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Barriers and incentives to potential adoption of biofuels crops by smallholder farmers in the Eastern Cape Province, South Africa

Abstract

The main objective of the study was to identify barriers and incentives that influence the potential adoption of biofuels crops by smallholder farmers. The study utilized a semi-structured questionnaire to record responses from 129 smallholder farmers that were identified through a snowballing sampling technique. The respondents were from the Oliver Tambo and Chris Hani District Municipalities in the Eastern Cape Province, South Africa. A Heckman two-step model was applied to analyze the data. Results obtained show that variables; arable land, incentives offered, challenges faced, labor source, were statistically significant to awareness of farmers to biofuels crops. Adoption of biofuels crops was statistical related to gender, qualification, membership to an association and knowledge on biofuels. It is recommended that smallholder farmers should be made aware of the proposed biofuels crops in order for them to adopt. Furthermore, for the biofuels industry to succeed, farmers in the semi-arid regions need to be educated on land improvement and notified of the expected returns if they are to participate in the production of biofuels crops.

Keywords: barriers, incentives, adoption, South Africa, biofuels, smallholder.
JEL Classification: Q0, Q01, Q16, Q18, Q40, Q48.

Introduction

Biofuels are described as solid, liquid, or gaseous fuel consisting of, or derived from biomass. Yet, biofuels crops are crops that are used to generate biofuels. In 2004, a joint meeting of the Southern Africa Development Committee (SADC) under the theme 'Farming for Energy' stressed that biofuels production provides or presents an opportunity for the region to produce its renewable energies. The rise in fossil fuels and its effects on the SADC economies justify the proposal of a green economy. Therefore, biofuels have now become an alternative to fossil fuels, with fuel production through farming expected to increase rural employment, reduce Greenhouse Gases (GHG) as envisaged by the Kyoto Protocol (Takavarasha et al., 2005). As emphasized by the SADC (2005) report, the potential of agriculture to contribute in reducing poverty and increasing economic growth depends on smallholder farmers. In Africa, the real potential of biofuels production lies in social development.

In 2007 the Department of Mineral and Energy (DME) launched a Biofuels Industrial Strategy for South Africa. A number of factors influenced the launch of the Biofuels Industrial Strategy (BIS), some of the reasons for the launch were that it was part of the government efforts to uplift smallholder farmer's productivity (DME, 2007). Other factors included: support for cleaner and environmentally friendly energy; support of renewable energy and the upliftment of the agricultural sector using surplus farming land; promoting sustainable development and improve energy security. Of particular importance are the BIS (2007) targets in the upliftment of agricultural sectors and unlocking of economic benefits in the sub-Sahara region by attracting investments in rural areas and the promotion of agricultural development. These targets will help overcome trade distortion that the sub-Sahara has faced subsidized agricultural production. A special requirement within the strategy is to create a connection between the first and second economy by creating agricultural opportunities in areas previously undermined by the apartheid system (DME, 2007). Since 2007, the Department of Minerals and Energy (DME) in collaboration with the Department of Agriculture, Fishery and Forestry (DAFF) have been actively involved with smallholder farmers in the production of biofuels (Shi et al., 2009).

In South Africa, smallholder farmers face a number of challenges that impede their growth and ability to contribute to agriculture. According to the DAFF (2012), some of the challenges faced include lack of access to land, inadequate infrastructure and institutional challenges. Smallholder farmers struggle to pay for inputs like fertilizers, seeds to name a few. In order to address these challenges, the Biofuels Industrial Strategy Policy was launched. However, the adoption of biofuels crop production has been very low.

The purpose of this paper was to examine the barriers and incentives that influence the potential to adopt biofuels crops in the Eastern Cape Province, South Africa. The paper argues that the low adoption rate in biofuels crops production can be pointed to a lack of awareness of the existence of biofuels crops to smallholder farmers. This is true in instances where technology or seed varieties are new.

The paper is organized as follows. Section 1 presents literature review on awareness and adoption of

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new technology. Section 2 and Section 3 present methodologies used in the study and results analysis. Final Section summarizes major findings and policy recommendations.

1. Literature review

Beale and Bolen (1955) conducted a study on adoption of agriculture technology. The study suggested that awareness of a technology was the first stage in adoption. The authors defined awareness as a stage where an individual learns of the existence of a technology or has little knowledge about it. Similarly, McBride et al.'s (1999) research suggested that awareness and attitude were influenced by agricultural producers' social economic characteristics. Rogers (2003) further reinforced similar claims. In 1998 a study done by Nowak and Korsching, pointed that ignoring the awareness stage in adoption process and treating adoption as a dichotomous event could be partly responsible for the poor predictive power of research using binary analytic models.

In introducing new technology or seed varieties, the first phase consists of making the farmers aware of such technology, for instance, through demonstrations or other means and the new technology would then be adopted if seen as beneficial. Although the link between awareness and adoption of technology might be very clear, Diagne (2010) and Daberkow and McBride (2003) are of the opinion that an individual can adopt technology/crops without knowing anything about its performance or characteristics. However, studies conducted by Diagne (2010), Diagne and Demont (2007) acknowledge that any adoption study that does not account for awareness of the technology/crops to the individuals leads to spurious conclusions about the potential adoption rate for the targeted population.

Kinuthia (2010) discovered that awareness of tree planting program was positive and statistically significant. The claim was that farmers who received information were in a better decision of choosing to adopt new technology than those who were not. Furthermore, Gollier et al. (2002) had similar results that farmers with better information on labor afforestation were in a better place to engage in tree planting activities in their land. However, Dolisca et al. (2006) refute that claim and states that although improving information flow to a decision maker is a necessary condition, it does not necessarily mean everyone who receives it would act on it.

A study conducted in Benin by Dandedjrohoun et al. (2012) on determinants of diffusion and adoption of improved technology for rice parboiling pointed that number of years in parboiling experience, membership of women in association, and ethnic group contributed immensely to the awareness of to the new technology. Similarly, Kromm and White (1991) were of the same view that media, agricultural extension, crop consultants play an important role in early stages of adoption. Studies done by Rollins (1993), Korsching and Hoban (1990), noted that information sources are very influential in the initial stages of adoption, because it is through media that individuals get to be aware of the technology existence.

According to literature, there is a consensus about including awareness as a determinant to adoption of innovation or new seed varieties. It can be noted that any adoption study that excludes awareness, yet it is testing for a potential to adopt a certain technology runs the risk of producing spurious regression results. A number of adoption studies dwell much on the post period when an individual has adopted the innovation, and ignore the awareness to such innovation. It can be noted that most studies assume that all individuals under study are aware of the technology, yet adoption is done in stages as proposed by Rogers (1985).

1.1. Determinants to farmers' adoption of new technology. In order to understand the adoption process better, factors affecting or influencing adoption needs to be identified. These factors are explained in the preceding section.

1.1.1. Institutional factors. Institutional factors can be summed up as factors such as having credit, price information, being a member of an association, access to extension services. These factors have been widely used as variables in a number of adoption studies in order to evaluate farmers' behavior. Uaiene et al. (2009) analyzing agriculture technology adoption in Mozambique reported that difficulties in accessing credit were a major constraint in adoption. Pattanayak et al. (2003) note that access to extension services, other stakeholder and Non-Governmental Organization have an influence in farmers' adoption of new technology. The argument was that farmers who usually meet extension officers and do demonstration on the proposed technology have a high chance of adopting technology. On the other hand, Bandiera and Rasul's (2005) study on social networks and technology adoption by farmers pointed out that farmers with access to paved roads, markets, farmers association and in contact with extension agents, are more likely to adopt technology because they were exposed to information. Concisely, it is clear that institutional factors also play a major role in determining if whether farmers adopt certain technology or decline it.

1.1.2. Farmers' socioeconomic factors. A number of studies have used social economic characteristics (i.e. gender, age, education, household head) to explain household adoption behaviors. A study by Adegbola and Gardebroek (2007) on adoption of technology by farmers noted that educated farmers are more able to process inputs, allocate them efficient, and assess the profitability of new technology better than the less educated farmers. Uaine et al. (2009) are of the same view that educated households are high adopters in agriculture. With reference to age, numerous studies are of the view that young farmers are better adopters than old farmers are. Contrary, a study by Adesina and Forson (1995) on adoption of new agricultural technology notes that young and old farmers adopted new technology. This was mainly influenced by that, young farmers are risks takers and have long-term goals; yet old farmers have more capital or have access to credit. However, Zavale et al. (2005) dispute that notion and reports that older farmers in Mozambique were less likely to adopt improved maize variety compared to young farmers.

1.1.3. Farmers perceptions. Neil and Lee (2001) are of the view that adoption of new technologies is affected by farmers perceptions of the amount of investments or initial capital outlay and labor that will need to be allocated if they adopt the technology. Direct costs, profits associated with the improved seeds, and yields were identified as factors affecting farmers' perceptions (Adegbola and Gardebroek, 2007). However, Martel et al. (2000) offer a different opinion on new technology adoption after conducting a study in Honduras on adoption of dry beans. The findings were that farmers adopt new technology when they perceive that it will reduce labor costs, reduce risks in crop diseases and other farm costs. In addition, farmers are more likely to adopt when they see a seed variety as having a potential to increase their income or survive under different environmental conditions. Gonzales (2003) study purports that farmers also consider environmental aspects such as climate, soil fertility and if such seed varieties were made for those conditions. Hence, it can be drawn from literature that farmers' perceptions differ when it comes to adoption and no clear factor can be generalized to each new technology.

1.1.4. Economic benefits and risks. Economic profitability and risks of new technologies have an inherent effect on farmers when adopting. Adegbola and Garbroek (2007) state that farmers who are aware of certain technology will adopt if they evaluate the profitability or benefit that they anticipate will be gained, taking into consideration investments and costs associated with such a technology. Yet a study conducted in the United States by Cornejo and McBridge (2002) on adoption of bio engineered crops discovered that farmers evaluate the impacts of farm location, distance, soil fertility, and climatic conditions on new technology before they adopt. However, farmers who own land with poor physical conditions like fertility may adopt fertilizer with the hope of improving those conditions. A study by Uaiene (2009) finds no positive correlation between land tenure or farm size and land physical futures on farmer adoption behaviors. The study notes that farmers with land are less likely to adopt any technology like fertilizer because land is abundant. Therefore, literature is inconclusive about economic factors that influence adoption. However, one view that is held is that if the technology leads to economic benefits it will be adopted.

The literature review reveals that farmers' attitudes and perceptions remain a focus point in any decision to adopt technology or farm programs. However, the varying degrees of factors influencing adoption have led to the adoption debate to be inconclusive in literature, with some researchers arguing that a number of factors such as economic situation, attitudes affect adoption and so on. Although much of the current research on technology adoption goes beyond awareness and focuses on adoption rate or extent of adoption (Rogers, 1995; Feder et al., 1985; Adesina and Forson, 1995), there is broad consensus amongst researchers that awareness does have an influence in adoption of technology or seed varieties. Diagne (2010) states that studies which exclude the awareness of technology in adoption studies usually run the risk of producing an unidentifiability model. Moreover, the lack of consensus amongst researchers suggests that a number of variables influencing awareness and adoption produce contrasting results when used in different models. This may suggest that a huge gap exists in literature especially on ways of measuring the awareness effect in adopting new technology or crops. Therefore, this justifies the undertaking of this study.

2. Methods and materials

A total of 129 smallholder farmers were sampled in selected areas of Chris Hani and Oliver Tambo District Municipalities in the Eastern Cape Province. The selection of the municipalities was done purposive because of their agricultural potential, geoclimatic, soil characteristic and cropping history. The farmers were sampled using a snowballing sampling technique. The main reason for choosing this method was to focus on particular characteristic of the population of interest. This technique helps in gaining deeper insights into units under study. The list of farmers was obtained from the respective Agriculture Departments in each area. Hence, farmers were identified into two groups of land utilizers and non-land utilizers. Farmers who utilized their land in the past two seasons were classified as land utilizers or otherwise. A total of 79 farmers both land and non-land utilizers were selected from Chris Hani Municipality and 50 farmers with similar characteristics were from the Oliver Tambo Municipality. To ensure reliability of the data collected, enumerators were trained for data collection. Data that were collected are coded and analyzed using SPPS version 21.

In order to analyze the econometric model, the coded data were then transferred to Eviews version 8 for analysis. A Heckman two-step model was used for data analysis. The model has been widely used in adoption studies (Usman et al., 2011; Deressa, 2007; Gennrich, 2004; Demeke, 2003). Furthermore, it has been widely used to correct for any sample selection bias. It takes the following form as explained below:

The first equation in a Heckman model is a probit estimator. The model estimates the effects of X_i on response $Pr\ [y = 1 \mid X]$. The probit model of awareness of biofuels crops is derived from an underlying latent variable model expressed as:

$$Y_i^* = \beta_0 + \beta_{ij} X_{ij} + \varepsilon_i , \tag{1}$$

where Y_i^* is an underlying index reflecting the difference between the utility of awareness and non-awareness to biofuels; β_0 is the intercept, β_{ij} is a vector of parameters to be estimated; X_{ij} is independent variables which explain biofuels awareness; ε_i is a standard normal distributed error term that is independent of X_{ij} and symmetrically distributed about 0.

The second stage is estimated by ordinary least squares and uses observations with positive values of the dependent variable, hence, it is the outcome equation that includes the inverse Mills ratio and X variable as regressors.

$$\Gamma_J = \phi \gamma'_J + \vartheta \Lambda_J + E_J , \tag{2}$$

where Γ_J is the non-function, γ'_J is the inverse Mills ratio and Λ_J represents variables such as socioeconomic (age, education, farm size), economic variables (income) and more. The error term is E_J and consistent estimates of Ø and $\alpha = 1$. The dependent variables of this model is whether a farmer has the potential to adopt biofuels crops or not. The variables used in this study and the expected signs are shown below in Table 1.

Table 1. Variables used in the study

Variable	Definition	Type	Unit of measurement	Expected sign
Dependent variables				
ADOPTBIO	Adoption of biofuels	Binary	1 = adopt & 0 otherwise	
AWAREBIO	Awareness to biofuels	Binary	1 = aware & 0 otherwise	
Independent variables				
HHGENDER	Household gender	Binary	0= Male & 1 = Female	+/-
HHAGE	Household age	Continuous	years	+/-
HHEDU	Household education	Continuous	Level	+
HHSIZE	Household size	Continuous	members	+/-
HHINCOME	Household income	Continuous	South African Rands	+
UTILAND	Utilization of land	Binary	0 = yes & 1 = no	+/-
HUTILAND	Amount of utilized land	Continuous	Hectares	+/-
TENURE	How land was acquired	Discrete	tenure	+
DISTANCE	Distance to market	Continuous	Kilometres	-
FARMEXPE	Level of farming experience	Continuous	years	+
CREDIT	Access to credit	Binary	0= yes & 1 = no	+
LABOR	Source of labor	Discrete	Type of labor	+/-
MEMASSOC	Member of association	Binary	0= yes & 1 = no	+
AGRICEXTE	Contact with agriculture extension agents	Binary	0= yes & 1 = no	+
INCENTIVE	Offered incentives	Binary	0= yes & 1 = no	+
CHALLENGES	Challenges faced by a farmer	Continuous	Type	-

3. Results and discussions

The results in Table 2 revealed that 54% of the households were male and 47% were female. This represents the general norm in Africa were most households are male headed or dominated. This observation is similar to Montshwe (2006), who discovered that males still dominate in the agricultural sector in South Africa.

Table 2. Descriptive results

Variable	Description	Percent
Gender	Male	53.5
	Female	46.5
Age of respondents	15-34	16.3
	35-50	52.7
	51 and above	31
Qualifications	Grade 11 or lower	39.5
	Grade 12	28.7
	Post matric diploma	16.3
	Bachelor degree	6.2
	Postgraduate degree	9.3

Most of the respondents (52.7%) were 35-50 years old followed by 51 years and above who had 31% of respondents, and last 15-34 years old (16.7%). Therefore, the mean age from the respondents was 38 years old. With regards to level of education, the majority of respondents had at least a primary education. A total of 39.53 percent attended grade 11 or lower, at least 28.68 percent attended grade 12; 16.28 percent had a diploma, 6.2 percent had a bachelor's degree and 9.3 percent received a post graduate degree.

3.1. Empirical results. The study made use of the Heckman two stage model in order to correct for any sample bias. The model was used to examine demographic, social economic, farm specific and biofuels factors that influence the adoption of biofuels crops. The results are presented in Table 3.

Table 3. Heckman two step model

Variable	Coefficient	Std. error	t-statistic	Prob.
Response equation – ADOPT				
C	0.308152	0.628281	0.490469	0.6250
HHS	0.081327	0.043241	1.880771	0.0632**
HINCOME	0.013285	0.057942	0.229273	0.8192
ARABLE	-0.134692	0.054412	-2.475421	0.0152***
INCENTIVESPART	0.342467	0.131541	2.603505	0.0108***
CHALLEN	0.027538	0.014278	1.928683	0.0569**
UTILISELAND	0.092340	0.298934	0.308899	0.7581
BORROWMONEY	-0.094266	0.111505	-0.845396	0.4001
LABSOURCE	0.382582	0.114837	3.331514	0.0012***
LANDACQUIRE	-0.074320	0.094449	-0.786875	0.4334
DISTANCE	-0.081809	0.064931	-1.259933	0.2109
Selection equation – AWAREBIO				
C	-0.418891	1.433957	-0.292122	0.7709
AGE	-0.070168	0.265638	-0.264149	0.7923
GENDER	0.858991	0.380165	2.259521	0.0262**
QUALIFICA	-1.393838	0.256512	-5.433810	0.0000***
MEMBERASS	0.935929	0.333940	2.802688	0.0062***
CONTACTEXT	0.340332	0.372853	0.912778	0.3638
KNOWLEDGEBIO	-0.415618	0.131579	-3.158705	0.0022***
FARMEXPERI	0.382349	0.209052	1.828970	0.0707*
FARMEQUIP	0.122361	0.084102	1.454915	0.1491
OCCUPATION	0.327695	0.216156	1.516010	0.1330
Mean dependent var	0.234043	S.D. dependent var		0.427976
S.E. of regression	0.276261	Akaike info criterion		1.117695
Sum squared resid	6.945156	Schwarz criterion		1.669735
Log likelihood	-40.70862	Hannan-Quinn criter.		1.341737

Note: Values marked with a ***represent significant at 1 percent and values marked ** represent significant at 5 percent level, and values marked * represent significant at 10 percent.

3.2. Selection model. The selection equation was composed of the following variables; age, gender qualification, membership in association, contact with extension, knowledge of biofuels, farm equipment, farm experience and occupation. It was discovered that gender, qualification, contact with the extension and knowledge of biofuels were statistically significant.

Gender – the results suggest a positive and significant relationship between awareness of biofuels crops and gender of household (coefficient: 0.858991). Male headed households are more likely to be risk takers, therefore they are likely to be aware of biofuels and willing to adopt. Asfaw and Admassie (2004) note that male headed household tend to receive information quickly about new technologies in agriculture as compared to female headed household. Similar findings are held by the Department of Agriculture, Forestry and Fisheries (2012), who noted that female households had a low participation rate in agricultural activities. Diagne (2010) recorded a negative correlation between female and awareness of parboiled rice in Guinea.

Qualification or high level of education had a negative association with awareness of biofuels (coefficient: -1.393838). Education is believed to have an influence in agriculture production. This is quite true as educated people are usually associated with access to information on agricultural technology (Norris & Batie, 1987). Surveys conducted by Oyedele and Yahaya (2009), Owuba et al. (2001) identified that a high level of education contributes to the degree of agricultural productivity of the households. Hence, this improves awareness of farmers to innovations or new technology. The findings of this study contradict Daberkow & McBride (2003) who discovered that higher education level increased the likelihood of awareness in Precision Agriculture technologies. Although education has been highlighted in numerous studies as significant in adoption of technology, literature has been inconclusive on its effect on awareness of new technology.

Membership in association – membership and frequent participation in activities in line with agriculture has a positive (coefficient: 0.935929) influence on awareness of agricultural technology. As expected participation or belonging to a membership society in agriculture had an influence in the awareness of people on biofuels crops. Hence, this states that the more the individual attends or participates in association the higher the chance of the individual is receiving the information that would influence his/her decision to adopt biofuels. A study conducted by (Dandedjrohoun et al., 2012) recorded a positive association between membership in association and awareness in new technology. The findings state that being involved in associations helps in the sharing of information through informal and formal discussion, which increase the awareness level.

Knowledge of biofuels – any knowledge of biofuels was hypothesized to have a huge effect on the awareness of biofuels crops. Therefore, as expected the variable was statistically significant and negative (coefficient: -0.415618). This means that people who are aware of the existence of such crops would likely participate in the production of biofuels crops because of the knowledge they possess. Moreover, knowledge was one of the incentives identified by many respondents as lacking. A study that was conducted by McBride & Daberkow G. (2003) states that access to information services improves the knowledge about that technology, hence, it has a positive influence to awareness of new technology. Although, the variable was significant but negative, it still remains to be tested in literature if having more knowledge about a new technology or seed variety improves awareness of such a technology.

Farm experience – the variable was hypothesized as having an influence in the awareness of biofuels crops. It was expected that most farmers with a number of years of experience in farming are most likely to be aware of new technology or seed varieties due to well-established communication networks. The coefficient was positive (0.382349) and statistically significant at 0.10 percent level. The positive relationship between awareness and farm experience means that the more experience a farmer has, the higher the chances of being aware of biofuels crops.

3.3. Outcome model. The second stage of the equation was to analyze the extent in potential adoption of the biofuels. The inverse Mills Ratio from the selection equation was then added to the outcome model to capture the selection bias effect.

Arable – this variable measures arable land. It can be expected that farmers owning arable land would likely adopt a new technology or crops in agriculture. This is influenced by the fact that they expect to earn higher profits if they adopt new technology or crops. As expected, the variable was found to be statistically significant (coefficient: -0.134692) in influencing adoption of biofuels crops. The results are supported by Dereje's (2006) study which posits that farmers owning arable big land are in a better position to adopt new technology compared to farmers who own small land because they face difficulties.

Incentives – this variable exhibited a positive relationship (coefficient: 0.342467) with adoption and a statistical significant result. This means that as incentives are increased farmers have a high probability of adopting the proposed technology, in this case adoption of biofuels crops. It is particularly true that incentives may influence farmers in adopting new agriculture technology or crops. The chances of an individual adopting a certain technology without motivation is diminished as long as there are risks involved in such adoption. It can be concluded that farmers are risk averse people and usually behave rationally. This means that given a choice to transfer the risks to someone they will do so. In this case incentives would act as insurance for the risk they face in adopting new crops.

Challenges – this variable captures factors that hinder adoption to farmers. It was found to be having a positive and significant coefficient of 0.027538. As expected challenges limit the potential of farmers to adopt biofuels crops. It cannot be expected that farmers facing challenges in improving their productivity would be motivated to adopt new biofuels crops. Furthermore, as explained before that many farmers are struggling to make ends meet and this was reflected by a decline in land utilized for farming in the past seasons. Climate change, lack of equipment, theft, pest and weeds are serious obstacles to farmers' adoption. Without proper correction measures it would be hard for farmers to adopt biofuels crops.

Labor source – the coefficient (0.382582) of labor is positive and significant. This means that a unit increase in labor; we can expect an increase in the propensity to adopt biofuels crops. Farmers who obtain labor from the community incur more costs than ones who utilize family labor. Therefore, since most subsistence farmers rely on family labor that in most cases is not paid, they struggle to increase productivity because of lack of motivation. On the other hand farmers who have access to community labor are likely to be interested in adopting new technology or crops with the hope of increasing productivity since labor is paid and available. It can be seen that from the challenges faced by farmers and incentives wanted in order to adopt biofuels that labor is a critical part of any adoption.

Household size – the coefficient for this variable was positive (0.081327) and statistically significant at 0.10 level. A larger household may be expected to be interested in any venture or opportunity that would secure their livelihoods. As such, the higher the number of members of a household the easier it may become to adopt biofuels crops. The coefficient means that as a household grows in number the chances of adopting biofuels increase as well.

Conclusion and recommendations

The main aim of the study was to identify barriers and incentives that influence or affect the potential adoption of biofuels crops. A Heckman two-step model was used to determine factors that influence adoption. The relevant significant explanatory variables included in the model were age, education, gender, membership in association, knowledge of biofuels, incentives, labor sources, and challenges. These entire variables were significant at 1%, 5% and 10% level. The study noted that awareness is a huge factor in the adoption of new agriculture technologies or seed varieties.

The findings of this study can be used to infer conclusions on the potential adoption of smallholder farmers. Some of the recommendations suggested as a guideline for improving the biofuels policy are as follows:

The government can introduce price support schemes or direct income payment system for smallholder farmers. All direct income payment have an effect on agricultural production, but the effects differ according to the instruments used. For instance, the effect is high for deficiency payments as compared to hectare payments. Direct income payment offers more possibilities compared to price support because they can be differentiated. As such, they can be made conditional, for instance, in terms of number of hectares farmed. However, price support can also lead to direct higher production, thus leading to an increase in output in the long run. The only challenge in doing a price support scheme is that the government will need to draft a trade policy that will lead to a decline in supply (using import tariffs or supply quotas) and increasing demand (using export subsidies). Similarly, the government can provide the following:

- The government should engage community leaders when disseminating information to farmers. This would make it easier for farmers to be aware of agriculture innovations.
- There is a need to come up with solutions to fix smallholder challenges hindering productivity like pests and weed control.

The identification of farmers with under-utilized land is necessary in tapping potential for adoption of biofuels crops.

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