

An ecological-economic analysis of biodiesel feedstock production from smallholdings in rural South Africa

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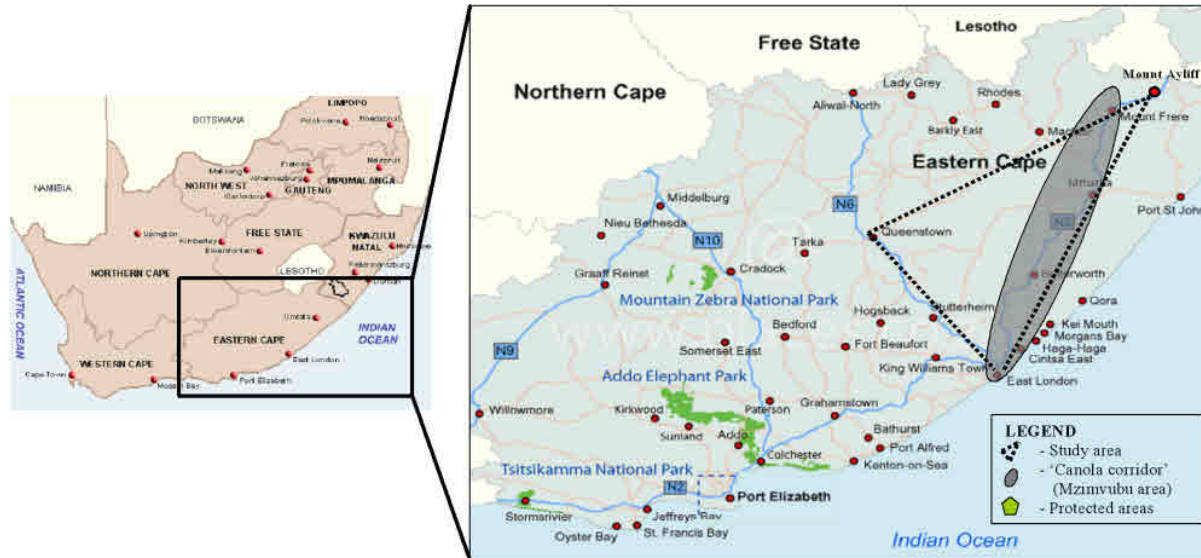


Background / Justification

- There is growing research & interest in biofuels for transportation purposes due to:
 - climate change concerns
 - need to secure petroleum supplies
- In SA – Government interest in biofuels is largely driven by:
 - the need to stimulate rural economic development to address poverty, unemployment
- The recently approved SA Biofuels Industrial Strategy
 - aims at a 2% penetration level of biofuels in the national liquid fuel supply
 - prioritizes feedstocks include sugarcane, sugar beet; canola, sunflower, soybeans
 - targets areas - former homelands

Eastern Cape Province, South Africa

- **The case-study area**



- Area prioritized for economic development due to high levels of poverty & unemployment
- Most farmers are informal subsistence farmers of food crops & livestock

The land-use system

- Maize-soybeans-canola rotation
 - Five repeat rotations this system
- State of the soil
 - range from low fertility (due to exploitation and poor management) to intermediate fertility
- Possible management regimes
 - Fertilizer additions
 - Organic matter additions

Research objectives

- To determine how various crop-production & management practices of rural small-scale farmers affect the profitability and sustainability of growing canola & soybeans for biodiesel feedstocks in the Eastern Cape, SA
- To determine the feasibility of participating in a carbon-sink project

Analytical approach

- A bioeconomic modelling approach within a cost-benefit analysis framework was adopted in this study

The biophysical model - SCUAF

- mimic the effects of tree/crop systems on soils and yields under various management & environment conditions
- run simulations of 15-25 years
- Parameter values for a range of crops, soils, climate
- Tested for a range of environments & management conditions

Implementing the model

The bioeconomic models was solved for 24 management regimes

Farm management practice	Fertiliser applications Kg/ha/yr			
	High	Medium	Low	Zero
	N = 180 P = 45	N = 120 P = 30	N = 60 P = 15	0 Kg
Conservation (180-250 Kg soil lost / yr)	1	2	3	4
Semi-conservation (370-560 Kg soil lost / yr)	5	6	7	8
Conventional (560-930 Kg soil lost / yr)	9	10	11	12

And each of these was simulated for two levels of initial soil fertility

- Low initial soil fertility 38 Mg C ha⁻¹ & 3.8 Mg N ha⁻¹
- Medium soil fertility 77Mg C ha⁻¹ & 7.7 Mg N ha⁻¹

Analytical approach

- The economic model
 - Estimated the net present values (over 20 years with a base-case discount rate of 8%) of the flow of benefits and costs from the sale of:
 - canola and soybean feedstocks into biofuels
 - maize for food
 - eligible carbon (sequestered in the soil, and offset from the use of biofuels)
 - NPV's were estimated for each of the 12 management regimes for both low and medium initial soil fertility

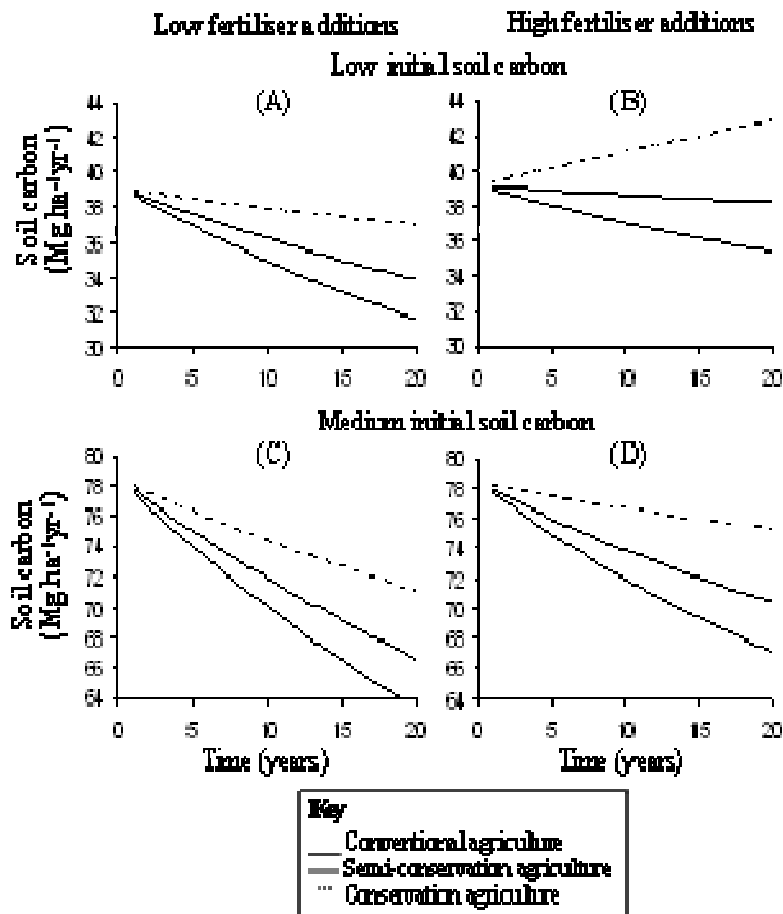
Economic parameter values

Base case parameter values for the deterministic economic analysis

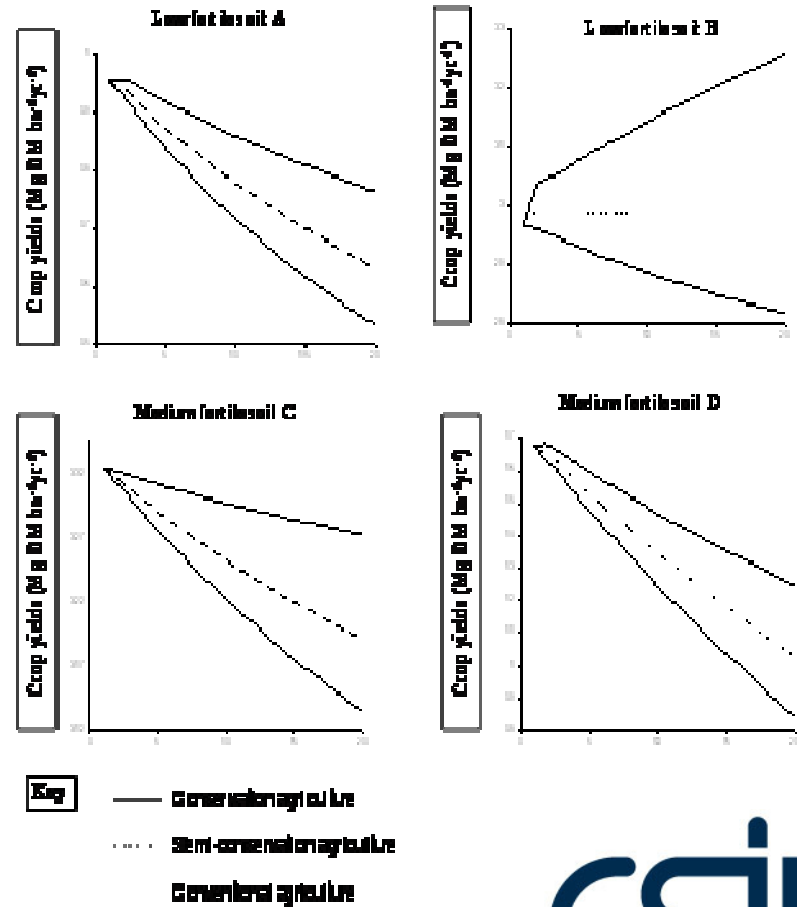
Variable	Units	Soybean	Maize	Canola	Carbon
Yield price	US\$/tonne				26.4
Yield price	US\$/tonne	350.0	225.0	425.0	
Input costs conventional	US\$/ha	365.0	285.0	240.0	
Input costs semi-conservation	US\$/ha	325.0	255.0	210.0	
Input costs conservation	US\$/ha	285.0	230.0	185.0	
Harvest costs	US\$/ha	60.0			
Training/consultants	US\$/ha	10.0			
Fertiliser price	US\$/kg	0.2, 08, 1.2			
Carbon monitoring costs	US\$/ha				10

Biophysical outputs

Soil carbon trajectories



Crop yield trajectories



Biophysical outputs

Average annual change in **soil carbon** ($Mg\ C\ ha^{-1}$) as simulated by SCUAF

Fertiliser regimes	Low initial soil fertility			Medium initial soil fertility		
	Agricultural practice					
	Conservation	Semi-conservation	Conventional	Conservation	Semi-conservation	Conventional
Zero	-0.25	-0.37	-0.47	-0.50	-0.72	-0.90
Low	-0.10	-0.25	-0.36	-0.34	-0.55	-0.71
Medium	0.04	-0.14	-0.26	-0.20	-0.44	-0.59
High	0.17	-0.04	-0.18	-0.14	-0.37	-0.53

Soil C losses over time decrease as management changes from conventional to conservation agriculture – the more conservative the management practice the lower the average annual soil losses

Decreases in soil-carbon losses are further enhanced by the addition of fertilizer – fertilizers improve the carbon-storage potential of soils

The soil-carbon losses that are avoided through appropriate management are greatest in the poorer quality degraded soils – even becoming positive, the greatest gains in soil C sequestration are attained in degraded soils.

Biophysical outputs

Average annual **crop yields** ($Mg\ ha^{-1}\ yr^{-1}$) for canola, maize and soybeans

Fertiliser regimes	Low initial soil fertile			Medium initial soil fertile		
	Agricultural practice					
	Conservation	Semi-conservation	Conventional	Conservation	Semi-conservation	Conventional
Zero	0.86	0.78	0.72	1.46	1.34	1.24
Low	1.62	1.52	1.45	2.22	2.09	1.99
Medium	2.38	2.25	2.17	2.98	2.82	2.71
High	3.14	2.98	2.89	3.30	3.25	3.22

As management changes from conventional to conservation agriculture – yields improve

Fertilizers improve yields

Economic results

NPV (US\$ ha⁻¹ yr⁻¹) from the sale of canola, maize & soybeans

Fertiliser regimes	Low initial soil fertile			Medium initial soil fertile		
	Agricultural practice					
	Conservation	Semi-conservation	Conventional	Conservation	Semi-conservation	Conventional
Zero	-73.22	-89.53	-103.89	16.10	-5.15	-23.67
Low	-0.42	-19.09	-34.47	88.84	66.02	47.69
Medium	72.19	50.54	33.87	161.03	135.53	116.15
High	145.00	119.78	101.26	172.58	160.09	149.07

- In none of the scenarios investigated was it feasible to for a landholder to participate in a carbon-sink project if the opportunity were to arise because of soil-carbon losses!

Conclusions

- Profitability varies depending on your initial soil fertility and management decisions
 - Conservative management practices need to be encouraged since they lead to higher returns irrespective of soil fertility
 - Farmers in low fertile soils can not make profits without subsidies
- Role of modeling in informing decisions on implementation

Issues requiring further research

1. Economic feasibility when transport logistics are dealt with
– consider infrastructure requirements, optimal scale
2. Since landholders keep livestock – one may investigate effect of incorporating livestock into the system
3. More detailed assessment of the energy balance of the production system and the value chain

END!

THANK YOU