The New Frontier: Welfare Effects of Foreign Bifuel Investments in Africa (Case Study: Sierra Leone)

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Invited paper presented at the 5th International Conference of the African Association of Agricultural Economists, September 23-26, 2016, Addis Ababa, Ethiopia

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Abstract

This research analyzes the market and welfare effects of foreign biofuel investments into Sierra Leone. A log-linear comparative static displacement model is used to carry out the analysis. A 30% demand shock was introduced into the equilibrium system to represent an increase in biofuel demand as a result of increased foreign biofuel investments. Results revealed large welfare enhancing gains for consumers of inedible biofuels but resulted in welfare losses in the staples and edible biofuel consumer markets. Producers (farmers) generally reported welfare gains by virtue of owning factor inputs (land and other). Equilibrium quantities of inedible biofuels, edible biofuels and food increased by about 8.8%, decreased by 0.22% and increased by 0.6% respectively. Prices for both inputs and outputs increased while quantities of inputs also increased.

Key Words: Biofuels, Comparative Static, General Equilibrium, Log-linear.

1.0 Introduction

Africa is the second largest continent by landmass and second most populous continent next to Asia. With an area of about 11.7 million sq. miles, it covers 6% of the earth's total surface area and 20.4% of the total land area (World Atlas, 2011). 30.3% of the continent's land mass, which represents 906 million hectares of land, is potentially suitable for rain-fed agriculture. Unfortunately, only 10% of this land is considered prime land for rain-fed agriculture (FAO, 2012), with the remaining 800 million hectares being non-prime land. On a global scale, the outlook on land availability is very promising for Africa. As reported in the Mckinsey 2010 report, "*Lions on the move"*, about 60% of the world's available landmass suitable for rain-fed agriculture is from Africa.

Such estimates like those listed in Mckensey-2010 may suggest that issues of land access for either agricultural purposes or otherwise would not be such a big problem in Africa. Paradoxically however, recent studies have shown that land access inequality happens to be a major bottleneck for economic development in some African countries (ECA, 2004)**.** This reality has been attributed to several factors. One most commonly referred is the legacy of Africa's colonial system of land tenure. While this communal land ownership system has the advantage of protecting communal social welfare for current and future generations, it has been shown to hinder private sector investment, particularly its potential to discourage foreign direct investment as a result of lacking clearly defined property rights (Pierpont B., 2007).

With the world tending towards cleaner energies and a growing demand for biofuel products, the resulting demand for land use change has created land access crunches for investors and government biofuel initiatives. With this, developed countries are left with two alternatives: substituting food crops in place of biofuel crops (a politically sensitive option) or seeking new land frontiers to grow more biofuel crops. Recent trends in Africa confirm that there is a growing shift towards the latter from both foreign investment companies and foreign government initiatives.

This interest in land investments in Africa has raised an even more sensitive question about the role western nations and stronger emerging economies are playing towards the development or demise of African nations in their search for these new frontiers. In all these countries, Switzerland in Sierra Leone, South Korea in Sudan, India and Saudi Arabia in Ethiopia, China in Zambia and Congo, to name few (Von Braun, 2012); land is being leased from the government or individuals to grow crops for biofuels like Sugarcane, Jatropha, Palm Oil and more, in place of previously grown food crops like rice, wheat, cassava etc. In return, these companies/governments promise to provide jobs to these displaced farmers, build local infrastructure in addition to the taxes they pay to the government and periodic rent on the land leases.

Some African leaders see these investments as sources of foreign capital which would help their local economies. An initial survey in Sierra Leone showed that farmers who lost their land to foreign investors but had rent acquisition rights see themselves better-off after giving up their land than when compared to their status when they themselves were farming on the land. By the same token however, farmers who had only farming rights (communal ownership or family ties) to the land but had no rights to claiming rents are furious because they have lost their entire livelihood in the process. This sends a signal that the prevailing land tenure system and property rights regimes have a significant role to play in determining the welfare impacts of these investments on the local land users/owners. These responses are based on their short term reactions. Given that these land acquisition leases are reported to be long-term (50 to 90 years), the long term economic and environmental effects are also crucial to understanding the true welfare effects of these investments. As a result of this, a follow-up survey one year later in the same Sierra Leonean communities revealed different results. The jobs that were created by these projects were very unskilled and were required only for the first six months of the projects. One year after the project’s inception, these farmers have been laid-off their jobs and are now left with no farms to return to.

1.1 Objectives:

For a better understanding of the implications of these investments and to adequately guide policy makers towards either encouraging more land investments or have them curtailed, it is but proper to carry out country specific empirical studies to capture the likely market and welfare effects of these investments both in the short term and in the long-term. For this research, we shall first focus on consistently analyzing the short-term effects in Sierra Leone. Two main objectives are investigated in this research. These are, to:

- Analyze the static (short-term) market effects of foreign biofuel investments in Sierra Leone

- Investigate the welfare implications of these investments.

In the next section, we showcase two of the largest biofuel companies in Sierra Leone that are in the center of the land-grab debate:

1.2: Biofuel Companies in Sierra Leone

1.2.1: ADDAX Bio-Energy

Addax Bioenergy Sierra Leone Limited is one of the leading bioenergy companies in Sierra Leone. Given its operational land requirements, the company happens to be in the heart of most of the controversies related to land acquisitions and farm displacements for poor farmers. The company is a subsidiary of Addax & Oryx Group, a Swiss-based energy corporation. To commence its biofuel operations in Sierra Leone, the company leased 20,000 hectares of land for 90 years in the northern part of the country. The main purpose of this acquisition is to grow sugarcane to produce ethanol for export. The project area is located approximately 15km west of the town of Makeni in the chiefdoms of Makari Gbanti and Bombali Shebora in the Bombali district and in the chiefdom Malal Mara in the Tonkolili district. This piece of land is the largest piece of boli-land (most ideal land for rice production) in the country and once the largest rice producing area in the country.

1.2.2: SOCFIN

Socfin SL is a subsidiary of the Belgian corporation, Socfin, (Société Financière des Caoutchoucs), an investment holding company, which operates in diverse sectors, including plantations, agro-engineering, banking, finance, and real estate, among others. The main shareholder of the company is Bolloré Investissement SA (Bolloré Group), owned by a prominent French businessman, Vincent Bolloré.

In 2011, Socfin Agricultural Company Sierra Leone Ltd. (Socfin SL) secured a 50 years lease of 6,500 hectares (ha) of prime farmland for rubber and oil palm plantations in Malen chiefdom in Pujehun district in the south part of Sierra Leone. The company is currently seeking an additional 5,000 ha in expansion plans in the Malen region or neighboring chiefdoms. The initial investment, estimated at $100 million, with promises of job creation, compensation for lost farms, and construction of infrastructure, has enjoyed high-level government support. Despite its political support, the company has had its fear share of resistance from the local population.

2.1: Equilibrium Displacement Model (EDM)

There has been a long list of contributions made towards the general equilibrium displacement model literature. Throughout the literature's evolution, the name has kept changing and the current nomenclature has held on for the last two decades. The literature can be traced far back as Buse's work on EDMs in 1957 (Buse, 1958) who developed a system of reduced form elasticities from supply and demand equations for two commodities. He then contrasted his "total elasticities" with Marshallian ceteris paribus elasticities. Some reviews however pay more homage to Muth (Muth, 1964) who developed the reduced forms for proportional displacements from equilibrium for a system of equations of supply and demand for a product dependent on two factors of production and exogenous shifters for each of the functions. Both of these contributions we think were very significant and paved the way for several other contributions to their methods.

Several developments have followed these pioneering contributions by Muth and Buse. Some notable ones are those that have applied these techniques to model issues in other specializations. Some of these include Perrin 1997's application of EDM techniques to develop a framework that can be used to obtain impacts of technological change, either ex ante or ex post.
This research contributes very little in terms of methods and follows closely the model developed in Perrin (1997) (Perrin R.K, 1997) and in Perrin's updated class notes for the graduate course AECN 840 "Applied Welfare and Policy Analysis", University of Nebraska, Lincoln (Perrin R.K, 2007). The latter have been a widely used tool box for practitioners. In this research, we use a very simple multi-market model to develop a system of demand and supply equations. Using matrix algebraic methods and sensitivity analysis, we test the market and welfare effects of increased demand and supply of the biofuel crop.

3.0. Methodology

3.1. The displacement model

In this paper, the whole agricultural sector in Sierra Leone is modeled as consisting of three output markets and two input markets. The agriculture industry produces energy crops, and staple crops while using land and other inputs. We specify three main output markets: one for non-edible energy crops, one for edible energy crops and one for staples. We also specify two input markets: market for land and market for other inputs.

Consider a biofuel influenced farming industry producing three outputs, Q_b, a product solely used as a biofuel input, Q_f, an edible oil product, and food staples, S, using two inputs, land L^Q and other O^Q. (Example of Q_b can be Jatropha while that for Q_f can be either sugar cane or palm oil). We model both industries to have one underlying technology that can be represented by the cost function $C(S,Q_b,Q_f,w^L,w^O)$, where the w's are prices of land and other inputs.

The equilibrium equations consist of three demand equations:

$Q_b=f(p^{Qb},p^{Qf})$ + shock due to biofuel (β)
$Q_f=g(p^{Qf},p^S)$
$S= h(p^{Qf},p^S)$

Some "supply" equations, production chosen so as to set marginal cost equal to price:

$C_{Qb} = p^{Qb}$,
$C_{Qf} = p^{Qf}$
$C_S = p^S$

Some output-constant, derived demand equations, using Shephard's lemma:

$C_{wL} = L$,
$C_{wO} = O$,
And some input supply equations:

$L=g(w^L,)$,
$O=f(w^O,)$

This system of 10 equilibrium conditions provides solutions to 10 unknowns ($dlnQ^b$, $dlnQ^f$, $dlnS$, $dlnP^{Qb}$, $dlnP^{Qf}$, $dlnP^S$, $dlnW^L$, $dlnW^o$, $dlnL$, $dlnO$). To test the effects of foreign biofuel investments on our equilibrium system, we introduce an increase in demand of inedible biofuel as a shock to its demand equation. We then solve the system of equations to obtain the change in value of the unknowns after the demand shock.

3.1.1: Log-linear comparative static equations:

The following is a key describing the variables presented in the equations below:

Q^b = Equilibrium quantity of Inedible Biofuel
Q^f = Equilibrium quantity of edible biofuel
S = Equilibrium quantity of Staples
P^{Qb} = Equilibrium Price of inedible biofuel
P^f = Equilibrium Price of edible biofuel
P^S = Equilibrium Price for Staple
W^L = land prices
W^o = price of other inputs.
L = Total Land used by all three industries
O = other inputs used by all three industries

Demand Equations (H=Elasticity)

$$dlnQ^b = H_{Qb/p}^{Qb} dlnP^{Qb} + H_{Qb/P}^{Qf} dlnP^{Qf} + H_{Qb/P}^{S} dlnP^S + \beta \qquad \ldots 1$$

$$dlnQ^f = H_{Qf/P}^{Qf} dlnP^{Qf} + H_{Qf/P}^{Qb} dlnP^{Qb} + H_{Qf/P}^{S} dlnP^S \qquad \ldots 2$$

$$dlnS = H_{S/P}^{Qf} dlnP^{Qf} + H_{S/P}^{S} dlnP^S + H_{S/p}^{Qb} dlnP^{Qb} \qquad \ldots 3$$

Equations one to three represent demands for biofuels, edible biofuels and staple products respectively.

Supply equations (∑=Elasticity)

$$(\sum_{Qb}{}^{s}{}_{/P}{}^{Qb})^{-1} dlnQ^{bs} + (\sum_{Qf}{}^{s}{}_{/P}{}^{Qb})^{-1} dlnQ^{fs} + (\sum_{S}{}^{s}{}_{/P}{}^{Qb})^{-1} dlnS^s + (\sum_{W}{}^{L}{}_{/P}{}^{Qb})^{-1} dlnW^L + (\sum_{W}{}^{o}{}_{/P}{}^{Qb})^{-1} dlnW^o = dlnP^{Qb} \ldots 4$$

$$(\sum_{Qb}{}^{s}{}_{/P}{}^{Qf})^{-1} dlnQ^{bs} + (\sum_{Qf}{}^{s}{}_{/P}{}^{Qf})^{-1} dlnQ^{fs} + (\sum_{S}{}^{s}{}_{/P}{}^{Qf})^{-1} dlnS^s + (\sum_{W}{}^{L}{}_{/P}{}^{Qf})^{-1} dlnW^L + (\sum_{W}{}^{o}{}_{/P}{}^{Qf})^{-1} dlnW^o = dlnP^{Qf} \ldots 5$$

$$(\sum_{Qb}{}^{s}{}_{/P}{}^{S})^{-1} dlnQ^{bs} + (\sum_{Qf}{}^{s}{}_{/P}{}^{S})^{-1} dlnQ^{fs} + (\sum_{S}{}^{s}{}_{/P}{}^{S})^{-1} dlnS^s + (\sum_{W}{}^{L}{}_{/P}{}^{S})^{-1} dlnW^L + (\sum_{W}{}^{o}{}_{/P}{}^{S})^{-1} dlnW^o = dlnP^S \ldots 6$$

On the supply side, one cost function was used for all three crops and the first order conditions maintained (MC=P). The general forms for all three equations are: C_{Qb} (Q_b, Q_f, S,w^L, w^O) and. C_{Qf} (Q_b, Q_f, S, w^L, w^O), C_S (Q_b, Q_f, S, w^L, w^O).

Output Constant Derived Demand

$$Z_{L/Qb} dlnQ^{bs} + Z_{L/Qf} dlnQ^{fs} + Z_{L/S} dlnS^s + Z_{L/W}{}^{L} dlnW^L + Z_{L/W}{}^{o} dlnW^o = dlnL \qquad \ldots 7$$

$$Z_{O/Qb} dlnQ^{bs} + Z_{O/Qf} dlnQ^{fs} + Z_{O/S} dlnS^s + Z_{O/W}{}^{L} dlnW^L + Z_{O/W}{}^{o} dlnW^o = dlnO \qquad \ldots 8$$

Using Shephard’s lemma, the above output constant equations were derived. The general forms are: C_{wL} = L; C_{wO} = O.

Supply and Market Clearing Conditions

$dlnL = \Omega_L{}^T{}_{/W}{}^L dlnW^L + \Omega_L{}^T{}_{/W}{}^o dlnW^o$ ..…………………………………………..9

$dlnO = \Omega_O{}^T{}_{/W}{}^o dlnW^o + \Omega_O{}^T{}_{/W}{}^L dlnW^L$ ……………………………….………..10

$dlnQ_b = dlnQ_b{}^s$ ……………………………………….……..11

$dlnQ_f = dlnQ_f{}^s$ ……………………………………….……..12

$dlnS = dlnS^s$ …………………………….……………13

These market clearing conditions were used to derive the input supply equations.

Based on the above log-linear relationships, the graphs below try to describe the relationships with the shock introduced.

The graphs show the three output markets (staples, edible biofuel and inedible biofuel markets) and two input markets (land and other). The bolded black plots represent demand and supply curves describing the benchmark (that is, without the shock) while the other lines (dashed) represent the resulting effects as a result of the shock (orange graph).

3.2: Market Effects

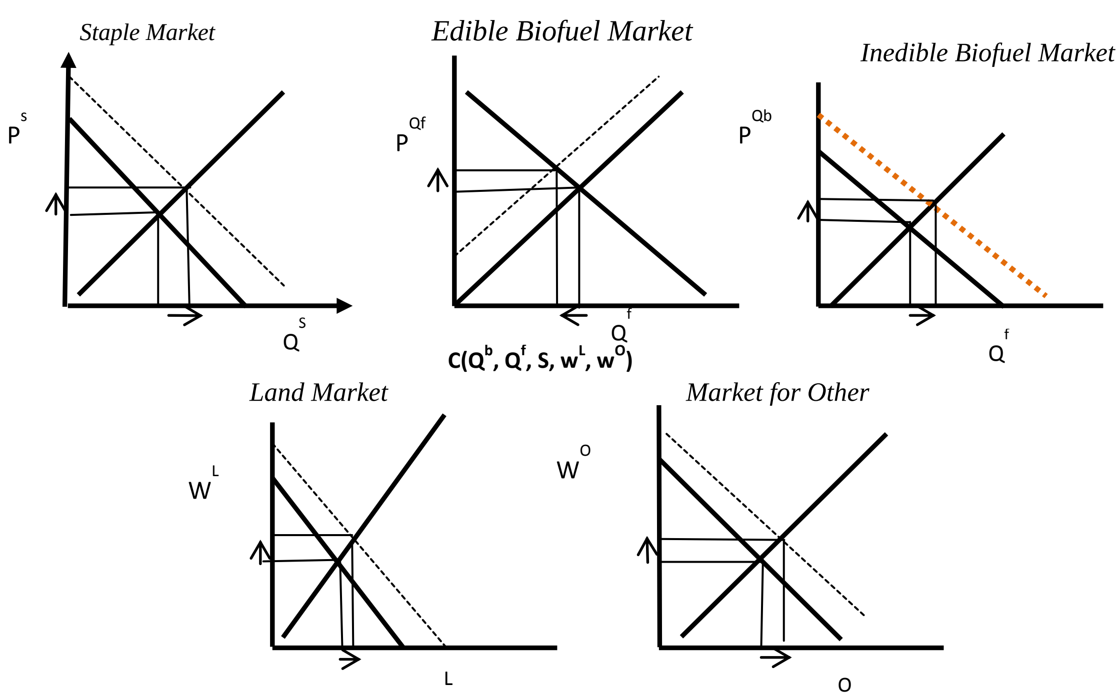

Figure 1.0: Resulting Market Effects

And the matrix of elasticities corresponding to a system representing two input markets and three output markets is as shown below:

Table1.0: Matrix Containing Elasticities and Shares for a System of Three Output and Two Input Markets.

$dlnQ^{b}$	$dlnQ^{f}$	$dlnS$	$dlnP^{Qb}$	$dlnP^{Qf}$	$dlnP^{S}$	$dlnW^{L}$	$dlnW^{o}$	$dlnL$	$dlnO$				
-1	0	0	$-H_{Qb/p}^{Qb}$	$-H_{Qb/P}^{Qf}$	$-H_{Qb/P}^{S}$	0	0	0	0		$dlnQ^{b}$		**β**
0	-1	0	$-H_{Qf/P}^{Qb}$	$-H_{Qf/P}^{Qf}$	$-H_{Qf/P}^{S}$	0	0	0	0		$dlnQ^{f}$		0
0	0	-1	$-H_{S/P}^{Qb}$	$-H_{S/P}^{Qf}$	$-H_{S/P}^{S}$	0	0	0	0		$dlnS$		0
$(\Sigma_{Qb}{}^{s}/_{P}{}^{Qb})^{-1}$	$(\Sigma_{Qf}{}^{s}/_{P}{}^{Qb})^{-1}$	$(\Sigma_{S}{}^{s}/_{P}{}^{Qb})^{-1}$	-1	0	0	$(\Sigma_{W}{}^{L}/_{P}{}^{Qb})^{-1}$	$(\Sigma_{W}{}^{o}/_{P}{}^{Qb})^{-1}$	0	0		$dlnP^{Qb}$		0
$(\Sigma_{Qb}{}^{s}/_{P}{}^{Qf})^{-1}$	$(\Sigma_{Qf}{}^{s}/_{P}{}^{Qf})^{-1}$	$(\Sigma_{S}{}^{s}/_{P}{}^{Qs})^{-1}$	0	-1	0	$(\Sigma_{W}{}^{L}/_{P}{}^{Qf})^{-1}$	$(\Sigma_{W}{}^{o}/_{P}{}^{Qf})^{-1}$	0	0		$dlnP^{Qf}$	=	0
$(\Sigma_{Qb}{}^{s}/_{P}{}^{S})^{-1}$	$(\Sigma_{Qf}{}^{s}/_{P}{}^{S})^{-1}$	$(\Sigma_{S}{}^{s}/_{P}{}^{S})^{-1}$	0	0	-1	$(\Sigma_{W}{}^{L}/_{P}{}^{S})^{-1}$	$(\Sigma_{W}{}^{o}/_{P}{}^{S})^{-1}$	0	0		$dlnP^{S}$		0
$Z_{L/Qb}$	$Z_{L/Qf}$	$Z_{L/S}$	0	0	0	$Z_{L/W}{}^{L}$	$Z_{L/W}{}^{o}$	-1	0		$dlnW^{L}$		0
$Z_{O/Qb}$	$Z_{O/Qf}$	$Z_{O/S}$	0	0	0	$Z_{O/W}{}^{L}$	$Z_{O/W}{}^{o}$	0	-1		$dlnW^{o}$		0
0	0	0	0	0	0	$-\Omega_{L/W}{}^{L}$	$-\Omega_{L/W}{}^{o}$	1	0		$dlnL$		0
0	0	0	0	0	0	$-\Omega_{O/W}{}^{L}$	$-\Omega_{O/W}{}^{o}$	0	1		$dlnO$		0
				A							X		b

β represent the potential shock to the system, the increase in the demand of inedible biofuels. The inedible biofuel market is affected by an increase in foreign investments into Sierra Leone's biofuel industry and we represent this by an increase in demand (parallel outward shift of the demand curve).Solving the equation $A_{10x10}*X_{10x1}= b_{10X1}$ helps us characterize the market effects of the shocks introduced. The resulting estimates of X (market effects) represent the percentage by which the different market parameters change for the percentage increase in the shock**.** Furthermore, given the linear relationship between X and b, the magnitude of the shock has no effect on the direction of the market effects. That is, doubling b_{11} (the shock) would double X_{11}. We therefore only introduced one shock to the system (30%). As the size of the shock increases, however the accuracy of the linear approximation of the system deteriorates.

3.3: Welfare Analysis

The measurement of welfare has seen decades of evolution particularly as practitioners' attempt to narrow the gap between theory and application. These tools have been central to most public policy applications. Slesnick D.T (1998) argues that full consideration of policies like taxes, subsidies, transfer programs, health care form and more, must ultimately address the question of how these policies affect the well-being of individuals. These welfare tools become very handy in conducting these types of policy analysis. Due to data limitations, we suggest the use of classic welfare measurement techniques "change in Consumer and Produce Surplus".

Consumer Surplus and producer Surplus:

Consumer surplus is a measure of an individual consumer's willingness to pay for the consumption of a given good or service over what he/she actually pays to consume that good. This can be shown by the area with the darker and upper triangle in figure 1.1 below. Similarly, producer surplus is a measure of a producer's willingness to produce a commodity or provide a service at a cost less than what h/she actually spends in producing that good or service (Varian

(1992)). This can also be shown by the area with the lighter and lower triangle in figure 1.1 below.

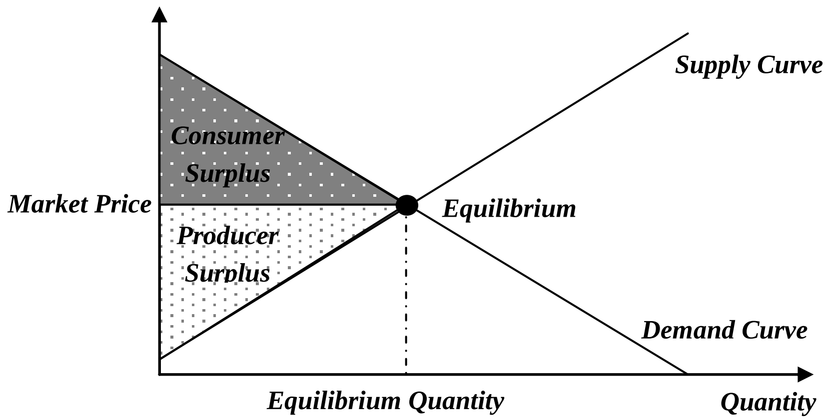

Figure 1.1: Graph Illustrating Consumer Surplus and Producer Surplus

The welfare effects of an equilibrium change are generally approximated as the changes in consumer and producer surplus. In a multimarket framework using log-linear comparative static techniques as discussed in Perrin (1997) and in Perrin's updated class notes, welfare changes as a result of exogenous shocks can be expressed as fractions of the initial value of the good. If demand and supply curves are stationary, the relationship used to compute these welfare measures are as shown below:

Δ Consumer Welfare/$P_i^0 Q_i^0$= (-dlnp_i^d(1+lnQ_i/2) ……………………… 14

Δ Producer Welfare/$P_i^0 Q_i^0$= (dlnp_i^s(1+lnQ_i/2) ……………………… 15

Where:

P_i^0=initial price before the shock was introduced for market i.

Q_i^0=initial quantity before the shock was introduced for market i.

This computation of change in consumer surplus is obtained by summing the rectangle measured by the change in equilibrium product price times initial quantity (area of rectangle) and the triangle measured by half of the change in price times the change in equilibrium quantity (area of triangle). Changes in producers' surplus in each of the input markets are measured by a comparable trapezoid under the new price for that input. To understand the computation of the welfare measures above, see figures 14a and 14b below. In 14a the change in producer surplus is represented by the area P_0P_1BA which is a trapezoid. In 14b the change in consumer surplus is represented by the trapezoid P_1EFB.The price change indicated by E - P_1 is calculated as dlnP=dlnQ/eta, where eta represents demand elasticities:

$eta = \frac{dQ}{dP} x \ \frac{P}{Q} = \frac{\frac{dQ}{Q}}{\frac{dP}{P}} = \frac{dlnQ}{dlnP}$ Hence $dlnP_i = dlnQ/eta$ 16

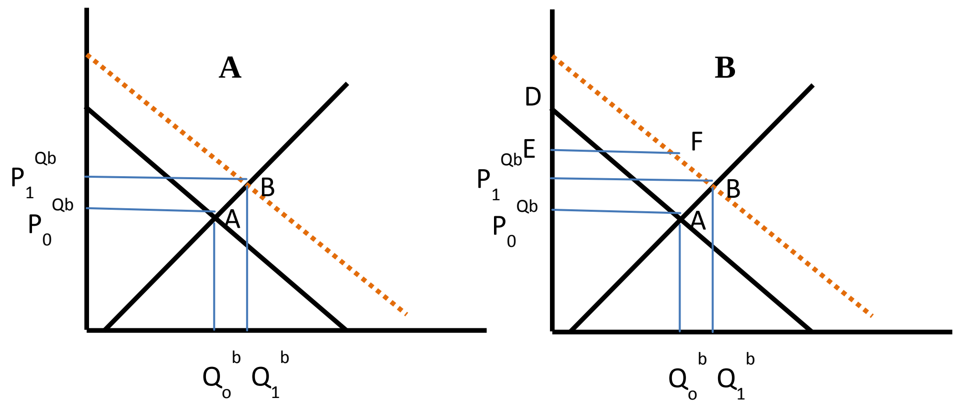

Figure 2.0: Illustrating Computation of Consumer Surplus and Producer Surplus.

Our welfare measures (changes in consumer surplus and producer surplus as percentages of the initial values of the respective products) are obtained considering the effects in the three output markets (for consumer surplus effects) and the effects in the two input markets (for producer surplus effects). That is, we obtain five welfare measures with three being percentage changes in consumer surplus from the three output markets while two being percentage changes in producer surplus from the two input markets.

3.4: Elasticities:

Three main methods have been employed in the literature when trying to obtain the elasticities and shares needed to populate the matrix of elasticities and shares above. These include an estimation of the elasticities through econometric methods, using secondary estimates from other studies in the literature or the use of micro economic theory and assumptions based on knowledge of the prevailing markets. Due to data limitations, we use a mixture of the last two methods to develop the elasticities and shares for the matrix. In the next section, we discuss all the considerations we took cognizant of to populate the different parts of this matrix.

Demand Elasticities

Demand is homogeneous of degree zero in prices: i.e.: horizontal sum of elasticities should equal to zero. Because of downward sloping demands the own price elasticity of demands should be negative. By symmetry (Young's theorem) the signs of $H_{Qb/P}^{Qf}$ and $H_{Qf/P}^{Qb}$, $H_{Qb/P}^{S}$ and $H_{S/P}^{Qb}$, $H_{Qf/P}^{S}$ and $H_{S/P}^{Qf}$ are the same but comprise different magnitudes.

Table 1.1: Matrix of Demand Elasticities

dlnP^Qb	dlnP^Qf	dlnP^S	
-1	0	0	**dlnQ^b**
0	-1.5	1.5	**dlnQ^f**
0	0.375	-0.375	**dlnS**

The above matrix was populated using mainly our knowledge of the Sierra Leone food industry and some references from the literature. Some relevant references used in this vein include: FAO 2011 outlook on Rice in developing countries, an article by Ambiyah Abdullah 2009 on demand and supply elasticities for Indonesia palm oil sector and World Bank (D.R Larson -1996).

Supply

By constant returns to scale (CRS), cost is linearly homogenous with respect to output and supply is homogenous of degree 0 with respect to prices. Therefore inverse supply elasticities horizontally sum to zero. Also by young's theorem, we assume reciprocity. By CRS the following input cost shares of land and other inputs are obtained:

$$\frac{W^o O}{W^o O + W^L L} + \frac{W^L L}{W^o O + W^L L} = 1$$

The share of producer costs that goes towards expenses on land and other inputs were obtained from apriori knowledge of the land prices and expected costs on labor, machinery and other inputs needed to produce all three crops.

Table 2.0: Matrix of Supply Elasticities and Cost Shares of Inputs

Supply Elasticities			
dlnQ^b	dlnQ^f	dlnS	
2.1	-0.5	-0.6	dlnP^Qb
-0.22	2.12	-0.9	dlnP^Qf
-0.34	-1.15	2.5	dlnP^S

Shares		
dlnW^L	dlnW^o	
0.4	0.6	dlnP^Qb
0.4	0.6	dlnP^Qf
0.4	0.6	dlnP^S

Input Demand Elasticities and Shares

By constant returns to scale, the first three elasticities in the input demand system represent output shares:

$$\frac{Q_b P_b}{Q_b P_b + Q_f P_f + SP_s} + \frac{Q_f P_f}{Q_b P_b + Q_f P_f + SP_s} + \frac{SP_s}{Q_b P_b + Q_f P_f + SP_s} = 1$$

The inputs derived demands are homogenous of degree zero in input prices. Therefore; the derived demand elasticities should sum to zero and reciprocity is imposed. The diagonal is negative because the cost function is assumed concave.

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Input Demand Elasticities **Shares**

dlnWL	dlnWo	
-0.3	0.3	dlnWL
0.2	-0.2	dlnWo

dlnQb	dlnQf	dlnS	
0.2	0.45	0.35	dlnWL
0.2	0.45	0.35	dlnWo

Table 2.1: Matrix of Input Demand Elasticities and Shares

Elasticities of Inputs Supply

For the same reasons discussed above under output own supply elasticities, Input own elasticities are assumed positive.

Table 3.0: Matrix of Input Supply Elasticities

dlnWL	dlnWo	
0.1	0	dlnL
0	2	dlnO

Table 3 below shows the complete table of elasticities and shares.

Table 3.0: Matrix of Elasticities and Shares

dlnQ^{b}	dlnQ^{f}	dlnS	dlnP^{Qb}	dlnP^{Qf}	dlnP^{S}	dlnW^{L}	dlnW^{o}	dlnL	dlnO			
-1	0	0	-1	0	0	0	0	0	0	dlnQ^{b}		**-0.3**
0	-1	0	0	-1.5	1.5	0	0	0	0	dlnQ^{f}		0
0	0	-1	0	0.375	-0.375	0	0	0	0	dlnS		0
2.10	-0.50	-0.60	-1	0	0	0.4	0.6	0	0	dlnP^{Qb}		0
-0.22	2.12	-0.90	0	-1	0	0.4	0.6	0	0	dlnP^{Qf}	=	0
-0.34	-1.15	2.50	0	0	-1	0.4	0.6	0	0	dlnP^{S}		0
0.2	0.45	0.35	0	0	0	-0.3	0.3	-1	0	dlnW^{L}		0
0.2	0.45	0.35	0	0	0	0.20	-0.20	0	-1	dlnW^{o}		0
0	0	0	0	0	0	0.1	0	-1	0	dlnL		0
0	0	0	0	0	0	0	2	0	-1	dlnO		0

3.5: Description of Different Players

For a better understanding of the potential losers and winners when there is a 30% increase in demand of inedible biofuels, it is important to describe or identify the different players in both the input and output markets.

In the output market, the consumers of staples are mainly all Sierra Leoneans as these staples may include a crop, like rice, which happens to be the main staple food of the country. Consumers of edible biofuels are also all Sierra Leoneans. This is because palm oil is used to produce most dishes that are eaten with rice. That is, there are some complementarities in the consumption of rice and palm oil. Consumers of inedible biofuels are mainly owners of the biofuel industry. Given that the biofuel processing industry is not well developed in Sierra Leone, these biofuel products are exported, hence making the end consumers of inedible biofuels, foreigners. It is important to note that consumers of staples and palm oil are sometimes farmers or producers also.

From the production side, the producers of all three products are local Sierra Leonean farmers. These farmers are also the consumers of the inputs in the production of the three outputs. Different from the input consumers, identifying input suppliers may not be as clear-cut. This is because an input like land does not have well defined property right schemes in some regions of Sierra Leone and the traditional communal land ownership scheme makes it even complicated. On average, most farmers in Sierra Leone have user rights to the land but may not have ownership rights (cannot sell the land) as a result of the traditional ownership scheme. Labor is much simpler because we assume there are no forms of slavery hence owners of labor are the laborers themselves; basically the farmers themselves. The above should help us better understand potential winners and losers as discussed in the next section.

4.0: Key Results:

4.1: Market Effects

The primary focus of this analysis is to determine the directions and magnitudes of change in the prices and quantities in each market when the shock of interest is introduced into the system. As a result of a 30% increase in the demand of inedible biofuels, the ensuing market effects are shown in table 3.1 below:

Table3.1: Market Effects from a 30% Demand Increase in Inedible Biofuel

Effects	$dlnQ^{b}$	$dlnQ^{f}$	dlnS	$dlnP^{Qb}$	$dlnP^{Qf}$	$dlnP^{S}$	$dlnW^{L}$	$dlnW^{o}$	dlnL	dlnO
β = 30%	8.76%	-0.22%	0.06%	21.24%	0.31%	0.16%	5.10%	1.22%	0.51%	2.45%

The results indicate that with a 30% increase in demand of inedible biofuels, equilibrium quantities of inedible biofuels increase by about 8.8%, equilibrium quantities of edible biofuels decrease by about 0.22%, while equilibrium quantities of staples increase by 0.6%. Furthermore, as a result of this shock, equilibrium prices for both inputs and outputs increase with the largest effects being a 21% increase in inedible biofuel prices and a 5% increase in land prices. Equilibrium quantities of inputs also increased, with those of land increasing by 0.5% and those of other products by 2.45%. Figure 12 above presents these shifts.

4.2: Welfare Effects

Consumer Surplus

Results for changes in consumer surplus for the whole system, computed as shown in the methodology section above, are presented in this section. These are computed separately for every output market, expressed as a percentage of the initial market value of the commodity.

These represent the only consumer welfare effects for the whole system. The results obtained are as shown below:

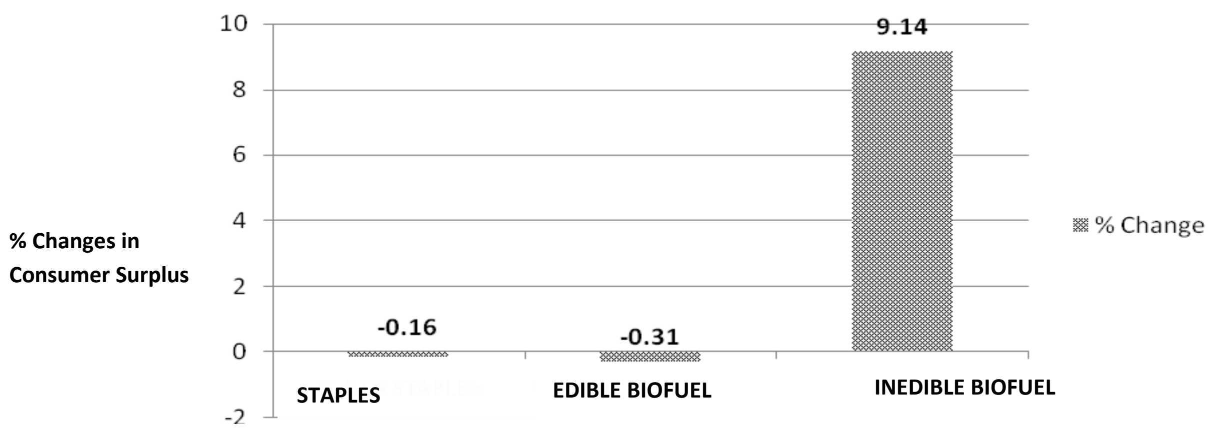
Table 4.0: Change in Consumer Surplus as a results of a 30% Increase in Demand for Inedible Biofuels, as a percent of the value of the commodity

	% Change
% Δ CS STAPLE >	-0.16
% Δ CS EDIBLE BIOFUEL >	-0.31
% Δ CS INEDIBLE BIOFUEL >	9.14

Note that these percentage changes are relative to the value of the commodity. The results show that consumers of staples loose by 0.16% while consumers of edible biofuels loose by 0.31%. This means that the 30% shock to the inedible biofuel market is welfare dis-enhancing to consumers of staples and edible biofuels by 0.16% and 0.31% respectively.

On the other hand, the consumers of inedible biofuels gained by 9.14% as a result of the shock. This means the shock to the inedible biofuel industry is welfare enhancing to consumers of inedible biofuels. We also graphically represent the results in figure 2.1 below:

Figure 2.1: Change in Consumer Surplus as a percentage of the value of commodity in Output Markets



Producer Surplus

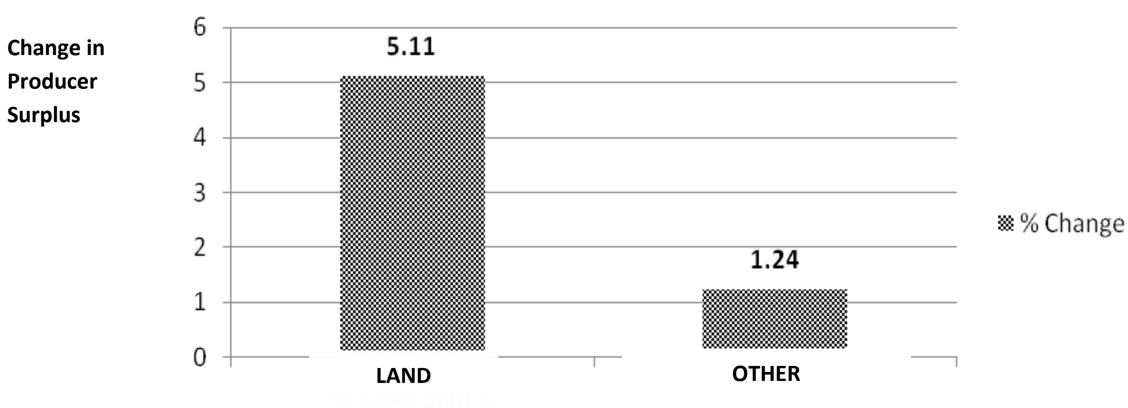
Here we present results from the estimation of the changes in producer surpluses expressed as a percentage of the original value for each input market as a result of the demand shock. These two measures represent the whole system's producer welfare effects because changes in producer surpluses from the output markets are only returns to the inputs.

Table4.1 : Changes in Producer Surplus as a percentage of the value of commodity due to a 30% increase in demand for Inedible Biofuels

	% Change
% Δ PS LAND>	5.11
%Δ PS OTHER >	1.24

The results from the above table reveal that all the welfare effects on all producers were positive. This means that the demand shock to the biofuel industry enhanced welfares of all land owners and owners of other inputs, which are primarily labor. The magnitudes of these effects were however very different. The effects associated with land were welfare enhancing by 5% while those associated with other inputs enhanced welfare by 1.24 %

Figure 3.0: Graphs Showing Change In Producer Surplus in Input Markets



5.0: Discussion of Results and Conclusion

Over the last two decades, there has been an influx of foreign investments into Africa by different natural resource seeking industries. The worldwide increase in demand for energy, in particular for biofuels, has resulted to increased demand for arable land. This trend continues to persist as western countries continue their investments on clean energy sources and as the rate of growth of developing countries like China continues strong. This induced increase in demand for land and other natural resources in the developing world in general, and in particular in Africa, has been a very contentions issue as the short and long term ramifications of these investments have not been thoroughly investigated.

This paper attempts to answer a very fundamental question: what are the short run market and welfare effects in the agricultural sector of a developing country like Sierra Leone in Africa as a result of these investments.

In achieving these objectives, a log-linear comparative static system is developed and used to measure market and welfare effects. One shock (an increase in demand of inedible biofuels) is applied to the system and the market and welfare effects measured. The magnitude of the shock tested is 30%. That is we investigate how prices and quantities in agricultural input and output markets would respond to a 30% increase in demand of inedible biofuels. We also trace out the effects of this increase on consumers and producers' welfare.

From the market effect estimates shown above and further discussed in table 18 below, an increase of 30% in the demand of inedible biofuel, given representative elasticities for these markets, resulted in increased quantity demanded of both inedible biofuels (8.7%) and staples and a small reduction in the quantity demanded of edible biofuels (0.22%). Prices in all three output markets increased; the highest being in the inedible biofuel market (21%). Quantity demanded of all inputs used in production of these three outputs increased as well as their prices. In particular, land prices increased by 5%.

From the welfare analysis carried out, percentage changes in consumer surplus were largely positive for the inedible biofuel industry (9%) but negative and very small for the consumers of edible oils and staples. This means that the shock to the inedible biofuel industry had large welfare enhancing effects on consumers of inedible biofuels but had small welfare dis-enhancing effects on the other two sets of consumers. From a food security stand point, the shock would have negative welfare effects on food consumers (every Sierra Leonean).

From the point of view of the owners of resources, both measures of change in producer surplus obtained were welfare enhancing. However, as a result of the increase in demand for inedible biofuels (like Jathropa), land owners benefited more (welfare of land owners enhanced by 5%) than owners of other resources, like labor (where welfare of laborers enhanced by 1%)

Table 5.0: Winners and Losers from Market Effects

Market Effects		Winners and Losers
$dlnQ^b$	8.76%	Consumers of inedible biofuels gain so does the farmers of inedible biofuels. The former are mainly non-Sierra Leoneans while the latter are Sierra Leonean farmers.
$dlnQ^f$	-0.22%	This negatively affects all Sierra Leonean consumers.
dlnS	0.06%	This marginally affects all Sierra Leonean consumers positively
$dlnP^{Qb}$	21.24%	This is very encouraging for small holder farmers that grow inedible biofuels. This serves as a further stimulant to encourage farmers to grow less of their staple products and more of the inedible biofuel product
$dlnP^{Qf}$	0.31%	Producers of edible biofuels and staples gain as a result of the 30% increased demand of inedible biofuel. However when compared to the increased prices of inedible biofuel products, the gains are very small.
$dlnP^S$	0.16%	
$dlnW^L$	5.10%	Farmers input costs increase. However, for farmers that own their own land, this increased land prices are reflected in their profits
$dlnW^o$	1.22%	Similarly, labor costs increase. However to laborers, this appears as increased profit.
dlnL	0.51%	As a result of the increased demand of inedible biofuels, more inputs are employed, hence creating more income to farmers that are input owners. For non-input owners, this signifies added costs.
dlnO	2.45%	

Table 5.1: Winners and Losers from a Welfare Perspective

Welfare Effects		Winners and Losers
% Δ CS Staples	-0.16	Welfare of consumers of staples is disenchanted. This includes all sierra Leoneans
% Δ CS Edible Biofuels	-0.31	Welfare of consumers of edible biofuels is dis-enhanced even higher than those of staples
% Δ CS Inedible Biofuels	9.14	Welfare of consumers of inedible biofuels is largely enhanced far more than consumers of other two products. These consumers are mainly from the export market at this time.
% Δ PS Land	5.11	Welfare of owners of land in significantly enhanced. These are mainly farmers who own land
%Δ PS Other	1.24	Welfare of owners of other inputs (like labor) is also enhanced but not as much as owners of land

Looking at the gains to consumers and producers (figures 2and 3), clearly there are winners and losers as a result of an increase in the demand for inedible biofuels. Welfare effects on farmers are dependent upon ownership of factor inputs. Land owners, in particular, gain the most while owners of other resources like labor gain but not as much as land owners. This means that farmers that own land that also work on their own farms and also produce inedible biofuels gain the most. The next tier down is those that own only land and produce inedible biofuels. The lowest category of winners that are farmers are those that, at least, works on these inedible biofuel farms.

For consumers, only those that demand inedible biofuels presumably for energy production can be considered winners. Consumers of staples and edible biofuels clearly have their welfare decreasing as a result of this increased demand in inedible biofuels. Given that majority of the inedible biofuel product is exported at this stage, majority of individuals that gain from consuming inedible biofuels are foreigners while all those consumers that have their welfare dis-enhanced are all Sierra Leoneans. Given that some consumers are also producers, the gains as a result of owning some factors of production, can off-set the losses from consumption. Consumers that are not involved in the production process and producers that do not have ownership rights to factor inputs (like land) stand to lose the most.

Therefore, for the average Sierra Leonean, this increase in demand for an energy crop results to higher prices of staples and edible oils, main ingredients of their diet, a loss in their welfare, even though labor income might increase slightly. These results, that only consider the short run effects of the worldwide increase in demand of biofuels, indicate potential severe implications for food security in the country. It would be important to follow with a study of the long run implications for the resident country of extractive foreign investments.

References

Brautigam D, 1992. Land Rights and Agricultural Development in West Africa: A Case Study of Two Chinese Projects. The Journal of Developing Areas, Vol. 27, No. 1 (Oct., 1992), pp. 21-32

Buse RC, 1958. 'Total elasticities - a predictive device', Journal of Farm Economics 40(4), 881-91.

Cotula, L., Toulmin, C., & J., Q. 2008 "*the Right to Food and Access to Natural Resources – Using Human Rights Arguments and Mechanisms to Improve Resource Access for the Rural Poor*, Rome: FAO(Right to Food Unit) and International Institute of Environment and development (IIED)

ECA (2004). Land Tenure Systems and the Imlacts on Food Security and Sustainable Development in Africa. Economic Commission for Africa Policy Research Report. Addis Ababa: ECA

FAO, 2012. Climate Change, Water and Food Security. Food and Agriculture Organization of the United Nations, Rome. http://www.fao.org/docrep/014/i2096e/i2096e.pdf

Lund C. 2001**.** Zeolite-Catalyzed Chlorination of Toluene by Sulfuryl Chloride:Rectivity, Selectivity and Deactivation of NaKL Zeolite," *Applied. Catalyst. A: General*, **219** (1-2), 1-12.

MGI, 2010. *Lions on the move: the progress and potential of African economies*, New York, McKinsey Global Institute

Obeng-Odoom, F., 2012. Land reforms in Africa: theory, practice and outcome. Habitat International 36, 161–170.

Muth R. F, 1964**.** "The Derived Demand Curve for a Productive Factor and the Industry Supply Curve." *Oxford Economic. Papers.* 16:685-99.

OECD/FAO, 2011. OECD-FAO Agricultural Outlook 2011-2020, OECD Publishing and FAO. http://dx.doi.org/10.1787/agr_outlook-2011-en

Onsrud, & Harlan J., 1992. In Support of Cost Recovery for Publicly Held Geographic Information. GIS Law, , 1(2): 1-7

Perrin R.K., 1997. The Impact of Technological Change on a Competitive Industry. *Journal of Agricultural and Resource Economics 22(2):345-355*

Perrin, Richard K., "Ethanol, Oil and Corn" (2007). *Cornhusker Economics.* Retrieved September 2011, Paper 304 http://digitalcommons.unl.edu/agecon_cornhusker/304

Pierpont, B. (2007), "Democracy, property rights and FDI in developing countries: a regional analysis", Macalester college economics department Paper 4. http://digitalcommons.macalester.edu/economics_honors_projects/4

Slesnick D.T (1998)" Empirical Approaches to the Measurement of Welfare" *Journal of Economic Literature*" 36(4) 2108-65

Von Braun, J. & Meinzen-Dick, R.S. 2009. "Land grabbing" by foreign investors in developing countries: risks and opportunities., Policy Brief 13. Retrieved June 2012, Washington, DC, IFPRI. http://www.ifpri.org/publication/land-grabbing-foreign-investors-developing-countries