Participation of Smallholder Farmers in Biofuels Crop and Land Rental Markets: Evidence from South Africa

Athur Mabiso
International Food Policy Research Institute (IFPRI)
Development Strategy and Governance
2033 K St NW
Washington DC, 20006
United States

Email: a.mabiso@cgiar.org
Tel: +1 202 862 4616
Fax: +1 202 467 4439

Selected Paper prepared for presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August, 2012.

Abstract

This study investigates smallholder farmer participation in biofuels-related crop and land rental markets and estimates whether participation is associated with farm income. Multinomial treatment-effects models are estimated using farm household data from 247 South African smallholder farmers. Results reveal, among other things, that receiving price information increases smallholders' likelihood to participate in biofuels cropping markets by 18% and by 27% the likelihood to participate in biofuels land-rental markets. While not statistically significant, the mean income of smallholders growing biofuels crops is 33% higher than that of those renting land to biofuels firms and 16% higher than that of non-participants.

Key Words: Sub Saharan Africa, South Africa, Biofuels contracts, Land rental markets, Smallholder participation

JEL: O12, Q12, Q13, Q15, Q16

Acknowledgements: This study was funded by the United States Agency for International Development (USAID) through the Borlaug LEAP Fellowship program. The author would like to thank Dave Weatherspoon for providing invaluable comments and advice. The author is also grateful to Lisa Cook, Satish Joshi and Bob Myers for guidance and comments provided during the author's PhD research, from this paper is drawn.

1. Introduction

Participation of smallholder farmers in biofuels crop and land rental markets is a relatively new phenomenon that has generated much controversy for various reasons, including the food-versus-fuel debate, "land-grab" criticism and concerns that smallholder farmers might be exploited by foreign firms and local politicians who too often give concessions to foreign biofuels investors with little or no say from smallholder farmers (Rossi and Lambrou, 2009; Sulle and Nelson, 2009; Arndt, et al. 2008a; Arndt et al, 2008b; Cotula et al., 2008). In general there is still debate on the effects of biofuels investments on smallholder farmers and whether these initiatives, often operated by large-scale foreign firms, have any real benefits for the rural poor. Do biofuels, through feedstock cropping contracts or biofuels land rental markets, improve the livelihoods of smallholder farmers or are these biofuels investments exploitative, leaving smallholder farmers with less income and less control over their land?

These questions that have beset the debate on biofuels in many parts of Sub-Saharan Africa are important to consider for agriculture policymaking and investment decisionmaking aimed at improving the livelihoods of smallholder farmers.

In South Africa, some of the smallholder farmers that have recently benefited from the land redistribution program have had to decide if they want to grow food crops for own consumption and/or sale or participate in new biofuels market opportunities such as biofuels feedstock contracts and biofuels land rental contracts (Cartwright, 2010; Colin and Woodhouse, 2010). As these new biofuels market opportunities continue to propagate the literature on biofuels still has limited evidence on smallholder farmer participation in biofuels. Instead much of the research has focused on food-fuel tradeoffs and more recently on "land grabs" and land governance issues (Rosegrant et al., 2008; Cotula et al., 2008; von Braun and Meinzen-Dick, 2009). Research on rural household-level effects of biofuels investments, particularly on incomes and consumption expenditure, are still very few yet this is arguably central to understanding how biofuels investments directly affect the rural poor. Thus, the objective of

this study is to provide a first step in addressing this literature gap. Specifically, we analyze factors influencing smallholder farmers' participation in biofuels markets and compare farm household incomes and grocery expenditures of smallholder farmers participating in biofuels markets to those not participating in biofuels markets. The plan of our paper is as follows. In the next section we describe the complexity of smallholder farmer participation in biofuels markets in South Africa, which is important for defining what biofuels participation means – the subject matter of the ensuing section 3. In section 4 we discuss the theoretical and empirical underpinnings employed to analyze smallholder farmer participation in biofuels markets. Section 5 describes the data and descriptive statistics while section 6 presents the econometric results. The study is concluded in section 7 where policy implications and areas of future study are put forth.

2. Complexity in Smallholder Biofuels Participation

When this study was initiated, smallholder farmer participation in biofuels markets was thought to mainly entail growing crops for sale to a biofuels firm potentially under contract. This notion, which is quite common in the media and literature, turns out to be quite limited as evinced by pilot interviews that we conducted with biofuels firms' managers. Findings showed that biofuels firms in South Africa mostly offered smallholder farmers a variety of feedstock supply contracts or land rental contracts. Thus we focused our analysis on these two broad categories of biofuels market participation.

While it would have been informative to further analyze smallholder participation in biofuels markets by the type of feedstock (crop) and type of biofuels output (biodiesel or ethanol), these variables were deemed predetermined for smallholder farmers and largely based on the firms' choice of investments, local climatic conditions and government policy on allowable biofuels feedstock. This implies that in large part the prevailing types of biofuels output and biofuels feedstock were not a decision made by the smallholder farmers. Instead smallholder farmers only decided whether or not to participate in any

biofuels market opportunity available in the opportunity set they were offered by the firms or government programs. This is typically the case in any other contract market opportunity that smallholder farmers have in developing countries.

A potentially beneficial form of smallholder participation in biofuels-related markets was that of biofuels labor markets e.g. the supply of non-farm labor to biofuels processing plants or the supply of farm labor to commercial feedstock farms operated by the biofuels firms. However, the biofuels firms interviewed in this study did not significantly hire local labor for their operations. This in itself warranted further investigation as it implied that biofuels firms did not create significant farm and non-farm rural employment. Indeed, further qualitative analysis revealed that the only biofuels-related labor activity was that of four smallholder farmers who were hired by a biodiesel firm to mentor less-experienced farmers that had newly been contracted to grow sunflowers and soybeans for the biodiesel firm. To understand this limited form of biofuels-related labor activity, we found it useful to characterize the biodiesel firm as well as the farmers who were hired and the nature of their labor contracts.

The biodiesel firm was a not-for-profit organization with a philosophy and business model of empowering entrepreneurs in biodiesel crop markets. It provided basic training in business management and crop farming, free of charge to the participating farmers, and had been in operation for five years. These characteristics lend support to the explanations provided by two biofuels firm managers, on why their for-profit biofuels firms generally did not hire local labor. One explanation that was given is that local labor lacked the necessary skills and experience and that it was less profitable for firms to invest in training smallholder farmers for a long period of time compared to employing external labor already experienced and knowledgeable of biofuels production processes. More importantly, biofuels production was deemed to be a capital intensive production process implying that it did not require many laborers (both skilled and unskilled). Therefore biofuels investments would generally not be expected to generate significant employment through direct hires for work in the biofuels processing

facilities. As indicated by the biofuels firms' managers, one could expect hiring some local labor for less skilled operations, particularly if overall demand for biofuels increased. However, most employment would likely be generated indirectly through backward linkages at the farm level in the production of biofuels crops used as feedstock.

Regarding the characteristics of the farmers who were hired and their labor contracts, the four farmers were hired on a piece rate to provide mentorship to new farmers and had initially been contracted four years earlier to supply biodiesel feedstock (sunflower and soybeans) to the biodiesel firm. These mentors were among the first batch of successful smallholder farmers to have received assistance and training in sunflower and soybean production for sale to the biodiesel firm. Moreover, the mentors had a long standing relationship with the firm when they were hired to work as mentors. The fact that even those that were hired by the not-for-profit biodiesel firm were only hired after attaining a certain level of training, experience and relationship (four years) augments the argument that participation in biofuels labor markets in South Africa may be rationed by the low skill and experience of locals both at the farm and processing levels of the biofuels value chain but primarily by the limited capacity of biofuels investments to generate direct employment due to its capital intensive nature. Therefore, rather than treat the four farmer mentors as participating in a biofuels labor market we treated them as participating in the biofuels crop market as this continued to be their main occupation and source of income.

An important feature of smallholder farmer participation in biofuels markets in South Africa is that while several crops were being used as feedstock by the biofuels firms, the smallholder farmers only grew a subset of these crops. Generally biodiesel firms in South Africa used sunflower, soybeans or canola while ethanol firms used maize, sugar beets and sugarcane. This set of feedstock was limited when the South African government banned the use of maize and jatropha in 2006, citing concerns of food-fuel tradeoffs, water scarcity and fears that jatropha was an invasive species (Brent, et al., 2009; Nieuwoudt,

2007; Visagie and Prasad, 2006). This in turn appears to have limited the scope of smallholder farmer participation in biofuels markets as they could no longer grow maize for biofuels feedstock supply, a crop which they are more familiar with.

Another reason why smallholder farmers had limited participation in the biofuels feedstock crop markets is that some biofuels firms chose not to involve smallholder farmers, at least at the onset. For instance, a firm that had invested in sugar beets-ethanol production chose to start off by contracting seasoned large-scale commercial farmers (at least for the time being) and did not engage any smallholder farmers. However, the firm indicated having plans to contract smallholder farmers in the future for the production and supply of sorghum to complement sugar beets feedstock. This was mainly because the sugar beets production season in South Africa is short due to climatic conditions such that sugar beets can only meet the firm's feedstock demand ten months of the year[1]. Thus the plan would be to use an additional feedstock such as sorghum to keep the ethanol plant running year-round.

Overall, smallholder farmers who were growing crops for sale to biodiesel firms grew sunflower or soybeans, while those engaged by an ethanol firm grew and sold maize despite the ban, at least for time being. The finding that smallholder farmers were participating in maize feedstock production is in itself supportive of the argument that smallholder farmers in South Africa have limited knowledge and training on the production of a variety of the crops that biofuels firms have chosen to invest in. It also suggests that while the government's ban on the use of maize for biofuels created a constraint to smallholder farmer participation in biofuels markets, it may not have been fully enforced at least at the beginning. Interviews with the firm involved revealed that the use of maize as a biofuels feedstock had since stopped and that the firm had switched to sugar beets instead. According to the ethanol firm manager, this switch from maize to sugar beets was likely to bar smallholder farmers from participating in the ethanol feedstock market, as most smallholder farmers did not know what sugar beets were or how to grow them; therefore smallholder farmers would need training and technical support if they

were to begin growing sugar beets. Interviews with the farmers corroborated the response from the ethanol firm, as most farmers that previously sold their maize to the ethanol firm complained that the maize ban would limit their maize marketing options and potentially lead to lower maize prices.

In addition to this limitation in smallholder farmer participation in ethanol, no smallholder farmer was growing canola as a biodiesel feedstock, even though a biodiesel firm was using canola as its feedstock. Instead, smallholders involved in the canola-biodiesel value chain participated by leasing their land to the biofuels firm, which then farmed the canola crop itself. The reason cited for this arrangement was that the canola-biodiesel firm had decided to focus on renting land from smallholder farm households rather than training them to produce canola given that canola had never been grown in the area before. These cases of limited smallholder farmer participation in canola and sugar beets production combined with the government's ban on maize and the smallholder farmers' limited knowledge and skill on biofuels showcase the complexity of smallholder farmer participation in biofuels markets. Particularly, this evidence highlights the importance of exogenous constraints on crop choices and feedstock procurement choices made by the government and biofuels firms, respectively. The feedstock ban by government and the decision not to engage smallholder farmers by the sugar beets ethanol firm may have created significant barriers to entry for smallholder farmers interested in participating in biofuels markets. In the same way, the farmers' limited knowledge on biofuels feedstock and production processes may have limited their opportunities despite the emergence of new biofuels investments in their area; especially since smallholder farmers mostly knew how to farm maize (the banned feedstock). This emphasizes the interface of farmers' knowledge, training and experience in farming relative to the biofuels investors' choices.

Regarding smallholder participation in biofuels labor markets, the canola-biodiesel firm did not hire significant local farm-labor and even though the land rental market participation was said to have freed up smallholder farmers' labor, there were few employment opportunities available for them to take

advantage of the freed up labor. Part of the explanation for this is that the biofuels firm adopted a plantation-style configuration that was highly mechanized and operated by external labor, an "expert mentor" commercial farmer that had previously owned land in a different province[2]. Another part of the explanation is that previously, the canola-biodiesel firm had actually attempted to train smallholder farmers in canola production during farm trials conducted in partnership with a government development program – the Accelerated Shared Growth Initiative for South Africa (ASGISA). Unfortunately, the canola production farm trials that involved smallholders were relatively unsuccessful[3]. This lack of success is said to explain in part, why the firm resorted to renting land from the smallholder farm households as well as engaging experienced labor of external expert mentor commercial farmers instead of providing out-grower contracts to the smallholder farmers. Moreover, the land rental arrangement was executed through the local village chiefs in partnership with ASGISA, which helped make it relatively easy to coordinate land rentals from multiple farmers with 10 hectares of land or less.

Although there were 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 scope of data collection to the Eastern Cape, Limpopo and North West provinces. Thus inferences from this study are limited to non-sugarcane biofuels investments in Eastern Cape, Limpopo and North West provinces of South Africa, which accounts for more than 60 percent of the biofuels investments in South Africa (IDC, 2009 – personal communication). In the sampled areas biofuels firms were not producing ethanol from sugarcane because climatic conditions are not suitable for sugarcane production.

3. Defining Biofuels Market Participation

While it is important to consider the different types of crops used as biofuels feedstock in South Africa in order to define participation of smallholder farmers in biofuels-related markets, in this study the distinction of crops was given less importance. The main broad distinction that was considered was that between participation in biofuels *land* rental markets and participation in biofuels *crop output* markets[4]. Similarly, specific uses of crops were deemed less important since agricultural crops generally have multiple potential uses—food, feed, fiber and biofuels (biodiesel or ethanol) which can further be disaggregated into many different categories; hence for pragmatic reasons we only distinguished crop uses in general terms of biofuels versus non-biofuels uses. Moreover, a crop could have been viewed by a farmer as a cash crop or an own-consumption crop depending on whether it was eventually sold to the market or consumed by the household, irrespective of the type of crop or type of use (food, feed, fiber or fuel). This classification of crops was not given much importance either in defining biofuels versus non-biofuels participation; again we simplified the definition and focused on whether the market involved was a *factor* or *output* market in general and whether it was for biofuels or non-biofuels purposes.

Had the main goal been to analyze issues of food-fuel tradeoffs, it may have been relevant to keep some of the detailed specifications of defining biofuels participation, particularly given the fact that almost all biofuels crops in South Africa are also used for human food consumption (with the exception of sugar beets[5]). It may have been important to also consider the timing of the participation decision given the participation decision could be dynamic. For instance, a farm household could initially decide to grow a crop for own-food consumption only to later sell it to firms for food processing or biofuels production or possibly both depending on market conditions such as prices, farmers' ability to store output and/or consumption needs, etc. at the time of the selling decision.

Given the complexity in defining biofuels market participation by smallholder farmers we necessarily simplified the definition criteria without loss of relevance. Thus a farm household was considered to have participated in a biofuels-related crop market if any positive amount of any crop was sold to a biofuels firm irrespective of the type of biofuel produced (ethanol or biodiesel). Participation in biofuels-related land-rental market was also defined as leasing any positive[6] amount of land to any biofuels firm for production of any crop produced for biofuels feedstock supply by the firm. These parameters used to define participation in biofuels markets certainly aggregate numerous different activities and decisions. Nevertheless they provide a manageable set of categories of the myriad biofuels developments in South Africa while maintaining policy relevance. Table 1 shows the broad classification of the different choices smallholder farmers could have made to participate (or not participate) in biofuels markets.

4. Theoretical and Empirical Models

We considered smallholder farmers to be rational utility-maximizing, choosing out of a set of market participation opportunities (described in the previous section), to either participate in a biofuels-related market or not. This multinomial decision is based on the farm household's utility obtainable from participation subject to a 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 utility from participating in a particular market *p* be:

$$U_p^* = Z'\alpha_p + l_p'\delta_p + e_p, \quad (1)$$

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 market 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 a multinomial index denoting the specific market participation choice of a smallholder 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 then be expressed as:

$$E(y) = \mu\,(x'\beta + I_p'\gamma_p + l'\lambda) \qquad (2)$$

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 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. Given this desirable property we estimate the multinomial probit model and include household characteristics as independent variables as well as village-specific variables (i.e. village-level output prices, wages, land rental rates and distance to main agricultural market). However, because we are not only interested in the determinants of participation in biofuels related markets but also the estimates of the effects of participation on farm household earnings, we also estimate a simulated multinomial logit treatment effects[7] model (Deb and Triverdi, 2006). While the multinomial logit treatment effects model maintains the IIA property, it does allow 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 employ this method because a solution is econometrically feasible unlike with an analogous multinomial probit treatment effects model, which to the author's knowledge has not been econometrically developed.

The use of a treatment-effects model is necessitated by the potential selection bias associated with smallholder farm households' participation in different biofuels-related markets, which is likely to result from unobserved latent variables l_p. Self-selection may arise when participation in a particular biofuels market p is chosen by a distinct group of smallholder farm households that find it more beneficial than others to participate in that particular market. For example, it is probable that farm households with agricultural land recently acquired from the land redistribution program, but with low farming ability, would be more inclined to participate in a land rental market than to grow the crops themselves. In contrast, farmers who have high farming ability and the necessary land and farming resources (capital and inputs) may find it feasible and more profitable to exercise their abilities and resources by farming crops themselves for sale and or consumption. Therefore, if we directly compare the effects of leasing land to a biofuels firm versus growing crops and selling them to the biofuels firm, we would potentially underestimate (or overestimate) the effects of participation on household earnings. Thus, we accounted for potential selection bias using the mixed multinomial treatment effects model. In estimating the mixed multinomial treatment effects model it was necessary to impose 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 excluded in the probability distribution of the outcome variable (household income). In our case we excluded three variables: (i) membership in a cooperative or other group in the year before the biofuels firm was operational in the area, (ii) savings from the previous year available at the beginning of the planting season prior to the existence of the biofuels program and (ii) distance to main agricultural market.

As Deb and Trivedi (2006) show, the joint distribution of the participation and income model can be obtained by multiplying the two probability distributions specified as follows,

$$\text{Prob}\,(y, I = p \mid Z, x, I) = \mathbf{f}(x'\beta + I'\gamma + l'\lambda) \times \mathbf{g}(Z'\alpha + l'\delta) \quad (3)$$

where **f** is the probability distribution of the household earnings and **g** is a multinomial probability distribution of the participation decision. By assuming that 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, the joint density is

$$\text{Prob}\,(y, I = p \mid Z, x, I) = \int [\,\mathbf{f}(x'\beta + I'\gamma + l'\lambda) \times \mathbf{g}(Z'\alpha + l'\delta)\,]\mathbf{h}(l)dl \quad (4)$$

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 some initial inferences on how farm household participation in biofuels-related markets might affect household purchases of food and other non-durable consumption goods.

5. Data and Descriptive Statistics

This study used data collected from a farm household survey administered in rural areas of South Africa between September and December, 2009. The final sample of analysis consists of 247 farm households, 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 firm investments in the areas. Prior to the farm household survey, key informant interviews were conducted with the managers of biofuels firms and officers in

provincial government departments involved with biofuels initiatives in each area. This was done 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).

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 feedstock 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 data from the local village markets, biofuels firms and government department officers. The price data used for analysis were average prices of maize, soy beans and sunflower (the main cash crops also used for biofuels in the study areas). In addition, farm and non-farm wage rates for each village area were collected as well as land rental rates offered by the biofuels firms. These village-level price/wage/rental data were included in the analysis to control for relative incentives associated with participating in different market opportunities in each village.

Table 3 presents descriptive statistics of the smallholder farm households sampled. Also included in Table 3 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 a 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 reported attaining less than 10 years of formal education, 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 chose to grow 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), owned 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 and education were more likely 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 government's land redistribution 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 3,650 for households that participated in biofuels crop markets to Rand 2,735 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 may not have had a significant 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 explanation for this result is that most farmers that participated in growing crops for biofuels firms also grew some crops for their food consumption requirements. Thus, unlike households that leased all their land, they were still able to grow significant quantities of food which supplemented their food purchases.

6. Results

To determine the factors influencing participation in each biofuels-related market we started 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 marginal effects from the multinomial probit model and shows that at 1% significance level, receipt of price information significantly increased participation in both biofuels crop and land rental markets. Farm households that reported receiving price information were 18% more likely to participate in the biofuels crop market and 27% more likely to participate in the land rental market than those who did not receive 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 crop market. A higher maize price implied an increased probability of participation in a biofuels crop market, while increased land rental rates reduced participation in a biofuels crop market. Land holding size was also a strong predictor of the probability to rent land to a biofuels firm but did not appear important in the decision to grow crops for a biofuels firm.

These results are quite expected, given that one would have to own land in order to rent it out to a biofuels firm and given that biofuels firms preferred to rent larger areas of land rather than multiple small pieces of land. For two potential explanations it would stand to reason that farm households with larger land areas had a higher probability of renting their land to biofuels firms. One is that given limited farm inputs and labor but abundant land, rental markets would allow resource and ability constrained landowners to earn an income they would otherwise not earn. Secondly, biofuels firms preferred to rent land from landowners with larger areas as this minimized the transaction costs associated with renting from multiple landowners with small pieces of land. Moreover, prices of crop output, land rental rates and wages would be expected to act as market signals to landowning households, influencing their land use decisions.

In addition, because maize was initially grown as a biofuels feedstock for the maize-ethanol biofuels firms in some of the sample areas, the price of maize would be expected to influence participation in biofuels crop markets. Also, maize prices are generally highly correlated with prices of other biofuels feedstock crops, thus higher prices of maize would likely serve as a general output price signal for land owners to grow crops rather than rent their land.

As for the rental rate, it was expected that a higher rental rate would attract farmers into the land rental market and away from crop production; again an incentive signal this time in the form of returns to land rentals. While only significant at the 10% level, distance to the main agricultural market was also found to influence the decision to participate in a biofuels crop market. Being located an additional 10 km

further away from a major agricultural market decreased the likelihood of participation in a biofuels crop market by 1.25E-05% compared to not participating in any biofuels market at all. The fact that the marginal effect is very small may be a result of the high level of road infrastructure development in South Africa and the highly integrated nature of markets; thus while distance to market may generally influence smallholder participation decisions, this appeared less important.

Supporting this argument is the result that distance to a major market did not seem to influence the probability of leasing land to a biofuels firm either. This augments the argument, that while offering additional marketing opportunities to distant farmers, biofuels markets do not offer significantly better market opportunities in remote villages in South Africa relative to non-biofuels markets. Results in other countries with poorer road infrastructure and market access might be expected to differ.

Regarding the effect of wage rate on the participation decision, an increase in the wage rate would result in a decreased probability of growing crops for a biofuels firm while increasing the probability of renting land to a biofuels firm. This suggests a labor-land trade-off whereby farm households are willing to rent land in order to free up labor and find employment in the non-farm rural labor market when wages are high. However, when wages are low, farm households are less inclined to lease their land and seek non-farm rural employment; instead they would choose to grow crops for themselves. These results on labor-land market relationships, while associated with biofuels investments in this case, are in line with general findings of previous studies that have shown that in labor-constrained rural environments, land rental markets offer an important avenue for relaxing the labor constraint and for allocating land to more efficient land users (Rosenzweig, 1980; Deininger, et al., 2005; Kimura et al., 2007).

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 might be explained by the fact that fewer women owned land in the study areas and had limited access to factors of production. Thus, inequitable distribution of factors of production and resources disfavored female-headed households' participation in biofuels-related market opportunities and even if new biofuels market opportunities were to present themselves in a village, women and female-headed households would likely be left behind and/or excluded from the potential benefits of biofuels opportunities compared to male-headed households. It is particularly worth noting that the gender difference was more pronounced for biofuels land rental markets. Evidence from qualitative interviews with farmers in the field also suggested that women were less likely to participate in land rental markets for fear of losing their recently acquired land because if seen renting land instead of farming it, they would be deemed unproductive such that the land would have to be allocated to more productive landowners (mostly men). It may also be the case that the land reform program, while it made efforts to include women and female-headed households as beneficiaries, had not done enough to achieve equitable land distribution in terms of gender. These finding are particularly important in as far as the government's land redistribution program is concerned, vis-à-vis gender equity and land governance goals. If women and female-headed households are to effectively participate in biofuels-related markets, or any other agricultural markets, they need secure land rights that protect their titles even if they decided to lease the land. Thus, it may be worth exploring mechanisms that guarantee women's land rights such that they are not subject to losing their newly acquired land due to their choice to lease out rather than farm the land. In addition women deciding to grow crops would need access to a whole suite of productive resources (e.g. adequate farming equipment, inputs and extension services etc.)

As expected, landholding size was a significant determinant of participating in a land rental market, with households owning larger areas of land being more likely to rent land to biofuels firms. Corroborating this finding was qualitative evidence obtained during personal interviews with the managers of the

biofuels firms. Managers of several biofuels firms said they preferred renting larger areas of land as this allowed them to realize economies of scale in farm production while minimizing transaction costs associated with coordinating a large number of farmers with small pieces of land. Thus, farm households with smaller areas of land often had to coordinate themselves to combine their pieces of land and then rent their land as a group, if they wanted to participate in biofuels-related land rental markets. This often presented challenges of coordination and limited the ability of many smallholder farm households (particularly female-headed 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 the local-government third-party initiatives. Improving coordination of land rentals and further investigations to address the coordination issue may be warranted.

An important finding, not readily revealed in the econometric results but was obtained from qualitative information during data collection is that farm households that leased their land and lacked resources often mentioned benefiting from freed up labor time which was used for household chores, rural farm employment or non-farm rural employment. This important feature of the biofuels land rental markets was however not fully complemented by availability of remunerative employment opportunities and presents an area that could be explored in terms of enhancing the benefits of biofuels land rental markets. From the view point of some households that were constrained by labor, especially households with women, young children and multiple household chore requirements, the biofuels-related land rental markets provided more than just money earned from leasing out land; mainly time which could

be used for other needs. Overall, a number of market-related incentives appear to have taken precedence in determining the kind of participation in biofuels markets. Thus, developing a variety of strong market institutions in areas where there are biofuels investments would appear to be critical for farm households to effectively participate and gain from new biofuels investments. Developing complementary markets, in the form on-farm and non-farm labor markets as well as the provision of necessary factors of production and farm inputs is important.

Regarding the effect of participation in biofuels markets on income and grocery expenditure, results of the multinomial treatment effects models are presented in Table 5. In general it was found that household income of farmers participating in biofuels crop markets was not significantly higher than that of non-participating households at 5% significance level. This result, while suggesting that incomes of biofuels participants are *statistically* the same as incomes of non-participant households possibly fails to capture the *economic* significance of the differences in the incomes. As shown in Table 3 the mean income of households growing biofuels crops was about 33% higher than that of households renting land to biofuels firms and about 16% higher than the mean income of households who did not participate in a biofuels related market. In addition, non-monetary gains such as those reported by the landowners who rented their land and were able to free up their labor may not be fully capsulated in the econometric analysis of income differences. In addition, it is important to bear in mind that farmers that did not participate in biofuels-related markets could have participated in other cash crop markets, whose prices could have increased due to competition arising from feedstock demand by biofuels firms, thus potentially implying a positive spillover effect on non-participating farmers. Other spillover or cross-contamination considerations are that there may have been knowledge/information spillovers arising from the existence of biofuels firms in the villages, such that the impact of biofuels investments may not be restricted to non-participants.

Nonetheless, factors that were found to significantly increase the level of household income were land area owned, the level of education attained by the households head, the local prices 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. The latter was negative relative to a higher education (the reference level), implying that schooling beyond the ninth grade had a significantly positive impact on household cash incomes; a somewhat expected result. Findings also suggest that gender of household head while influencing the participation decision, did not have a significant impact on the income level. This result is a little counterintuitive since one might expect that if gender mattered in terms of the participation decision it might also matter in terms of the incomes. However, this may be a reflection of the result that there was no statistical significant difference in cash incomes between participating and non-participating households. Therefore, while most female-headed households may have experienced barriers to participation in biofuels markets, the statistically insignificant differences in the earnings from participation may mean statistically similar incomes between male and female headed households in the areas studied.

Results of the multinomial treatment effects models where the dependent variable was the grocery expenditure, revealed that participation in biofuels crop markets significantly increased grocery expenditures at the 10% significance level but participating in a biofuels land rental market did not significantly affect the levels of grocery purchases. While the positive coefficient implies increased grocery expenditure for households participating in biofuels related markets, the weak statistical significance or lack of significance suggests that biofuels have a relatively small impact on grocery expenditures at the household level.

Other variables that were statistically significant included household size and the dependency ratio, which significantly decreased the level of grocery purchases. This is expected since larger households typically consume more and therefore purchase more groceries but would actually consume less on per

adult equivalent basis as household resources are spread across more members. Household head education level was marginally significant, suggesting that households with a head that had completed grade 12-diploma were likely to spend more on groceries. Also, those households with more landholding size were likely to spend more on groceries. Finally, maize prices, off-farm wage rate and land rental rate were all found to significantly influence the level of household grocery spending. Higher maize prices were likely to reduce the level of grocery spending, while higher off-farm wage rate and land rental rate were likely to increase the level of household grocery spending. These results are also expected, given that the wage and land rental rates were likely to be correlated with household incomes while for net food buying households, the maize price likely presented a cost when buying maize from the market rather than acting as a remunerative income variable associated with sale of maize produce.

Because the estimates of our econometric models can be sensitive to the sample size, covariates, distributional assumptions and parametric functional forms we subjected our models to several robustness tests. First, we examined alternative functional forms and estimation procedures to see if the estimates would change significantly both in terms of sign and magnitude. Table 6 shows results of alternative models where we used the Generalized Method of Moments (GMM) estimator. In addition, we estimated the effects of covariates on subsamples based on participation group. Generally results were similar across models suggesting that the model results are robust to estimation approaches.

7. Conclusions

This paper analyzed the determinants of farm household participation in biofuels crop and land rental markets and estimated the effects of participation on farm household income and grocery expenditure. Using a multinomial probit model, it was shown that market variables including access to price information, the price of maize and land rental rate were significantly important determinants of smallholder farmers' decision to participate in biofuels-related markets – smallholder farmers respond

to price and information signals from the market. As expected a higher land rental rate induced households to lease their land to biofuels firms, while a higher maize price would induce them to grow crops on their land for sale and own consumption. This result emphasizes the role of prices as signals that influence land use and market participation decisions in the context of biofuels investments, which is consistent with economic theory and previous research. It was also found that resource constraints such as land holding size limit the participation of poorer farm households in biofuels land rental markets. Households with less land were significantly less likely to rent out land to a biofuels firm. However, this was not the case with regards to growing crops for a biofuels firm. One explanation for this result might be that biofuels firms are reluctant to lease small parcels of land such that even if smallholder farmers with small areas of land want to lease their land they are less likely to enter the market.

Gender of household head was also found to influence the participation decision, with female-headed households less likely to participate in biofuels markets. Qualitative findings from interviews of smalholder farm households suggest that female headed households and poorer households (particularly those with more women and younger children) were more likely to participate in land rental markets than growing crops on their land, because this freed up their labor for household chores and other income generating activities that were less labor intensive, while allowing them to earn an income from leased land. Thus, land rental markets are seen as playing an important role in relaxing the constraints of relatively resource-poor female-headed households that at least had sizeable leasable land. However, based on farmer interviews, some women said they were less inclined to lease their land if it was recently acquired through the land redistribution program as they feared losing their land because of being considered unable or unwilling to farm. This raises a couple of important policy implications for the land redistribution program in South Africa. First, if beneficiaries are unable to farm because of other resource constraints they could still lease land to productive farmers thus securing rent

and improving their lives. However, if women are unable to farm because other resources are limiting, they may still not be able to benefit from renting their land because of gender-based social constraints such as fear that they may lose their recently acquired land. This may lead female headed households to enter into suboptimal farming simply because of the risk associated with leasing land and not farming it. In addition, this points to the importance of providing secure land rights, especially for resource poor and female beneficiaries and for providing adequate farm inputs and resources markets for those who wish to farm. Moreover, 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 an income-equalizing effect of the biofuels markets studied. However, substantive formal analysis is required to test this hypothesis.

In general firm manager interviews, village-level observations and qualitative interviews of smallholder farmers revealed that there is a complex web of market opportunities that arise when biofuels firms invest in a rural area. Thus smallholder farmers' options are immediately expanded by the introduction of biofuels investments in a rural area. However, labor related markets were not significantly expanded, both in terms of farm and non-farm biofuels related markets largely due to the capital intensive nature of biofuels investments but also because smallholder farmers had little or no experience in farming new biofuels crops recently introduced by the biofuels firms, e.g. sugar beets and canola. Interviews with both the farmers and firms suggested that labor quality was also an issue and farmers, while willing to learn how to grow these crops did not have the opportunity to do so given that the firms preferred to hire external experienced labor rather than train local farmers.

In addition, while most smallholder farmers reported having experience in maize farming, this crop was banned by the government of South Africa for use as a biofuels feedstock. This meant that biofuels firms that originally used maize as a biofuels feedstock had to switch to sugar beets or other crops and this

potentially barred smallholder maize farmers from participating in a biofuels crop output market. However, opportunities to grow maize crops as a food cash crop remained an option.

Results from a 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 statistically better off in terms of their household incomes. However, the mean incomes of those growing crops for biofuels firms were found to be 33% higher than those leasing land to biofuels firms and 16% higher than the incomes of those who chose not to participate in any biofuels related market. The analysis of the impact of biofuels participation on grocery expenditure found that participating in biofuels crop markets marginally increased grocery expenditures compared to household not participating. This potentially reveals income benefits of participating in biofuels crop markets. Moreover, non-monetary benefits not captured in the analysis of this study suggest strong linkages between biofuels land rental markets and biofuels labor markets, with freeing up of labor being observed for the resource constrained households, particularly women who subsequently use their time for other activities important to their households.

In summary, evidence from this study shows that there are benefits accruing to smallholder farm households from participating in biofuels investments in South Africa. However, there are no statistically significant differences in household cash incomes between households that participate in biofuels crop and land rental markets and those that do not participate. There may be opportunities to increase the levels of farm household participation in biofuels markets and the benefits thereof by expanding opportunities in other related markets, given that few farm households were involved in the biofuels labor markets. Future analysis of these complementary markets such as non-farm rural employment opportunities and associated benefits is needed to improve our understanding of the impacts of biofuels

market participation on smallholder farmers and how biofuels policy might be better designed to enhance overall benefits to the poor.

References

Arndt, C., Benfica, R., & Thurlow, J. T. (2011). Gender implications of biofuels expansion in Africa: the case of Mozambique. *World Development,* 39(9), 1649-1662. doi:10.1016/j.worlddev.2011.02.012

Arndt, C., Benfica, R., Maximiano, N., Nucifora, A. M. D., & 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., & Uaiene, R. (2008). Biofuels, Poverty and Growth: A Computable General Equilibrium Analysis of Mozambique. IFPRI Discussion Paper 00803. International Food Policy Research Institute, Washington D.C.

Bailey, R. (2007). Biofuelling poverty: why the EU renewable-fuel target may be disastrous for poor people. Oxfam Briefing Note. Oxford, UK: Oxfam International.

Bailey, R. (2008). Another inconvenient truth: how biofuel policies are deepening poverty and accelerating climate change. Oxfam Briefing Paper 114. Oxford UK: Oxfam International.

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

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, UK: International Institute for Environment and Development.

Clancy, J. S. (2008). Are biofuels pro-poor? Assessing the evidence. *European Journal of Development Research*, 20(3), 416–431.

Colin, J. & Woodhouse, P. (2010). "Introduction: interpreting land markets in Africa." *Africa: The Journal of the International African Institute,* 80(1), 1-13.

Cotula, L., Dyer, N., & Vermeulen, S. (2008). Fuelling exclusion? The biofuels boom and poor people's access to land: London, UK: International Institute for Environment and Development.

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

Deb, P. & 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(2), 307–331.

Deininger, K., S. Jin & S. Rozelle. (2005). Rural Land and Labor Markets in the Process of Economic Development: Evidence from China. Working Paper. Retrieved on December 2, 2010 from http://iis-db.stanford.edu/pubs/21649/migration_and_migration_working_paper_deininger.pdf

Elobeid, A & 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 Doctoral dissertation, Michigan State University, East Lansing, MI.

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

Hazell, P & Pachauri, R. K. (2008). Bioenergy and agriculture: promises and challenges. International Food Policy Research Institute Vision 2020 Focus 14 brief series. Washington D.C.

Headey, D. & 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.

Kimura, S., Otsuka, K., & Rozelle, S. (2007). Efficiency of Land Allocation through Tenancy Markets: Evidence from China. Working paper. Retrieved on December 2, 2010 from http://iis-db.stanford.edu/pubs/21646/land_allocation_rental_market_otsuka.pdf

IFAD (International Fund for Agricultural Development). (2003). Promoting Market Access for the Rural Poor in Order to Achieve the Millennium Development Goals. Discussion Paper. Rome, Italy: 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 & J.J. Nijhoff. 2006. Stabilizing food markets in eastern and southern Africa. *Food Policy,* 31(4), 328-341.

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

Pingali, P., Raney T. & 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*, Baltimore, MD: Johns Hopkins University Press.

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

Rosenzweig, M. R. (1980). Neoclassical Theory and the Optimizing Peasant: An Econometric Analysis of Market Family Labor Supply in a Developing Country. *Quarterly Journal of Economics,* 94(1), 31-55.

Rossi, A., & Lambrou, Y. (2009). Making sustainable biofuels work for smallholder farmers and rural households: issues and perspectives. Rome, Italy: Food and Agriculture Organization of the United Nations.

Sen, A. (1981). Poverty and Famines: An Essay on Entitlement and Deprivation. Oxford, UK: Oxford University Press.

Sulle, E., & Nelson, F. (2009). Biofuels, Land Access and Rural Livelihoods in Tanzania, London, UK: International Institute for Environment and Development.

Visagie, E. & 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. Washington D.C.: International Food Policy Research Institute.

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. Washington, D.C.: International Food Policy Research Institute.

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 smallholder farmers to participate in biofuels-related markets

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

Table 2. Description of Variables

Variable	Description and units of measurement	Sample mean or percentages; standard deviation, minimum and maximum values
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 (Rand)	1338.47 (2928.34)	94.09 (282.24)	650.09 (5672.40)	687.61 (4674.12)	(0.4357)
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	1053.33	1086.59	1081.92	1077.08	(<0.001) ***

per month)	(57.44)	(124.58)	(117.27)	(109.79)	
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 year)	429.59 (24.83)	421.82 (15.44)	419.03 (15.63)	421.62 (18.19)	(0.0017) ***
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 24.5%	44 25.0%	154 50%	247 100%	--

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

Table 4. Marginal effects based on multinomial probit model of participation in biofuels related markets

	Marginal Effect on:	
Variable	Prob (*I* = Grow crops for biofuels firm)	Prob (*I* = Lease land out to biofuels firm)
Household size	-9.66E-06	0.01
Dependency ratio	0.004749	-0.19*
Age: 41-60	0.000239	0.13*
61-89	-0.001955	0.33
Sex: Female	-0.015697*	-0.09**
Education:		
No schooling/Grade 0	-0.00238	-0.02
Grade 1-9	-0.00192	0.01
Completed Grade 12 - diploma	-0.00177	0.08
Bachelor's degree or higher	-0.00162	-0.17
Marital status:		
Married civil/religious	0.00211	-0.03
Married Traditional/Polygamous	0.04312	0.02
Landholding size	3.67E-06	0.01
Received price information	0.18***	0.27***
Distance to main market	1.25E-05*	6.37E-4
Savings from last year	1.27E-06**	-7.05E-5
Member of a cooperative/other group	2.18E-05***	0.02***
Price of maize	4.92E-06	1.73E-4
Off-farm wage rate	-4.96E-08	1.28E-3**
Land rental rate	-0.00235*	1.71E-3

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

Table 5. Marginal Effects of Biofuels Participation on Household Income and Grocery Expenditures

(based on multinomial treatment effects models)

	Marginal effect on:		
Variable	Household income	Grocery expenditure	Sample Mean or %
Household size	-230.88	40.78***	4.27
Dependency ratio	-126.54**	-28.66**	0.32
Age:			
41-60 years±	186.63	2.66	48.2%
61-89 years±	654.41	-14.42	40.1%
Sex: Female±	-112.59	11.67	35.8%
Education:			
No schooling/Grade 0±	587.26	39.90	12.4%
Grade 1-9±	-606.71**	21.27	49.2%
Completed Grade 12 - diploma±	862.90**	7.32*	13.6%
Bachelor's degree of higher±	325.95	3.09	2.5%
Marital status:			
Married civil/religious±	431.69	-56.63	49.2%
Married traditional/polygamous±	-301.10	-22.69	29.3%
Landholding size	73.68***	4.29***	8.82
Received price information±	-12.64	-10.42	57.5%
Price of maize	-4.91**	-0.03***	1398.68
Off-farm wage rate	7.63***	0.13**	2340.52
Land rental rate	16.13	-0.33*	421.57
Grow biofuels crop	620.21	18.68	19.8%
Rent land to biofuels firm	-93.82	18.15	17.9%

± If variable is continuous the marginal effect is evaluated at the mean shown in the fourth column otherwise for categorical variables the marginal effect is evaluated as the percentage change due to a change in the dummy variable from 0 to 1

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

Table 6. Generalized Method of Moments (GMM) results using whole sample and within group participation subsamples

	Whole sample		Grew biofuels crops		Leased land to biofuels firm		Did not participate in biofuels markets	
	Household Income	Grocery expenditure	Household Income	Grocery expenditure	Household Income	Grocery expenditure	Household Income	Grocery expenditure
Household size	-227.4***	-47.7***	-247.3	-74.7***	1.0	-41.4***	-231.4***	-45.4***
	(47.2)	(3.9)	(155.2)	(8.4)	(127.4)	(7.6)	(50.1)	(5.2)
Dependency ratio	-1286.7***	-71.1***	-5682.2***	77.0	-4215.4***	-11.7	-847.1	-94.5***
	(474.6)	(30.3)	(2261.4)	(54.8)	(2094.1)	(52.7)	(533.6)	(45.2)
Age:								
41-60 years	227.9	33.3	-2068.9***	34.4	4249.0***	120.3	-123.3	32.5
	(388.1)	(24.2)	(1111.8)	(51.2)	(2419.9)	(79.0)	(443.5)	(26.4)
61-89 years	682.3	9.4	-1482.1	-54.6	5493.7***	75.5	469.4	11.3
	(494.0)	(22.4)	(1079.3)	(41.4)	(2693.2)	(99.3)	(572.8)	(23.6)
Sex: Female	102.7	12.8	1049.2	13.9	366.5	34.1	113.6	5.2
	(260.1)	(18.7)	(948.3)	(68.6)	(795.3)	(43.0)	(279.5)	(20.8)
Education:								
No schooling/Grade 0	596.1	19.1	2198.8	-51.8	4513.5***	-16.2	-424.7	50.5
	(928.6)	(30.3)	(2583.7)	(48.9)	(2396.7)	(96.5)	(617.2)	(42.5)
Grade 1-9	-562.4	-0.6	-972.4	6.0	1233.9***	-27.9	-668.7	12.1
	(420.4)	(22.0)	(1143.5)	(57.4)	(840.5)	(84.5)	(447.1)	(22.7)
Completed Grade 12 - diploma	863.2	-25.8	1431.9	-44.8	2384.8	-38.8	1439.7	-19.9
	(542.3)	(24.3)	(1052.3)	(48.9)	(1088.4)	(83.3)	(898.1)	(32.2)
Bachelor's degree of higher	225.1	-9.1	-1056.9	-68.2	-	-	1656.7	29.5
	(1027.1)	(25.6)	(1229.8)	(52.4)	-	-	(1501.7)	(28.9)
Marital status:								
Married civil/religious	401.1	-24.7	3534.3***	24.1	-560.9	-66.5	388.5	-11.0
	(345.0)	(24.6)	(1391.0)	(66.2)	(729.6)	(76.7)	(323.1)	(28.8)
Married traditional/polygamous	-348.3	-61.9***	2052.8***	46.0	-1578.1	-123.5***	-159.4	-54.0***
	(357.4)	(24.1)	(1146.5)	(62.7)	(1137.3)	(74.6)	(289.0)	(27.0)

Landholding size	74.2***	0.8***	53.2	-0.8	125.1***	2.7***	64.6***	0.6***
	(23.1)	(0.3)	(34.5)	(1.1)	(72.6)	(1.1)	(15.9)	(0.4)
Received price information	-31.0	-17.2	-724.0	97.3	-200.0	-89.0***	104.3	-16.4
	(226.5)	(16.8)	(898.5)	(63.3)	(555.5)	(29.7)	(223.7)	(19.4)
Price of maize	-5.5***	-0.1	-34.7***	0.6***	-3.3	-0.2	-1.9	-0.1
	(2.0)	(0.1)	(8.9)	(0.4)	(3.4)	(0.3)	(1.8)	(0.1)
Off-farm wage rate	7.7***	0.1	18.5	-0.1	-3.7	-0.1	1.5	0.1
	(3.1)	(0.1)	(21.5)	(0.5)	(4.6)	(0.2)	(2.2)	(0.2)
Land rental rate	16.5	1.3***	92.9***	-0.7	20.5	2.2***	-8.1	1.0***
	(11.3)	(0.4)	(30.3)	(1.0)	(20.6)	(0.6)	(10.8)	(0.6)
Grow biofuels crop	-222.5	48.4***	-	-	-	-	-	-
	(572.9)	(23.4)	-	-	-	-	-	-
Rent land to biofuels firm	-264.4	26.3	-	-	-	-	-	-
	(363.7)	(21.7)	-	-	-	-	-	-
Intercept	-15547.5***	-138.1	-27302.7	-95.0	-	-	4439.8	-163.7
	(8659.0)	(349.0)	(51227.1)	(1350.4)	-	-	(5720.3)	(420.5)
Number of observations	242	242	45	45	44	44	153	153
Wald chi^2	100.87	466.38	91.19	325.40	49.54	1672.38	145.75	244.52
Prob > chi^2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
R-squared	0.3658	0.6433	0.4217	0.797	0.5896	0.751	0.4707	0.579
GMM weighted Robust Root Mean Squared Error	2123	107.53	2468.4	85.157	2122.8	97.618	1598	105.31

Note: Figures in parentheses are robust standard errors

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

ENDNOTES

1. [1] **Sugar beets are perishable and difficult to store such that even if the quantities harvested during the production season can meet annual feedstock demand, it would not be possible to store and maintain quality of the feedstock to allow for year-round ethanol production**

2. [2] **The expert mentor's land had been sold to the South African government as part of the land redistribution program**

3. [3] **In part, the lack of success was blamed on late distribution of fertilizer inputs by the South African government through the Accelerated Shared Growth Initiative of South Africa (ASGISA), which was part of the biofuels deal with the canola firm. Other factors were the poor moisture content in the soil since canola was being grown in the drier winter season. Also, birds and other insects that consume canola seed were said to have posed additional challenges for smallholder farmers in growing canola.**

4. [4] **The distinction was made on the basis of factor markets or output markets but did not include the labor or capital markets since these were not widespread**

5. [5] **Although sugar beets could potentially be used as a food crop (i.e. sugar/sweeteners and food ingredients) in South Africa they are new and not used for this purpose.**

6. [6] **While in reality a few households rented in land from other households to grow additional biofuels crops, we considered these farmers as participating as growers of biofuels crops instead of the biofuels land rental market that involved biofuels firms directly. In the case of farm households that leased the land to other farmers engaged in biofuels crops, we considered these as participating in the land rental market since they did**

not grow the biofuels crops. This emphasizes the complex set of options that arose from biofuels investments in rural areas.

7. **[7] 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).**