variable to measure access to market information (binary variable – Yes/No)	Has radio = 87.7% No radio = 12.4%
Television	Access to television; proxy variable to measure access to market information (binary variable – Yes/No)	Has television = 75.3% No television = 24.7%
Extension service	Whether household received any information or advice pertaining to crop farming from an extension officer (binary variable – Yes/No)	Received extension service = 59.4% Did not receive extension service = 40.7%
Cooperative	Operate as a member of cooperative or other	Member of a cooperative = 40.6% Registered private company = 22.7% Unregistered family farm = 36.7%
Credit/Loan	Whether household received credit/loan or not in the previous year	Received credit = 18.6% Did not receive credit = 81.4%
Price of sunflower	Price of sunflower in Rands per ton	R3043.00/ton (standard deviation=201.82

		minimum =R2722, maximum=R3300)
Price of maize	Price of maize in Rands per ton	R1401.30/ton (standard deviation=162.28 minimum =R1200, maximum=R1650)
Price of soybean	Price of soybeans in Rands per ton	R3252.43/ton (standard deviation=177.93 minimum =R2900, maximum=R3450)
Unskilled Non-farm wage rate	Non-farm wage rate (Rands per month)	R2341.21/month (standard deviation= 86.62 minimum =R2203, maximum=R2461)
Farm wage rate	Farm wage rate (Rands per month)	R1077.08/month (standard deviation=109.79 minimum =R967, maximum=R1262)
Land rental rate	Land rental rate (Rands per ha per year)	R421.62/year (standard deviation=18.19 minimum =R400, maximum=R450)

Table 3. Characteristics of farm households sampled

Variable (units)	Grow crops for sale to biofuels firm	Lease land to biofuels firm	Did not participate in biofuels-related market	Total	Pearson's or Fisher's Exact Chi-square test of association [P-value] or ANOVA F-test of differences in means (P-value)
Household size	2.8 (2.2)	4.6 (2.9)	4.6 (2.5)	4.2 (2.6)	(<0.001)***
Dependency ratio	0.22 (0.30)	0.26 (0.28)	0.36 (0.28)	0.31 (0.29)	(0.0024)***
Age of household head:					
21 - 40 years	20.4%	2.3%	11.7%	11.7%	[0.066]*
41 - 60 years	46.9%	59.1%	45.5%	48.2%	
61 - 89 years	32.7%	38.6%	42.9%	40.1%	
Age of household head (in years)	52.9 (13.7)	58.3 (11.8)	57.5 (13.1)	56.7 (13.1)	(0.0653)*
Education of household head:					
No schooling/Grade 0	17.4%	11.4%	11.0%	12.3%	[0.010]**
Grade 1-9	21.7%	56.8%	55.2%	49.2%	
Grade 10-not complete	32.6%	15.9%	20.8%	22.1%	
Grade 12 complete-Diploma	21.7%	15.9%	10.4%	13.5%	
Bachelor's degree or higher	6.5%	0.0%	2.6%	2.9%	
Gender of household head:					

Female	24.5%	25.0%	42.5%	35.8%	[0.019] **
Marital status					
Married (civil or religious)	40.4%	54.5%	49.4%	48.6%	[0.062] *
Married (Customary Traditional or polygamous)	46.8%	27.3%	26.0%	30.2%	
Not married (Never married, separated, divorced, widowed)	12.8%	18.2%	24.7%	21.2%	
Type of house lived in:					
Brick structure house	91.8%	70.5%	77.9%	79.4%	[0.031] **
Traditional hut/shack	8.2%	29.5%	22.1%	20.6%	
Own a vehicle	10.2%	6.8%	8.4%	22.6%	[0.842]
Own a cellphone	100.0%	90.9%	92.9%	93.9%	[0.075] *
Own a radio	87.8%	84.1%	88.3%	87.4%	[0.756]
Own a TV	83.7%	61.4%	76.0%	74.9%	[0.041] **
Own a computer	18.4%	4.5%	5.2%	7.7%	[0.007] ***
Have internet access	0.0%	2.3%	0.6%	0.8%	[0.444]
Land available for cultivation (ha)	16.06 (13.06)	10.87 (16.45)	5.95 (13.68)	8.83 (14.61)	(<0.001) ***
Irrigation used	8.2%	18.2%	19.5%	17.0%	[0.180]
Last year's remittances	579.59 (2858.54)	854.55 (2556.29)	812.21 (4206.80)	773.60 (3708.50)	(0.9183)
Last year's savings	1338.47	94.09 (282.24)	650.09	687.61	(0.4357)

(Rand)	(2928.34)		(5672.40)	(4674.12)	
Received credit (Yes or No)	20.4%	13.6%	19.5%	18.6%	[0.638]
Mentor	6.1%	0.0%	0.0%	1.2%	[0.002] ***
Distance to main agricultural market	50.98 (52.98)	50.05 (55.14)	31.37 (44.31)	38.59 (48.87)	(0.011) **
Member of cooperative					
Member of cooperative	24.5%	59.1%	40.9%	40.9%	[<0.001] ***
Registered private firm	59.2%	6.8%	14.3%	21.9%	
Unregistered family farm	16.3%	34.1%	44.8%	37.2%	
Received extension services	75.5%	75.0%	49.7%	59.3%	[<0.001] ***
Received crop price information	87.8%	77.3%	42.2%	57.5%	[<0.001] ***
Price of maize (Rand per ton)	1585.31 (63.84)	1351.59 (150.98)	1356.95 (145.34)	1401.30 (162.28)	(<0.001) ***
Price of soy beans (Rand per ton)	3386.73 (127.79)	3223.86 (173.03)	3217.86 (173.65)	3252.43 (177.93)	(<0.001) ***
Price of sunflower (Rand per ton)	3244.82 (136.68)	2982.86 (180.29)	2995.97 (184.88)	3043.00 (201.82)	(<0.001) ***
On-farm wage (Rand per month)	1053.33 (57.44)	1086.59 (124.58)	1081.92 (117.27)	1077.08 (109.79)	(<0.001) ***
Unskilled Off-farm wage (Rand per month)	2411.18 (35.34)	2303.45 (85.92)	2329.73 (86.52)	2341.21 (86.62)	(<0.001) ***
Land rental rate (Rand per ha per	429.59 (24.83)	421.82 (15.44)	419.03 (15.63)	421.62 (18.19)	(0.0017) ***

year)					
Household cash income (Rand per month)	3650.06 (4442.23)	2735.23 (4130.16)	3141.59 (5144.96)	3170.07 (4834.85)	"(0.6574)
Expenditure on groceries (Rand per month)	579.45 (101.83)	647.91 (115.83)	632.12 (113.35)	624.48 (113.57)	(0.0055) ***
Total count	49	44	154	247	
	24.5%	25.0%	50%	100%	--

*** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Table 4. Multinomial probit model of participation in biofuels-related markets

Variable	Coefficient	Standard error of coefficient
Prob (I = Grow crops for biofuels firm)		
Household size	-8.51E-03***	1.07E-01
Dependency ratio	0.58***	0.86
Age:		
41-60 years	0.18***	0.74
61-89 years	-0.19***	0.80
Sex: Female	-0.96***	0.54
Education:		
No schooling/Grade 0	-0.69***	0.74
Grade 1-9	-0.68***	0.59
Completed Grade 12 - diploma	-0.47***	0.59
Bachelor's degree or higher	-0.62***	1.51
Marital status:		
Married civil/religious	1.01***	0.80
Married Traditional/Polygamous	1.23***	0.78
Landholding size	0.01***	0.02
Received price information	2.12***	0.58
Distance to main market	8.59E-03***	4.57E-03
Savings from last year	1.11E-05***	4.66E-05
Member of cooperative/group	0.28***	0.56
Price of maize	2.05E-02***	4.77E-03
Off-farm wage rate	-3.31E-03***	6.58E-03
Land rental rate	-3.35E-02***	1.44E-02
Constant	-12.31***	16.68
Prob (I = Rent land to biofuels firm)		
Household size	0.05***	0.07
Dependency ratio	-1.26***	0.75
Age:		
41-60 years	2.05***	1.15
61-89 years	1.93***	1.17
Sex: Female	-0.86***	0.40
Education:		
No schooling/Grade 0	-0.15***	0.65
Grade 1-9	0.07***	0.48
Completed Grade 12 - diploma	0.43***	0.61
Bachelor's degree or higher	-10.43***	2.69E+08
Marital status:		
Married civil/religious	-0.21***	0.49
Married Traditional/Polygamous	0.11***	0.52
Landholding size	0.05***	0.02
Received price information	1.26***	0.35
Distance to nearest market	4.25E-03***	3.37E-03
Savings	-4.69E-04***	5.29E-04
Membership of cooperative/group	0.12***	0.36047
Price of maize	1.17E-03***	2.12E-03

Off-farm wage rate	-8.53E-03***	3.42E-03
Land rental rate	1.13E-02***	1.33E-02
Constant	9.72***	9.22

Table 5. Marginal Effects in multinomial probit model for participation in biofuels related markets

	Prob (*I* = Lease land out to biofuels firm)		Prob (*I* = Grow crops for biofuels firm)	
Variable	Marginal Effect	Standard error	Marginal Effect	Standard error
Household size	0.01	0.018	-1.68E-2	0.015
Dependency ratio	-0.19	0.188	1.27E-2	0.067
Age: 41-60	0.13	0.075	-9.5E-4	0.027
Age: 61-89	0.33			
Sex: Female	-0.09	0.04	-0.02	0.043
Education:				
No schooling/Grade 0	-0.02	0.051	0.022649	0.021
Grade 1-9	0.01			
Completed Grade 12 - diploma	0.08			
Bachelor's degree or higher	-0.17			
Marital status:				
Married civil/religious	-0.03	0.058	0.012894	0.022
Married Traditional/Polygamous	0.02			
Landholding size	0.01	0.004	0.001246	0.002
Received price information	0.27	0.123	0.002229	0.043
Distance to main market	6.37E-4	0.111	-0.06999	0.078
Savings from last year	-7.05E-5	0.054	-0.02737	0.029
Member of a cooperative/group	0.02	0.001	0.000532	0.001
Price of maize	1.73E-4	0.000	2.86E-05	0.000
Off-farm wage rate	-1.28E-3	2.0E-5	-4.58E-06	0.000
Land rental rate	1.71E-3			

Table 6. Results of the mixed multinomial treatment effects model for household cash income

Variable	Coefficient	Standard error	P-value
Prob (I = Grow crops for biofuels firm)			
Household size	-8.51E-3***	0.16	0.958
Dependency ratio	1.43***	1.27	0.260
Age:			
41-60 years	0.06***	1.08	0.957
61-89 years	-0.51***	1.16	0.658
Sex: Female	-1.44***	0.78	0.066
Education:			
No schooling/Grade 0	-1.34***	1.13	0.237
Grade1-9	-1.09***	0.89	0.220
Completed Grade 12-diploma	-0.50***	0.89	0.575
Bachelor's degree or higher	-1.22***	2.05	0.552
Marital status:			
Married civil/religious	1.31***	1.14	0.254
Married traditional/polygamous	1.79***	1.13	0.113
Landholding size	0.02***	0.03	0.485
Received price information	3.15***	0.89	<0.001
Price of maize	3.36E-02***	7.36E-03	<0.001
Off-farm wage rate	-5.03E-03***	9.67E-03	0.603
Land rental rate	-6.08E-02***	0.02	0.005
Distance to main market	1.11E-02***	6.89E-03	0.108
Savings from last year	2.24E-05***	6.78E-05	0.741
Member of cooperative/group	0.96***	0.87	0.268
Constant	-18.16***	24.40	0.457
Prob (I = Rent land to biofuels firm)			
Household size	0.06***	0.10	0.548
Dependency ratio	-1.90***	1.11	0.086
Age:			
41-60 years	3.00***	1.72	0.080
61-89 years	2.79***	1.75	0.111
Sex: Female	-1.33***	0.60	0.027
Education:			
No schooling/Grade 0	0.07***	0.96	0.943
Grade1-9	0.31***	0.73	0.674
Completed Grade 12 - diploma	0.80***	0.92	0.389
Bachelor's degree or higher	-43.40***	2.98E+09	1.000
Marital status:			
Married civil/religious	-0.26***	0.71	0.713
Married traditional/polygamous	0.16***	0.76	0.838
Landholding size	0.07***	0.03	0.012
Received price information	1.87***	0.53	<0.001
Price of maize	1.37E-03***	3.16E-03	0.664
Off-farm wage rate	-1.33E-02***	5.13E-03	0.010
Land rental rate	1.59E-02***	2.04E-02	0.437

Distance to main market	5.78E-03***	4.92E-03	0.239
Savings from last year	-7.37E-04***	7.95E-04	0.354
Member of cooperative/group	0.13***	0.53	0.807
Constant	16.68***	14.07	0.236
Household cash income			
Grow biofuels crop	-1489.0***	1111.19	0.180
Rent land to biofuels firm	153.2***	1461.58	0.917
Household size	57.8***	124.74	0.643
Dependency ratio	-2452.5***	1208.78	0.042
Age:			
41-60 years	282.4***	1099.50	0.797
61-89 years	1475.9***	1131.56	0.192
Sex: Female	-158.7***	676.74	0.815
Education:			
No schooling/Grade 0	254.8***	1120.48	0.820
Grade1-9	-1991.0***	821.06	0.015
Completed Grade 12 - diploma	2242.0***	990.19	0.024
Bachelor's degree or higher	1030.4***	2015.26	0.609
Marital status:			
Married civil/religious	953.6***	854.94	0.265
Married traditional/polygamous	-17.4***	920.34	0.985
Landholding size	61.4***	22.94	0.007
Received price information	111.3***	725.22	0.878
Price of maize	8.6***	3.65	0.019
Off-farm wage	17.9***	6.01	0.003
Land rental rate	6.2***	18.53	0.737
Constant	-29734.3***	14564.53	0.041
/lnsigma	8.144888***	0.15	<0.001
/lambda_Grow biofuels crop	2178.975***	857.35	0.011
/lambda_Rent land to biofuels firm	-1468.931***	1494.97	0.326
sigma	3445.721***	500.47	

*** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.