Journal of Energy in Southern Africa 22(1): 2–11
DOI: http://dx.doi.org/10.17159/2413-3051/2011/v22i1a3191

The impacts of biodiesel feedstock production systems in South Africa: An application of a Partial Equilibrium Model to the Eastern Cape Social Accounting Matrix

O Adeyemo
Sustainable Energy Futures, Natural Resources and the Environment, CSIR

Russell Wise
Environmental Resource Economics, Natural Resources and the Environment, CSIR

Alan Brent
Centre for Renewable and Sustainable Energy Studies, School of Public Leadership, University of Stellenbosch

Abstract
In this paper the impacts of biodiesel feedstock production in the Eastern Cape Province of South Africa is assessed through the application of a Partial Equilibrium Model to the Eastern Cape Social Accounting Matrix, using canola production in the Province as an 'external shock'. Six economic indicators were estimated. The results show that investment in biodiesel production in the Eastern Cape will generate, in 2007 terms, an additional GDP of R18.1 million and 410 employment opportunities per annum, R24.3 million per annum over an assumed lifetime of 20 years in capital formation, R2.1 million additional income generated in low income households, increase in government revenue, and a positive balance of payment. These indicators imply that, given the parameters that are accounted for in a Partial Equilibrium Model, every Rand invested in canola projects in the Eastern Cape will, overall, be of socio-economic advantage to the Province. It is envisaged that further applications of such models may lead to a better understanding of the implications of biofuels in the South African economy, and thereby inform decision- and policy-making in terms of the sustainability of biofuels production systems in general.

Keywords: Social Accounting Matrix, partial equilibrium, external shock, economic modelling, indicators, biofuels, biodiesel

1. Introduction

Energy intensity is a measure of the energy efficiency of a nation's economy. One measure of this intensity is the unit of energy per unit of GDP; a high energy intensity indicates that large amounts of energy are needed to generate GDP (Birol, 2006). South Africa's economy is particularly energy-intensive and since nearly all of its energy is from fossil-fuel sources, it is a substantial contributor to greenhouse-gas emissions per capita (Mwakasonda, 2007). These characteristics of the country, with the fact that South Africa is a signatory to the Kyoto Protocol and is particularly vulnerable to the impacts of climate change, mean that the country not only needs alternative sources of energy to diversify its energy supply, but these sources need to be renewable and emit low quantities of greenhouse gases (Winkler and Marquard, 2007).

Bio-energy is generally viewed as one of the promising alternative energy sources to address the risks and uncertainties associated with using fossil fuels, because it is renewable, the (first generation) technologies are available, and they can contribute to climate-change mitigation through the sequestration of atmospheric CO_2 and reduction of emissions (Calvert, 2003). The development of biofuel industries in countries such as the United States of America and Brazil has held both promises and challenges for South Africa and the region (von Maltitz *et al*., 2009).

The recently approved Biofuels Industrial Strategy of South Africa (DME, 2007), and the experienced volatility in the prices of petroleumbased transportation fuels, are likely to facilitate a rapid expansion of the biofuels industry in the country. However, as yet, no single, robust (econometric) method exists that is able to comprehensively assess the implications of biofuel systems in terms of technical, financial, socio-economic and environmental considerations so that users of such a method can take informed decisions, in terms of future projections and planning that lead to sustainable biofuel interventions. Nevertheless, there are several methods that can answer particular questions relating to the different components of biofuel systems; 'partial equilibrium' and other economic models offer one approach (Boulangera and Bréchet, 2005). Such models are capable of simulating the impacts of an intervention, in economics termed a 'shock', on South Africa's social and economic systems.

The primary objective of this paper is to quantify the nature and magnitude of the economic and socio-economic impacts that would likely emanate from the large-scale introduction of biodiesel production and processing systems in the Eastern Cape Province of South Africa, by utilising an economic modelling approach.

2. Modelling approach description

Models are primarily used to interrogate the possible effects (intended and unintended) that a new policy, programme or project will have on a socio-ecological system prior to its introduction (Boulangera and Bréchet, 2005). The most appropriate model to use depends on the type of policy, programme or project, the temporal and spatial scales of the analysis, the nature of the system and issues being investigated, and the purpose of the analysis. To evaluate the implications of policies, programmes and projects, at a macro-economic level, partial and general equilibrium modelling approaches are often utilised (Boulangera and Bréchet, 2005).

2.1 Partial Equilibrium and General Equilibrium models

The Partial Equilibrium (PE) methodology concentrates on a particular subsection of the economy, with all other variables treated as exogenous to the model. Given its relatively narrow focus, it is usually possible to model the particular industry or commodity chosen in much greater detail than is the case with General Equilibrium (GE) models. On the other hand, GE models attempt to describe the entire economic system, capturing not only the direct impact of a policy, programme or project shock on the relevant market, but also the impact on other areas of the economy, as well as feedback effects from these areas on the analysed market (O'Toole and Matthews, 2002).

PE models can provide valuable and useful insights when it is possible to realistically isolate a system from its broader, global context; the analysis then focuses on a sub-economic system and ignores the larger economy-wide effects. It is therefore useful for contextual argumentation. GE models account for the inter-industry linkages in an economy. More factors are assumed to be held constant in a PE analysis than in a GE analysis; it is assumed that flow-on effects, external to the system of interest, are small or non-existent (Starr, 1997). GE models are subsequently more complicated in that it is recognised that the complex interdependences of industries can be understood and communicated mathematically (Starr, 1997).

The Conningarth Economist (2010) model that was used in this investigation includes some features of GE modelling, namely Leontief inverse and technical coefficient matrices (see discussion in section 3), but without measuring larger, national economy-wide impacts. Thus, it is categorised as a PE model. The model uses a Social Accounting Matrix as its source of data.

2.2 Social Accounting Matrix

A Social Accounting Matrix (SAM) is an extension of a conventional input-output statistical table; for example, the original input-output tables, or the System of National Accounts (SNA), which StatsSA (1993) established. It is a comprehensive, economy-wide database, in the form of a matrix, that contains information about the flows of resources that take place between the different economic agents that exist within an economy, namely business enterprises, households, government, and others, during a given period of time; usually one calendar year. In other words, a SAM is a presentation of the SNA in a matrix format that incorporates the interrelationships that exist between the various agents in the economy, including the distribution of income and expenditure amongst household groups; thereby providing the SNA with a social dimension.

The accurate and consistent development of the SAM is pivotal to any analysis based on PE models as the SAM provides a framework in which the activities of all economic agents are accentuated and properly identified. By combining these agents into meaningful groups, the SAM makes it possible to clearly distinguish between groups, to determine the effects of interactions between groups, and to measure the economic welfare of each group.

To date, builders of these matrices have exploited their flexibility to:

- Highlight special interests and concerns;
- Display the various interconnections that exist in the economy;
- Disaggregate the households sector; and
- Show the link between income generation and consumption (Conningarth Economists, 2010):

2.3 Theoretical principles underpinning the SAM

When agents in an economy are involved in transactions, financial resources change hands. The SAM provides a comprehensive database of all transactions that take place between these agents in a given period, thereby presenting a 'snapshot' of the structure of the economy for that time period. As a system for organising information, a SAM represents a powerful tool whereby the economy can be described in a complete and consistent way:

- Complete in the sense that it provides a comprehensive accounting of all economic transactions for the entity being represented, namely country, region/province, city, and others; and
- Consistent in that all incomes and expenditures are matched.

Consequently, a SAM can provide a unifying structure within which the statistical authorities can compile and present the national accounts.

The most basic principles underlying a SAM are the concepts of circular flows and double-entry bookkeeping. The concept of circular flows relates to a particular angle from which an economic system is viewed and traced. The various productive sectors, namely the 'activities', in the economy act as producers and sellers of goods and services, namely the 'commodities', to institutions such as households, business enterprises, and the government, namely the 'purchasers' of the commodities. For their part, households, enterprises and the government act as sellers of factor services to the various activities, who then become the purchasers of these factors, namely labour, capital, and others.

Figure 1 presents a schematic representation of these flows. Going one way around the circular flow involves tracing out the flows of goods and services, namely the commodity markets. Going the other way around, the circular flow traces out the flows of funds, namely the factor markets. Transactions with the rest of the world (RoW) can take place through both the commodity and factor markets.

As shown in Figure 1, a continuous flow of factor services exists from the factor markets to the activities in the economy, which in turn provides commodities, namely products/goods and services, to the commodity markets, from where these commodities reach all of the institutions in the economy, namely households, enterprises and government. For their part, institutions provide factor services in factor markets, where activities act as purchasers.

The commodity market provides goods and services to two types of users. The first type of user includes the institutions, such as households, that use goods and services for purposes of final consumption, namely final goods. The second type of user is other producers in the economy that use goods and services in their own production process, namely intermediate goods. In addition, both the factor and commodity markets can interface with the rest of the world.

The SAM captures the monetary value of economic transactions, and organises them into a series of 'accounts'. There are six major types of accounts that form the basis of a SAM:

- Activity Accounts that capture the value of products/goods and services produced in an economy;
- Commodity Accounts that capture the value of products/goods and services traded in an economy;
- Factor Accounts that capture the value of payments made to the essential factors of production, namely labour, capital, land, and others;
- Institutional Accounts that capture the value of transactions by business enterprises, households and government;
- Capital Accounts that reflect savings and investments; and
- The Rest of the World Accounts that capture the value of imports and exports.

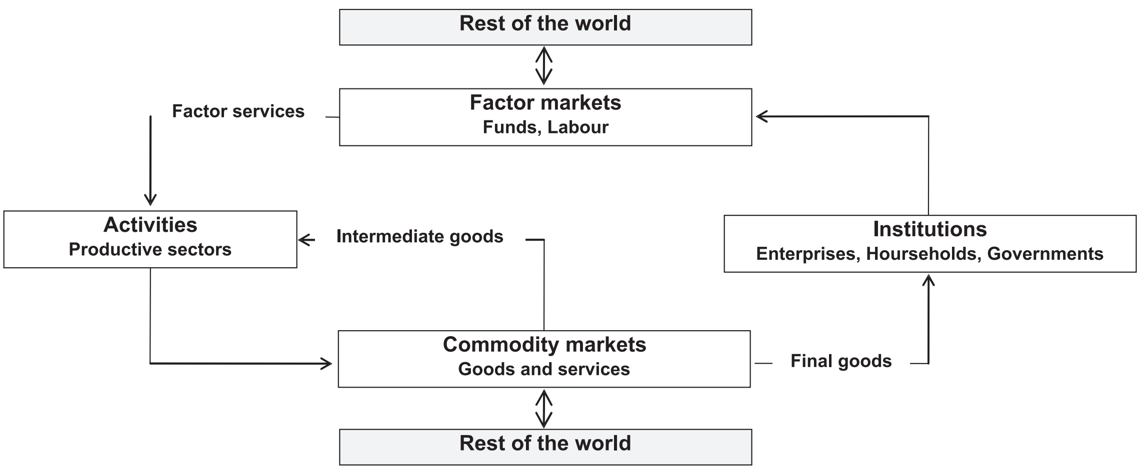

Figure 1: Circular flow of all transactions in an economy

Table 1: Description of the major SAM accounts

Activity Account Production activities use raw materials and intermediate goods and hire factor services to produce commodities. The expenditures of activities include the purchase of intermediate commodities with the remainder being value added, which is distributed to factors of production in the form of wage payments and of rent and in part payable to the government (e.g. a value added tax [VAT]). The receipts of the production activities derived from sales on the domestic market, exports and export subsidies received from the government (export taxes to the government are noted as negative export subsidies).
Commodity Accounts The commodity account represents a giant 'departmental store'. It buys goods, from domestic producers and foreigners (imports) and sells them to demanders including exports. The commodity account defines Gross National Product (GNP) from the expenditure side.
Factor Accounts Factors of production accounts typically include labour and capital sub-accounts. They receive income from the sale of their services to production activities in the form of wages, rent and net factor income received from abroad. In turn, these revenues are distributed to households as the labour income and distributed profits and to firms as non-distributed profits.
Institutional Accounts Institutions include households (typically further broken down by socio economic groups), firms and the government. Households receive factor income, as well as transfers from government and the rest of the world (RoW), e.g. remittances. Households' expenditures consist of consumption on goods, transfers, and direct taxes with residual savings transferred to the capital account. Firms receive profits and transfers, and spend on taxes and transfers with their residual savings channelled into the capital account.
Government Accounts The government account is distinct from administrative public activities included in the production activities' account. These public services (such as education) buy intermediate goods, pay wages and deliver public and administrative services. The government account per se allocates its current expenditures on buying the services provided by the commodities' account. Other government expenditures are transfers and subsidies to households and companies; the remaining savings are transferred to the capital account. On the income side, the government receives tax revenues from a variety of sources and current transfers from abroad.
Capital Accounts The sixth account is a combined capital account. On the income side, it collects savings from households, companies, the government as well as foreign savings, and in turn, channels these aggregate savings into investment.
Rest of the World Accounts Finally, transactions between domestic residents, and foreign residents, are recorded in the RoW account. These transactions include, on the receipt side, the commodities' account expenditures on imported final goods as well as intermediate goods and raw materials, factor payments and current transfers. The economy receives income from the RoW from export, factor and non-factor income earned. The difference between total foreign exchanged receipts and imports is by definition net capital received from abroad.

Table 1 provides a detailed description of these six accounts.

Because of the intrinsic characteristics of the SAM, once compiled, it renders itself as a useful tool for economic analytical purposes, because of the mathematical traits of the matrix notations that describe its structure. For example, the model can be used to quantify the probable impact on the economy of a new infrastructural project such as a new power station; both the construction phase and the operational part will be modelled.

3. The model applied in this investigation

Conningarth Economists (2010) have compiled a Social Accounting Matrix (SAM) for the Eastern Cape Province for 2007, which has been populated in the form of a database (BIOSSAM, 2010). The Partial Equilibrium (PE) model that utilises the database is suitable, given specific assumptions regarding the nature of the production function, to evaluate the effects of an autonomous disturbance in the Eastern Cape economy.[1]

The model derives matrices that are used as instruments for economic analysis. This is done by means of the so-called technical input coefficients' matrix and the Leontief inverse matrix. The technical input coefficient matrix forms the basis of the PE model and can only be calculated for sectors, and can be expressed in monetary or physical units. A technical coefficient (in monetary units) is defined as the quantity of intermediate inputs which a particular sector requires from another sector in order to supply a South African Rand unit of output. It is calculated by dividing all the elements in each column of the transaction matrix by the total of the gross inputs/outputs of the different sectors.

The transaction table of sectors may be written as a simultaneous set of equations as follows:

$$\begin{aligned} &x_{11} + x_{12} \ldots\ldots\ldots\ldots + x_{1n} + Y_1 = X_1 \\ &x_{21} + x_{22} \ldots\ldots\ldots\ldots + x_{2n} + Y_2 = X_2 \\ &x_{31} + x_{32} \ldots\ldots\ldots\ldots + x_{3n} + Y_3 = X_3 \\ &. \\ &. \\ &x_{n1} + x_{n2} \ldots\ldots\ldots\ldots + x_{nn} + Y_n = X_n \end{aligned} \quad (1)$$

Where x_{ij} = sales from sector i (rows) to sector j (columns), Y_i = sales from sector i to final demand, and X_i = total output of sector i; the specific elements in the transaction table are:

$$\frac{x_{ij}}{X_i} = a_{ij} \quad (i = 1 \ldots, n) \quad (j = 1 \ldots, n) \quad (2)$$

With the technical coefficients matrix then being an orderly collection of technical coefficients:

$$A_{ij} = \begin{bmatrix} a_{11} \ldots\ldots a_{12} \ldots\ldots\ldots a_{1n} \\ a_{21} \ldots\ldots a_{22} \ldots\ldots\ldots a_{2n.} \\ . \\ . \\ . \\ a_{n1} \ldots\ldots a_{n2} \ldots\ldots\ldots a_{nn} \end{bmatrix} \quad (i = 1 \ldots, n) \quad (j = 1 \ldots, n) \quad (3)$$

By substituting equation 2 into equation 1:

$$\begin{aligned} &a_{11}X_1 + a_{12}X_2 \ldots\ldots\ldots + a_{1n}X_n + Y_1 = X_1 \\ &a_{21}X_1 + a_{22}X_2 \ldots\ldots\ldots + a_{2n}X_n + Y_2 = X_2 \\ &a_{31}X_1 + a_{32}X_2 \ldots\ldots\ldots + a_{3n}X_n + Y_3 = X_3 \\ &. \\ &. \\ &a_{n1}X_1 + a_{n2}X_2 \ldots\ldots\ldots + a_{nn}X_n + Y_n = X_n \end{aligned} \quad (4)$$

By rearranging:

$$\begin{aligned} &Y_1 = (1-a_{11})X_1 - a_{12}X_2 - \ldots - a_{1n}X_n \\ &Y_2 = -a_{21}X_1 + (1 - a_{22})X_2 - \ldots - a_{2n}X_n \\ &Y_n = -a_{n1}X_1 - a_{n2}X_2 - \ldots + (1-a_{nn})\, X_n \\ &(j = 1 \ldots, n) \text{ and } (i = 1 \ldots, n) \end{aligned} \quad (5)$$

Which can be written in a matrix format as:

$$\begin{bmatrix} (1-a) - a_{12} \ldots\ldots - a_{1n} \\ - a_{21}(1 - a_{22}) \ldots\ldots - a_{2n} \\ . \\ . \\ - a_{n1} - a_{n2}) \ldots\ldots (1 - a_{nn}) \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ . \\ . \\ . \\ X_n \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \\ . \\ . \\ . \\ Y_n \end{bmatrix} \quad (6)$$

Which can also be written as:

$$Y = {}^*AX \quad (7)$$

Where X = output matrix, A = coefficient matrix, and Y = final demand matrix.

By multiplying equation 7 on both sides by $(I\text{-}A)^{-1}$:

$$(I\text{-}A)^{-1}Y = {}^*A\ (I\text{-}A)^{-1}X \quad (8)$$

Where (1-A) = *A:

$$X = (I\text{-}A)^{-1}Y \quad (9)$$

As is:

$$^*X = (I\text{-}A)^{-1}\Delta Y \quad (10)$$

where:
ΔY = change in final demand; and
ΔX = change in output/production

The inverse of (I-A) is known as the Leontief inverse.

3.1 Application of the model to biofuel value chains

The model may be used to measure the direct, indirect and induced impacts emanating from a biofuel value chain intervention on an economy, which consists of five major production stages:

- Agricultural production;
- Collection;
- First and second transformations;
- Demand for the main biofuel product; and
- Demand for by-products.

This specific model is limited to the first stage in the value chain, in terms of the following:

- The Direct Impacts; as far as the agricultural activity in the value chain is concerned, the direct impact refers to the effect of the activities that take place on the farm site, as well as activities related to land clearing, and installation of capital assets such as mechanical and electrical equipment, if any, that will form part of the investment project.
- The Indirect Impacts; which include all of the impacts that the farming production will have on all the other industries that supply inputs to the farming investment project, namely fertilizer, seeds, pesticides, electricity, water, and others, as well as the people who will be employed in producing the capital equipment items that will be installed.
- The Induced Impacts; which include all of the economic impacts that will result from the payment of salaries and wages to people who are employed in the agricultural farming component

of the value chain. This impact also takes into account the salaries and wages paid by businesses operating in the sectors indirectly linked to the project through the supply of inputs. These additional salaries and wages lead to an increased demand for various consumable goods that need to be supplied by other economic sectors of the economy.

The model was closed in the household sector. The consequence of closing the household sector is that it is assumed that, if households receive more income, they will automatically consume it and therefore stimulate the economy further. The same argument, to a lesser extent, holds also for additional government income and savings that will result through the activities at the farm. The more income government receives, the more it will consume, and the more savings will accrue in the economy and the higher investment will be. The relationship with government income and savings, in relation to the rest of the economy, is not as automatic as it is, for instance, with household income and spending, and therefore economists rather view this additional spending and investment resulting from additional government income as a conscious decision, and not an automatic event. The model is subsequently not closed with respect to government income and savings. The consequence is that the impact may be viewed as conservative.

The modelling focussed on the following well-known economic parameters:

- Gross Domestic Product (GDP);
- Employment opportunities;
- Capital utilisation (investment);
- Income Distribution – impact on low income groups;
- Government revenue; and
- Balance of Payments (BOP).

3.2 Eastern Cape SAM

The Eastern Cape SAM is a sub-set of the National SAM and, as such, captures impacts that are provincially based and of provincial interest. It captures the extent to which the benefits that accrue from a certain capital investment in the Province remains within the Province.

The Eastern Cape SAM, in econometric model form, can also be used to forecast the probable future growth of the provincial economy, showing, if necessary, from which sectors the growth impetus will come. Table 2 describes the Eastern Cape SAM, and Table 3 provides the details of the vectors in the matrix.

3.3. Data for a specific biofuels value chain in the Eastern Cape Province

A planned project in the Eastern Cape Province provided the data for biodiesel production with canola as feedstock (PhytoEnergy, 2008; 2010). Currently, plans are for a refinery to be producing in the order of 400kt/year from mid-2011, from canola feedstock proposed for 500 000 hectares of land (Figure 2).

Table 2: Eastern Cape SAM features

Expenditures		*Activities*	*Commodities*	*Factors payments*		*Enterprise*	*Households*	*Government*	*Capital account*	*Rest of the world*	
				Labour	*Capital*						
Receipts		1	2	3	4	5	6	7	8	9	
Activities	1	-	P	-	-	-	-	-	-	-	g
Commodities	2	X	Marg	-	-	-	C	G	I	E	q
Factor payments – Labour	3	Wa	-	-	-	-	-	-	-	We	e_L
Factor payments – Capital	4	Fa	-	-	-	-	-	-	-	Fe	e_c
Enterprises	5	-	-	-	Q_e	-	-	Trg_E	-	-	Z_u
Households	6	-	-	L	-	Qv	$Trh_H{}^1$	$Trg_H{}^1$	-	Trr_H	Z_H
Government	7	Ti	Ta	-	Tf	Tu	Td	Trg_G	-	Trr_G	Z_G
Capital account	8	-	-	-	-	Quv	Sh	Sg	-	-	ZC
Rest of the world	9	-	M	Wl	Qr	-	TrhH2	TrgH2	Sa	-	ZA
Total		g	q	e_L	e_c	Z_U	Z_H	Z_G	Z_C	Z_A	

Table 3: Description of the matrix vectors

Matrix columns/rows		*Vectors*
Activities	X:	Intermediate consumption; commodities required by activities as inputs (including the government)
	Wa:	Remuneration of labour (including the government)
	Fa:	Remuneration of capital.
	Ti:	Indirect taxes raised on activities
Commodities	P:	Production of commodities by each activity
	Marg:	Trade and transport margins
	Ta:	Indirect taxes on products (VAT).
	M:	Imports from the rest of the world
Factor payments – Labour and Capital	Q:	Dividends and interests to enterprises in the Province
	L:	Salaries and wages to households in the Province
	Tf :	Indirect taxes (tax on capital and labour) to government
	Wl:	Salaries and wages to households in rest of RSA and the rest of world
	Qr:	Dividends and interest to enterprises in rest of RSA and the rest of world
Enterprises	Qv:	Profits distributed to households
	Tu:	Enterprise taxes
	Quv:	Undistributed profits
Households	C:	Private consumption expenditure by households
	TrhH1:	Transfers between households
	Td:	Direct taxes and transfers paid to the government
	Sh:	Household savings
	TrhH2:	Transfers from households in the Province to households inrest of RSA and the rest of world
Government	G:	Government consumption expenditure
	TRgE:	Transfers to enterprises
	TRgH1:	Transfers to households in the Province
	TRgG:	Transfers to government
	Sg:	Government savings
	TRgH2:	Transfers to households in the rest of RSA and the rest of world
Capital account	I:	Gross investment
	Sa:	Capital flow from the Province to the rest of RSA and the rest of world
Rest of RSA and rest of the world	E:	Exports from the Province to the rest of RSA and the rest of the world
	We & Fe:	Factor payments from the rest of RSA and rest of world to the Province
	TrrH:	Transfers from households in the rest of RSA and the rest of the world to households in the Province
	TrrG:	Transfers from the rest of RSA and the rest of the world to the government in the Province

4. Results

4.1 Impact of canola production on Gross Domestic Product (GDP)

The GDP measures the value of all final goods and services (output) produced domestically over some given interval of time (Andolfatto, 2005). GDP is an indication of the contribution towards economic growth of the intervention. Value added consists of three elements, namely:

- Remuneration of employees;
- Gross operating surplus, which includes, amongst others, profits and depreciation; and
- Net indirect taxes.

The total impact on the GDP of the Eastern Cape Province from the introduction of a biodiesel industry is estimated to amount to approximately R18.1 million per annum (in constant 2007 prices) (Table 4).

Table 4: Macroeconomic impact of canola agricultural activities (R Millions, 2007 prices)

	Impact on macroeconomic indicators		
	Direct impact	*Indirect / induced impact*	*Total impact*
Impact on GDP	14.54	3.56	18.1
Impact on capital formation	18.45	5.88	24.3
Impact on low income households			2.41
Impact on total households			3.96
Fiscal impact			1.94
BOP impact			1.41
Impact on employment [numbers]	405	5	410

Figure 2: Areas suitable for cultivation of canola in the Eastern Cape Province of South Africa
Source: PhytoEnergy, 2008

4.2 Employment creation

Labour is a key element of the production process. It is also one of the main production factors in the economy and it also serves as an indicator as to what extent labour participates in economic processes. The model has determined the number of new employment opportunities that will be created and sustained by the agricultural activities of canola production. The impact on labour in the economy amounts to 410 in terms of the number of job opportunities that will be sustained per annum. Of this amount, 99% is estimated to be a direct result of activities at farming sites (see Table 4).

4.3 Capital utilization

For an economy to operate at a specific level, an amount of capital investment is needed to support the level of activity. Capital, together with labour and entrepreneurship, form the fundamentals needed for production in the economy. In a developing country, capital is a scarce resource and the availability thereof ultimately determines the long-term economic growth potential of an economy. The effectiveness and efficiency with which these factors are combined influences the overall level of productivity and profitability of the production process.

The model estimates that the total impact (direct, indirect and induced impacts) on capital formation in the Eastern Cape provincial economy, due to canola agricultural activities, amounts to R24.3 million per annum over an assumed lifetime of 20 years (see Table 4). This amount includes the investment of R18.45 million directly at farm sites. This implies that the average annual remainder of the capital will be required by other sectors across the entire economy to sustain the increased levels of economic activity associated with increased activity created by canola farming production.

4.4 Household income

One of the crucial elements of any macroeconomic assessment is poverty alleviation. The extent to which poverty alleviation is achieved is measured by the impact on household income, specifically to what extent low-income households will be affected by the introduction of canola agricultural production.

The model estimates that the total impact on low-income households will be R2.4 million per annum, which is about 61% of the total impact on households (see Table 4).

4.5 Fiscal impact

As shown in Table 4, the general government revenue will annually increase by approximately R1.94 million. Government taxes and other income are accrued on various tiers of government. The main taxes are direct tax and indirect tax, where direct tax consists mainly of personal tax and company tax. Examples of indirect taxes are value added tax (VAT) and customs and excise tax. VAT is a result of additional household spending and the resultant tax on that spending.

4.6 Impact on the balance of payments

In an economics term, Balance of Payments (BOP) is a record of the flows of goods, services and finance between an economy and the rest of the world for a specific period (usually a year or quarter). It covers:

- All the goods, services, factor income and current transfers an economy receives from or provides to the rest of the world; and
- Capital transfers and changes in an economy's external financial claims and liabilities.

It is estimated that the impact on the Balance of Payments will be a positive amount of approximately R1.41 million per annum.

4.7 Economic effectiveness criteria

The macroeconomic impacts discussed provide a sense of the contribution that canola production will make to economic and socio-economic performance indicators. However, it is also necessary to further interpret these impacts in order to determine whether or not such a project or programme represents a more effective use of scarce economic resources. Since capital is a scarce resource in South Africa, the effectiveness criteria used in this study measure the use of capital in terms of job and GDP creation, relative to averages for the total South African economy.

In order to make these comparisons, two key multipliers or ratios had been calculated, namely the GDP/Capital ratio, and the Labour/Capital ratio. Using these two ratios, it is possible to establish the contribution that the capital employed on a project will make towards economic growth and job creation. If continuous economic growth in the long-term is considered to be more important than job creation in the short-term, then the GDP/Capital ratio is the more important of the two. However, if job creation has priority, particularly in the short term, then the Labour/Capital ratio is the more important one to use in evaluating the project.

The effectiveness criteria measured for the canola agricultural activities are provided in Table 5. Table 5 also reflects the average criteria for the South African economy as a whole.

Table 5: Economic effectiveness criteria for the canola feedstock production

Effectiveness criteria	*Canola project*	*Total RSA Economy*
GDP/Capital Ratio (per R1 invested)	0.74	0.79
Labour/Capital Ratio (per R million invested)	16.85	1.07
Low Income/Total Income Ratio (%)	61	61

A comparison of the GDP/Capital ratio with the average for the total South African economy indicates that every Rand invested on the canola project produces slightly less overall GDP than the average Rand invested in the South African economy. This suggests that the project represents a non-optimal use of scarce capital and that the increased activity will contribute less to overall profitability in the South African economy. It should, however, be noted this investment is a major capital injection into the region and might not occur if this project does not take place.

When one makes a similar comparison of the Labour/Capital ratios, one finds that the proposed canola project will generate by far more jobs, 16.85 per million rand invested, as compared to the national average of 1.07.

The Low Income/Total Income Ratio indicates the proportion of total income that will accrue to low income households. The canola project generates about the same income ratio for low income households as compared to the national average.

5. Conclusion

This paper has presented estimations of six economic indicators using canola production (in 2007 terms) in the Eastern Cape Province as the external shock. The results show that the total impact of an anticipated canola project on the Province will generate an additional GDP of R18.1 million per annum (in constant 2007 prices), 410 jobs sustained per annum, R24.3 million per annum over an assumed lifetime of 20 years in capital formation; this amount includes the investment of R18.45 million directly on farm sites.

In terms of low income households, R2.1 million additional income will be generated per annum, which is about 61% of the total impact on households, while general government revenue will annually increase by approximately R1.94 million and a positive balance of payment. These indicators imply that for every Rand invested on such a canola project in the Eastern Cape Province will be of socio-economic advantage to the Province.

Acknowledgements

The authors express their gratitude to Dr Dave Mullins, Mr Albert Makochekanwa and Mr David Mosaka of Conningarth Economists for their assistance in completing this study.

Note

1. Details of the database and model can be downloaded from the BIOSSAM website in spreadsheet format: www.biossam.org/wp-content/uploads/2010/08/Canola_General_Econometric_ Model_Eastern_Cape.xls

References

Andolfatto, D., (2005). *Macroeconomic theory and policy*. Simon Fraser University, www.sfu.ca/~dandolfa/macro2005.pdf, accessed 13 February 2010.

BIOSSAM (Bioenergy Systems Sustainability Assessment and Management portal) (2010). *An econometric* *model for Canola in the Eastern Cape*. www.biossam.org/case-studies-and-pilot-programmes/biodiesel-from-canola-in-the-eastern-cape/, accessed 17 August 2010.

Birol, F., (2006). *World energy prospects and challenges*. International Energy Agency, www.iea. org/papers/ 2006/birol.pdf, accessed 13 February 2010.

Boulangera, P-M., and Bréchet, T., (2005). Models for policy-making in sustainable development: The state of the art and perspectives for research. *Ecological Economics*, 55 (3): 337-350.

Calvert, A., (2003). SRC for carbon sequestration. *Short Rotation Crops for Bio-energy: New Zealand*: 253-258, www.shortrotationcrops.org/ PDFs/2003Mtg/31-Calvert.pdf, accessed 13 February 2010.

Conningarth Economists, (2010). http://www.conningarth.co.za/, accessed 13 February 2010.

Department of Minerals and Energy (DME) (2007). *Biofuels industrial strategy of the Republic of South Africa*. Directorate of Clean Energy and Energy Planning, www.dme.gov.za/energy/documents.stm, accessed 13 February 2010.

Mwakasonda, S., (2007). *South Africa low carbon scenario report*. Energy Research Centre, University of Cape Town,

www.erc.uct.ac.za/Research/publications/07Mwakasonda_LowCarbonScenario.pdf, accessed 13 February 2010.

O'Toole, R., and Mathews, A., (2002). General Equilibrium, Partial Equilibrium and the Partial Derivative: Elasticities in a CGE model. *International Conference on Global Modelling, EcoMod*, Brussels,

www.ecomod.net/conferences/ecomod2002/papers/otoole.pdf, accessed 13 February 2010.

Phytoenergy (2008). Development of a biodiesel industry in South Africa. *3rd German African Energy Forum*, Hamburg/Hanover, www.energyafrica.de, accessed 13 February 2010.

PhytoEnergy (2010). *Biodiesel project South Africa*. www.phytoenergy.org/index.php?page= corebusiness, accessed 13 February 2010.

Starr, R., (1997). *General equilibrium theory: An introduction*. Cambridge University Press.

Statistics South Africa (StatsSA) (1993). *Final input-output tables*. Report-04-04-01, www.statssa. gov.za.

von Maltitz, G., Haywood, L., Mapako, and M., Brent, A.C., (2009). Analysis of opportunities for biofuel production in sub-Saharan Africa. *CIFOR Environment Brief*, June, www.cifor. cgiar.org/publications/briefs, accessed 13 Feb-ruary 2010.

Winkler, H., and Marquard, A., (2007). Energy development and climate change in South Africa: Decarbonising growth in South Africa. Occasional paper 2007/40, for UNDP's *Human Development Report 2007/8: Fighting climate change: Human solidarity in a divided world*. New York, Human Development Report Office. http://hdr.undp.org/en/reports/global/hdr2007-2008/papers/Winkler_Harald%20and%20Marquard_Andrew.pdf, accessed 13 February 2010.

Received 13 February 2010; revised 17 August 2010