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Full Length Research Paper

Comparative analysis of poverty effects of various candidate biofuel crops in South Africa

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The aim of this study was to investigate the poverty reduction impact of various potential biofuel crops in South Africa. A simple pro-poor development framework (in which income is substituted for by its function) is specified. After analysis for outliers with considerable leverage, a robust regression option was used to carry out estimations for physical output, values and inputs of each crop. For reasons of data availability, the crops considered were maize, wheat, sorghum and sugarcane for bioethanol, and groundnuts, soybeans and sunflower for biodiesel. The results suggest that various crops have different impacts on the different poverty measures. If a biofuel strategy's intent is to promote (income) poverty reduction, then for South Africa sugarcane should be prioritised for bioethanol and groundnut for biodiesel. Other crops like maize and sunflower would require stronger support to small farmers. The finding also suggests that poverty reduction comes mainly by employment of the poor in commercial farming. There is suggestion that investment in farming by the poor is often inadequate and would generally result to poverty exacerbation. The implication is that the capital base of the poor must be broadened for them to effectively participate in farming. This has to be done without stifling commercial farming which is simultaneously contributing to poverty reduction through employment. These recommendations hold for sugarcane, groundnut and maize. However, a weakness worth mentioning is that the data is likely to underestimate or completely ignore most of the subsistence producers whose production is mainly for own consumption. Therefore, poverty impact could equally experience a downward bias in the models estimated here.

Key words: Biofuel crops, comparative analysis, poverty effect, South Africa.

INTRODUCTION

International development agencies have of late highlighted agriculture's pro-poor potentials. For instance, the 2008 edition of the World Development Report (WDR) calls for agriculture to be placed at the centre of policy attention and for greater investment in developing countries' agriculture if the goals of halving poverty and hunger are to be realised. World Bank (2008) has highlighted three facts concerning agriculture's ability to enhance pro-poor growth especially in Sub-Saharan Africa (SSA). Firstly, GDP growth in agriculture is four times more effective in extreme poverty reduction than GDP growth originating from other sectors. Secondly, in developing countries 75% of the poor live in (agriculture-dependent) rural areas while only 4% of official development aid goes to agriculture. Thirdly, SSA countries rely heavily on agriculture for overall growth, highly taxing the sector while allocating only 4% of total government spending to the sector.

In South Africa, though agriculture contributes to less than 3% of GDP the employment per unit of GDP (relative to other sectors) remain the highest (Figure 1).

The main challenge of South Africa's policy authority is to uncover and harness agricultural potentials in order to achieve the policy goals contained in the Growth, Employment and Redistribution (GEAR) strategy. More specifically, the challenges are to:

(1) Increase agricultural productivity and output in order to step-up its contribution to national economic growth.
(2) Increase the incomes of the poorest groups through creation of production enhancing opportunities for small and medium-scale farmers.

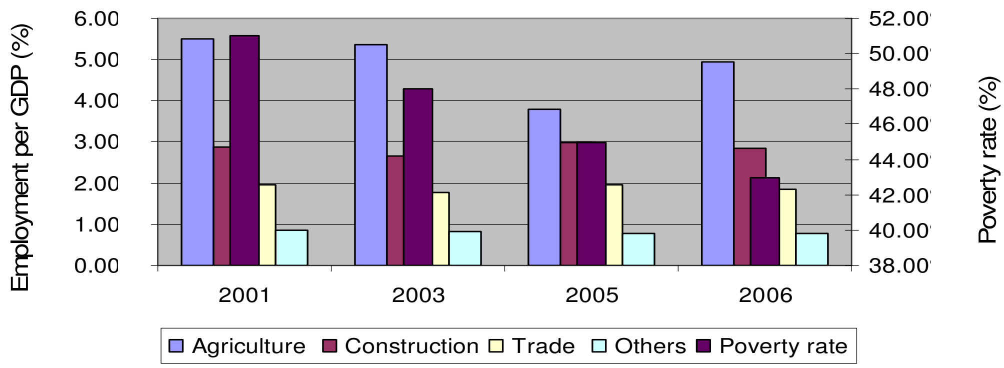

Figure 1. Employment per unit GDP of various economic sectors. Source: Based on STATSA and SA development indicators.

(3) Create additional employment in agriculture.
(4) Ensure more equitable distribution of resources in the agricultural sector.

Growth in the grain sector is however, constrained by lack of markets once the national markets have been saturated. Due to this, over one million hectare (Ha) of available commercial farmland and two million hectare of customary land (within the former homelands) is estimated as currently not being cropped annually.

Amidst high oil prices and low agricultural productivity, the pursuance of biofuel production strategy for most developing countries would be motivated by development objectives. It is generally thought that biofuels will boost agriculture, spilling-over from biofuel feedstock to other cash and food crop production. It is also thought that the establishment and operation of biofuel processing plants will boost the non-agricultural sector. As such, there will be a resulting absorption of farm and off-farm labours, resulting in the reduction of unemployment and poverty reduction in both agricultural and non-agricultural sectors. The main objective of South Africa's Biofuel Strategy is to address the issues of poverty and economic development using renewable energy as a driver. It aims to address the particular challenges of job creation and enhancement of productive opportunities of the poor in the agricultural sector, in underdeveloped and formerly disadvantaged "homeland" areas (Department of Mineral and Energy - DME, 2007). However, the development impacts of biofuels have not been empirically proven. Besides, serious concerns have recently been raised regarding the adverse effects of biofuels such as its impact on food security (FAO, 2008). Particularly, the use of crops for biofuel could lead to increase in food prices and concentration of land away from the poor and vulnerable farmers. A way of attenuating the negative socio-economic impact of biofuels may be through the selective use of crops with empirically proven potential.
The objective of this paper is to assess the poverty impacts of various biofuel crops in order to inform policy about crop suitability for poverty alleviation. Specifically, it aims to analyse the impact of selected candidate biofuel crops on income poverty incidence, depth and severity. Another related question that this work attempts to answer (some what indirectly) is whether poverty effect is a result of the poor's ownership of production value chain or his or her employment in the sector. The answer to this question (which merits further analysis beyond this work) is crucial in distinguishing between large-farms versus small-farm promotion policies. This is done by comparing the effects of crop yields (measured in tonnes) and the monetary value of the crop and the impact of labour and capital on the different poverty measures.

The framework

The framework used in this work is developed on the basis of the poverty-growth-inequality approach. There is consensus in theory and experience that economic growth and the resulting distribution of its fruits are the two means by which poverty reduction occurs (Easterly, 2002; Ravalion, 2004; Bourguignon, 2004). Following the pro-poor growth theory, Son and Kakwani (2006) show that for societal mean income (μ), and percentage share of the income of the bottom px100 of the population L(p), the growth rate of the mean income of the bottom p percent of the population is:

$$g(p) = \Delta \ln(\mu L(p)) \quad (1)$$

such that if $g(p) > 0$ (< 0), for all p, then poverty has decreased (increased) unambiguously between two periods. They suggest a pro-poor growth rate (γ^*) to be the area under the poverty growth curve as follows:

$$\gamma^* = \int_0^1 g(p)dp = \int_0^1 \Delta \ln(\mu L(p))\, dp$$

Or $$\gamma^* = \gamma - \Delta \ln(G^*) \quad (2)$$

where γ is the growth rate of societal mean income and

$\Delta \ln(G^{*})$ is the rate of change of inequality.

If inequality decreases (increases) in a given period, then the pro-poor growth rate is greater (less) than the actual growth rate for that period. Equation 2 can also be considered at level, such that poverty is a function of production and inequality. For any measure of poverty from the Foster-Greer-Thorbecke (FGT) family of indices $P^{\alpha}(\alpha = 0,1,2)$, income y, inequality index θ and δ parameters. A framework for poverty based on the pro-poor growth theory would be as follows:

$$P_t^{\alpha} = \delta_0 y_t^{\delta_1} \theta_t^{\delta_2} \quad (3)$$

Taking the double log of (3) and introducing the error term ε_{pt} gives the following functional form:

$$lnP_t^{\alpha} = \delta_0 + \delta_1 lnY_t + \delta_2 ln\theta_t + \varepsilon_{pt} \quad (4)$$

In order to evaluate the impact of various factors of production on poverty, the income variable in Equation (4) is substituted for by its underlying determinants in a simple Cobb-Douglass production function:

$$lnP_t^{\alpha} = \delta_0 + \delta_1 \ln(K^{\beta_1} L^{\beta_2}) + \delta_2 ln\theta_t + \varepsilon_{pt} \quad (5)$$

$$lnP_t^{\alpha} = \delta_0 + \delta_{11} \ln K_t + \delta_{12} lnL_t + \delta_2 ln\theta_t + \varepsilon_{pt} \quad (6)$$

Variables, data and estimation procedure

Due to its advantage of being additive across subgroups, the Theil–index is preferred here over Gini coefficient for the measurement of overall income distribution (θ). Turn after turn, total, between group and within group inequality are employed for the estimation of Models (4) and (6). This decomposition is relevant for a multi-racial society like South Africa where within and between inequality are likely to affect production differently such that total inequality would give only average effects. Poverty variable is captured by the Foster-Greer-Thorbecke (FGT) family of poverty indices, so named after Foster, Greer and Thorbecke (1984). For an increasing ordered vector of household incomes $(y_1, y_{2,} ..., y_n)$, a strictly positive poverty line *z*, i[th] household's income shortfall $g_i = z - y_i$, number of poor households $q = q(y;z)$ and total number of households $n = n(y)$, and $\alpha(\geq 0)$ a parameter of poverty aversion, the FGT class of poverty measures P^{α} is defined as:

$$P^{\alpha}(y;z) = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{g_i}{z}\right)^{\alpha} \quad (7)$$

Poverty incidence, intensity and severity are derived for $\alpha = 0,1 and 2$ respectively. These three measures are considered turn by turn, together with the three inequality measures considered.

Poverty and inequality data are taken from the South African Development Indicators (2009) published by the Ministry of National Planning at the Presidency of South Africa. Crop yields and values of selected crops are from the Abstract of Agricultural Statistics of South African Department of Agriculture (2007). Capital and labour force are compiled using farm budgets obtained from various farmers groups: maize, wheat Sorghum from the broksby area in the North West Province and Bergville in Kwazulu-Natal. Sunflower, soybeans from MMI farmers network in Limpopo and Mpumalanga, sugarcane employment from Cane-growers association. Wheat, sorghum and groundnut, information about employment was obtained from GRAINSA. These were used in conjunction with total agricultural employment and capital, to generate the shares for each crop. It was assumed that these shares mimic the weight in value of each crop in total agricultural value over time. With these, time series for employment and capital shares for each crop was generated. The resulting data set is from 1993 to 2007

The equations are estimated using robust estimation method. The dynamics of agricultural production involve natural and market stocks which may generate outliers with considerable leverage on the data. It has been shown that in the presence of outliers, the approach of re-estimating sample with deleted outlying observation is not the best (Darnell, 1994; Maddala, 1992). One of the main limitations suggested by Darnell (1994) is that outliers in residuals are not necessarily outliers in population. The presence of outliers especially those with bad leverage points can inflate the error variance and hence, the standard errors. In such case, the confidence interval becomes stretched, thereby decreasing the efficiency of estimation. After the OLS estimations for each crop, this work uses the Cook's D to determine the presence of and leverage exerted by outliers, in which case, robust estimates are considered over OLS. The Cook's D for i[th] observation is computed as follows:

$$Cook's D_i = \frac{r_i^2 . h_{ii}}{\rho.(1-h_{ii})} \quad (8)$$

where r_i is studentized residual, h_{ii} the leverage of i[th] observation and ρ is the number of parameters. Outlier is considered present if:

$$D_i > 2/\sqrt{n} \quad (9)$$

In the case of the presence of influential outliers, preference is given to the results of the robust regression, otherwise OLS.

Various methods for robust regression analysis are employed by various statistical packages. The variant used in this work is the Iteratively Reweighted Least Squares used by STATA9. This involves iteratively assigning weights to observations such that the better behaved ones receive higher weights. In extreme cases (Cook's d > 1), weights can be set to missing so that such very influential observations are not included in the analysis at all.

EMPIRICAL RESULTS

Here, the results of the empirical analysis are presented with the possible interpretations. Table 1 gives the summary statistics, indicating the range of variation of the variables used in the models.

Outliers investigation - Results of Cook's D

The cook's distance is compared against the critical

Table 1. Descriptive statistics.

Log of variable	Observation	Mean	Std. Dev.	Min	Max
Log of yield in Rand value					
Maize	17	15.75	0.48	14.85	16.85
Wheat	17	14.57	0.44	13.74	15.38
Sorghum	17	12.36	0.42	11.79	13.14
Sugarcane	17	14.78	0.41	13.93	15.23
Groundnut	17	12.44	0.51	11.57	13.42
Soybean	17	12.35	0.90	10.90	13.94
Sunflower	17	13.67	0.68	12.60	15.16
Log labour (indices)					
Maize	17	5.00	0.29	4.52	5.57
Wheat	17	3.82	0.29	3.27	4.35
Sorghum	17	1.61	0.49	0.56	2.47
Sugarcane	17	4.02	0.20	3.64	4.39
Groundnut	17	5.85	2.22	2.28	10.14
Soybean	17	1.60	0.51	0.72	2.35
Sunflower	17	2.92	0.45	2.24	3.71
Log of capital (indices)					
Maize	17	6.42	0.48	5.51	7.46
Wheat	17	5.24	0.48	4.01	5.99
Sorghum	17	3.03	0.41	2.45	3.75
Sugarcane	17	5.45	0.47	4.30	5.89
Groundnut	17	3.11	0.49	2.11	4.03
Soybean	17	3.03	0.92	1.26	4.55
Sunflower	17	4.35	0.71	2.87	5.77
Log of inequality and poverty					
Between-group inequality	17	-0.73	0.14	-1.07	-0.60
Poverty incidence	17	3.89	0.07	3.71	3.97
Poverty intensity	17	3.16	0.10	2.94	3.30
Poverty severity	17	2.67	0.13	2.40	2.83

Table 2. Outlier critical values for data.

At level	0.16
2 lags	0.173913
2 lags and fd	0.181818
2 lags and sd	0.190476

values as shown in Table 2. They are computed as two divided by number of observations in each case.

The outcome indicates the presence of outliers with significant leverage for wheat (observation 25), sorghum (observations 11 and 25), sunflower (3, 12 and 20) and soybeans (observation 12). Maize data does not indicate the presence of outliers, sugarcane and groundnuts data exhibit some outliers but their influences are not significant. The implication is that the results of simple OLS may not deviate significantly from that of robust estimation in the latter cases, whereas they do in the former. However, all the equations are estimated by robust regression method.

Estimation results

Tables 3 and 4 presents the results of the estimation of

Table 3. Poverty Estimates with yield values for bio ethanol Crops.

Parameter	Yield			Value		
	P_0	P_1	P_2	P_0	P_1	P_2
Maize						
$\log y$	-0.001 (-0.01)	0.033 (0.68)	0.042 (0.64)	0.034(0.97)	0.095* (1.87)	0.140* (1.96)
$\log T_B$	0.480*** (5.80)	0.614*** (4.17)	0.720*** (4.31)	0.583 (4.79)	0.867*** (4.39)	1.103***(4.47)
C	4.244*** (10.57)	3.308*** (4.63)	2.815*** (3.47)	3.775*** (7.73)	2.290** (2.89)	1.272 (1.29)
F(2, 13)	17.02	8.69	9.28	22.64	14.23	13.57
P-Val	0.000	0.004	0.003	0.000	0.001	0.001
Wheat						
$\log y$	0.101** (2.38)	0.174** (2.24)	0.258** (2.54)	0.076** (3.24)	0.142** (3.06)	0.180** (2.73)
$\log T_B$	0.461*** (7.86)	0.589*** (5.47)	0.733*** (5.23)	0.582*** (7.94)	0.891*** (6.18)	1.133*** (5.51)
C	3.460***(10.73)	2.270*** (3.84)	1.248 (1.62)	3.209*** (10.54)	1.751** (2.93)	0.872 (1.02)
F(2, 13)	32.52	16.66	15.98	41.14	22.42	17.80
P-VAL	0.000	0.000	0.000	0.000	0.000	0.000
Sorghum						
$\log y$	-0.005 (-0.16)	-0.006 (-0.11)	-0.030 (-0.45)	0.017 (0.59)	0.055 (1.16)	0.058 (0.92)
$\log T_B$	0.482*** (3.50)	0.585*** (3.50)	0.776*** (3.67)	0.498*** (5.68)	0.664*** (4.67)	0.788*** (4.19)
C	4.268*** (19.44)	3.556*** (9.16)	3.409 (6.95)	4.042*** (12.05)	2.973*** (5.47)	2.538***(3.53)
F(2, 13)	17.80	8.98	8.43	18.50	11.43	9.36
P-VAL	0.000	0.004	0.005	0.000	0.001	0.003
Sugarcane						
$\log y$	-0.092** (-2.05)	-0.159* (-1.90)	-0.171(-1.62)	0.058(1.64)	0.103(1.49)	0.117 (1.32)
$\log T_B$	0.520*** (7.65)	0.660*** (5.20)	0.821*** (5.12)	0.591*** (5.66)	0.791*** (3.88)	0.968*** (3.70)
C	3.364*** (7.89)	2.076** (2.61)	1.562 (1.55)	3.469*** (7.45)	2.220** (2.44)	1.648 (1.41)
F(2, 13)	29.60	13.49	13.11	24.02	9.89	9.30
P-Val	0.000	0.001	0.001	0.000	0.003	0.003

P_0 P_1 and P_2 stand for poverty incidence, intensity and severity. T_B stands for Between-group Theil inequality measure. , K, L and C are capital, labour and constant terms. P-VAL is the model probability of non-significance. Values in parentheses below each coefficient are their respective p-values. ***, ** and * indicate rejection of null hypothesis at one, five and ten percents respectively. All variables are specified in log form.

Table 4. Poverty Estimates with inputs for bio ethanol Crops.

Parameter	P_0	P_1	P_2	P_0	P_1	P_2
	Maize			Wheat		
$\log K$	0.053* (1.87)	0.092* (1.70)	0.110(1.39)	0.039* (1.82)	0.071* (1.84)	0.080 (1.22)
$\log L$	-0.006 (-0.20)	-0.045 (-0.78)	-0.071 (-0.88)	0.053*(1.84)	0.082 (1.59)	0.100 (1.27)
$\log T_B$	0.642*** (6.71)	0.849*** (4.47)	1.023*** (3.82)	0.522*** (6.48)	0.722*** (4.97)	0.873*** (3.96)
C	4.039*** (23.77)	2.971*** (8.81)	2.356*** (4.96)	3.870*** (31.81)	3.007*** (13.74)	2.511*** (7.55)
F(3, 12)	26.19	10.41	7.75	25.34	14.26	9.22
P-VAL	0.000	0.001	0.004	0.000	0.000	0.002

Table 4. Contd.

		Sorghum			Sugarcane	
$\log K$	0.053*** (3.71)	0.085 (1.29)	0.062 (0.67)	0.022 (0.90)	0.038 (0.82)	0.042 (0.62)
$\log L$	-0.034** (-2.91)	-0.017 (-0.32)	-0.014 (-0.19)	-0.097** (-2.09)	-0.138* (-1.80)	-0.151 (-1.19)
$\log T_B$	0.596*** (14.19)	0.721*** (3.73)	0.817** (3.00)	0.465*** (5.36)	0.596*** (3.68)	0.730** (3.05)
C	4.209*** (28.14)	3.456*** (22.89)	3.101*** (14.57)	3.721*** (18.72)	2.839*** (7.65)	2.368***(4.32)
F(3, 12)	98.51	7.28	5.10	21.06	9.88	6.64
P-Val	0.000	0.005	0.017	0.000	0.002	0.007

P_0 P_1 and P_2 stand for poverty incidence, intensity and severity.T_B stands for Between-group Theil inequality measure. , K, L and C are capital, labour and constant terms. P-VAL is the model probability of non-significance. Values in parentheses below each coefficient are their respective p-values. ***, ** and * indicate rejection of null hypothesis at one, five and ten percents respectively. All variables are specified in log form.

Equations (4) and (6), respectively, for bioethanol crops (maize, wheat, sorghum, sugarcane). The estimates are for yield and values for Equation 4 and capital and labour for Equation 6. Judging from the model F-statistics and P-values, all the equations have good performances. In all the equations, inequality has the expected poverty exacerbating effect for all measures of poverty.

Maize yield has a negative effect on poverty incidence, positive effect on poverty intensity and severity, but the effects are not significant. Maize value shows positive impact on poverty, but it is significant only on poverty severity. One percent increase in maize value results in 0.140% increase in poverty severity. Since maize is a staple food for poor households, this result may be capturing price effect, such that high value (implying high prices) leads to the very poor allocating higher proportion of their income to food. This is plausible since the physical quantities do not show significant impact on poverty. Employment in maize production has negative but insignificant effect on poverty. Capital in maize production increases poverty, but the effect is significant only for poverty incidence. One percent increase in capital for maize production results in 0.053% increase in poverty ratio. This may imply that the relatively less poor who invested poorly (insufficiently) in maize production, had a lower output (not enough to break even), hence not covering their capital cost. The insignificant effect on poverty intensity and severity could be understood in the sense that the abjectly poor may not participate in the production process, while maize employment has negative but insignificant effect on all poverty measures. Wheat quantity and value both have significant poverty enhancement effects across all measures of poverty. This is likely because while capital use in wheat increases poverty, labour is insignificant, with positive coefficient. Sorghum quantity has negative impact on poverty, while the value has positive impact on poverty, but none is significant for all the poverty measures. Sorghum capital and labour show positive and negative effects on all poverty measures respectively, but significant only on poverty incidence. One percent increase in capital and labour uses in sorghum production results in 0.053 increase and 0.034 decrease in poverty incidence respectively. Since capital and labour have similar magnitudes with opposing signs, this can explain the weak and insignificant effect of sorghum quantity and values on poverty.

Sugarcane yield has negative effect on all poverty measure, and is significant on poverty incidence and intensity. One percent increase in sugarcane quantity produced leads to 0.092 and 0.159% reduction in poverty incidence and intensity, respectively. The effect of the value of the crop on poverty (though positive) is not significant. This suggests that poverty reducing effect of sugarcane production comes by employment and not the ownership of value chain by the poor. This is also confirmed by the coefficients of capital and labour in sugarcane. While capital (though positive) is insignificant on poverty, employment has negative effects on all poverty measures, and is significant on poverty incidence and intensity. One percent increase in employment in the sugarcane sector leads to 0.097 and 0.138% reduction in poverty incidence and intensity respectively.

The results of the estimation of Equations (4) and (6), for biodiesel crops (groundnut, soybean and sunflower) are reported in Tables 5 and 6, respectively. Table 5 gives the estimates of yield and values on poverty (Equation 4), and Table 6 gives the estimates of capital and labour on poverty (Equation 6). The model F-statistics and P-values indicate that all the equations have good performances. Equally, inequality has the expected poverty exacerbating effect for all measures of poverty in all models.

Groundnut yield has a negative effect on all poverty measures, but the effect is not significant for poverty severity. One percent increase in groundnut output brings about 0.048 and 0.095% fall in poverty incidence and intensity. Its value shows positive impact on poverty, but

Table 5. Poverty estimates with yield values for biodiesel crops.

Parameter	Yield			Value		
	P_0	P_1	P_2	P_0	P_1	P_2
Groundnut						
$\log y$	-0.048* (1.77)	-0.095** (2.05)	-0.093 (1.33)	0.027 (0.96)	0.075* (1.78)	0.069 (1.07)
$\log T_B$	0.454*** (6.83)	0.552*** (4.90)	0.688*** (4.04)	0.535*** (5.32)	0.776*** (4.84)	0.895*** (3.86)
C	3.995*** (26.57)	3.122*** (12.28)	2.732*** (7.10)	3.948*** (13.19)	2.804*** (5.87)	2.471*** (3.58)
F(2, 13)	32.48	19.62	12.16	21.45	14.47	9.98
P-Val	0.000	0.000	0.001	0.000	0.001	0.002
Soybean						
$\log y$	0.013 (0.57)	0.025 (0.58)	0.051 (0.97)	0.021 (1.07)	0.046 (1.30)	0.073(1.59)
$\log T_B$	0.510*** (5.27)	0.660*** (3.72)	0.875*** (3.99)	0.589*** (4.70)	0.844*** (3.72)	1.153*** (4.40)
C	4.194*** (46.74)	3.519***(21.40)	3.044***(14.96)	4.061***(23.56)	3.208*** (10.27)	2.591*** (7.17)
F(2, 13)	21.25	9.99	10.33	24.39	12.25	15.41
P-VAL	0.000	0.002	0.002	0.000	0.001	0.000
Sunflower						
$\log y$	0.075*** (4.91)	0.150*** (4.00)	0.112* (1.83)	0.047** (3.08)	0.110** (3.27)	0.088* (1.92)
$\log T_B$	0.566*** (15.57)	0.739*** (8.35)	0.787*** (4.83)	0.688*** (9.28)	1.076*** (6.60)	1.031***(4.69)
C	3.820*** (41.60)	2.755*** (12.32)	2.528*** (6.46)	3.744*** (21.45)	2.454***(6.73)	2.228*** (4.30)
F(2, 13)	121.40	35.57	12.20	57.28	29.30	13.31
P-Val	0.000	0.000	0.001	0.000	0.000	0.001

Table 6. Poverty Estimates with inputs for biodiesel crops.

Parameter	P_0	P_1	P_2	P_0	P_1	P_2	P_0	P_1	P_2
	Groundnut			Soybeans			Sunflower		
$\log K$	0.018** (2.61)	0.015* (1.69)	0.089 (1.01)	0.001 (0.05)	0.001 (0.02)	-0.007 (-0.10)	0.036* (1.69)	0.038 (0.73)	0.034 (0.52)
$\log L$	-0.132** (-2.17)	-0.099** (-2.20)	-0.018 (-0.25)	0.036 (0.78)	0.078 (0.94)	0.142 (1.33)	-0.004 (-0.13)	-0.032 (-0.50)	-0.051 (-0.64)
$\log T_B$	0.614*** (10.29)	0.837*** (4.45)	0.966*** (3.42)	0.576*** (4.78)	0.806*** (3.74)	1.061*** (3.86)	0.647*** (7.78)	0.766*** (3.91)	0.883*** (3.58)
C	4.233*** (40.25)	3.490*** (31.46)	3.125*** (18.73)	4.247*** (77.55)	3.620*** (36.91)	3.232*** (25.87)	4.189*** (71.33)	3.464*** (25.04)	3.020*** (17.36)
F(3, 12)	62.57	10.23	6.55	15.28	7.92	7.76	30.90	8.04	7.16
P-Val	0.000	0.001	0.007	0.000	0.004	0.004	0.000	0.003	0.005

T_B stands for Between-group Theil inequality measure. , K, L and C are capital, labour and constant terms. P-VAL is the model probability of non-significance. Values in parentheses below each coefficient are their respective p-values. ***, ** and * indicate rejection of null hypothesis at one, five and ten percents respectively. All variables are specified in log form.

it is significant only on poverty intensity, with a percentage increase in value leading to 0.075% higher poverty intensity. Capital in groundnut production is significantly associated with higher poverty incidence and intensity. One percent increase in capital leads to 0.018 and 0.015% higher poverty incidence and intensity. Labour use in groundnut cultivation contributes to poverty reduction, but insignificantly for poverty severity. A percentage increase in employment for groundnut cultivation leads to 0.132 and 0.099% reduction in poverty incidence and intensity.

Both yield and value of sunflower are associated with higher poverty and are significant on all three poverty measures. One percent increase in yield (value) leads to 0.075, 0.150, and 0.112 (0.047, 0.110 and 0.088) increases in poverty incidence, intensity and severity respectively. Capital and labour have positive and negative coefficients on all three poverty measures, respectively, but only the coefficient of capital on poverty incidence is significant. As with maize, this may imply that poor household invest (insufficiently) in sunflower production, with lower output (not enough to break even). Neither soybeans yield nor value shows any significant effect on poverty. Capital and labour use in soybean cultivation equally show no significant impact on any poverty measure.

CONCLUSIONS AND POLICY IMPLICATIONS

The aim of this work was to investigate the poverty impact of various potential biofuel crops in South Africa. A simple pro-poor development framework (in which income is substituted for by its function) is specified. After analysis for outliers with considerable leverage, a robust regression option was used to carry out estimations for physical output, values and inputs of each crop. For reasons of data, the crops considered were maize, wheat, sorghum and sugarcane for bioethanol, and groundnuts, soybeans and sunflower for biodiesel.

The results suggest that various crops have different impacts on the different poverty measures. Maize output contributes to reduction of poverty rate, but has no impact on severe forms of poverty. The value of maize increases poverty severity. Since maize is a staple food for poor households, this result may be capturing price effect, such that high value (implying high prices) leads to the very poor allocating higher proportion of their income to food. Capital in maize production increases poverty incidence. This may imply that the relatively less poor who invested poorly (insufficiently) in maize production, had lower output (not enough to break even), hence not covering their capital cost. The insignificance of maize production on abject poverty reduction, imply that the abjectly poor do not participate profitably in the production process. Maize employment has negative butinsignificant effect on all poverty measures. Both wheat quantity and values enhance poverty. This is likely because while capital use in wheat increases poverty, labour is ineffective. While sorghum does not affect poverty, its capital and labour uses have positive and negative effects on poverty incidence with similar magnitudes. Sugarcane yield reduces poverty incidence and intensity. The insignificance of the value of the crop suggests that poverty reducing effect of sugarcane production comes by employment and not the ownership of value chain by the poor. The impact of capital (non-significant) and labour (negative and significant) corroborates this suggestion.

Groundnut yield reduces poverty incidence and intensity. Its value shows positive impact on poverty intensity. Capital in groundnut production is significantly associated with higher poverty incidence and intensity, while labour contributes to poverty reduction. This implies that poverty reduction benefits can only come by employment of the poor in groundnut farms, because their (most often insufficient) investment will only exacerbate their poverty state. Both yield and value of sunflower are associated with higher poverty. Sunflower capital increases, while its labour reduces poverty incidence. This may imply that poor household invest (insufficiently) in sunflower production, with lower output (not enough to break even). Neither soybeans output nor its associated inputs have any effect on poverty.

If the biofuel strategy should target (income) poverty reduction, then these findings suggest the following: the priority crops should be sugarcane for bioethanol and groundnut for biodiesel. Other crops like maize and sunflower would require stronger support to small farmers. The finding also suggests that poverty reduction comes mainly by employment of the poor in farming units. There is suggestion that investment in farming by the poor is often inadequate and only results in poverty exacerbation. The implication is that the capital base of the poor must be broadened for them to effectively participate in farming. This should be done without stifling commercial farming which can lead to poverty reduction through adequate employment. These recommendations hold for sugarcane, groundnut and maize. The use of maize (a staple food crop) for biofuel is likely to pose a fundamental food security problem to the poor in the non-farm sector, since increase in the price of maize is likely to cause more poor to allocate a higher proportion of their income to food, leading to more poverty. However, one has to bear in mind the weakness of the data considered in this work. Given that the data is likely to underestimate or completely ignore most of the subsistence producers whose production is mainly for own consumption, the poverty impact could equally experience a downward bias in the models estimated here.

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