The Expected Impacts of Jatropha Curcas Plantations Using Wastewater and Biodiesel Production on the Egyptian Economy: A CGE Modeling Approach

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Abstract:

Using a CGE model based on the ORANI-G model and introducing a new production nest that contains two new factors combined together through a Leontief Production function, this paper examines the expected impacts that expanding the Jatropha Curcas plantations will have on the Egyptian economy. We used an input-output table, derived from GTAP database version 8, for the Egyptian economy. Then, we introduced two new sectors into the existing economy with their data obtained mainly through a survey that was conducted at the plantation's location.

Results show a total increase in real GDP of about $206 million. Additionally, model shock caused Jatropha plantations to expand over approximately 111 thousand hectares. Furthermore, the sensitivity analysis of the CGE model shows that the primary factor sigma is the most likely to affect real GDP, rather than the other selected elasticities. Applying Chebyshev's inequality with 99% of confidence assures that whatever the distribution of real GDP, it will always lie between 0.14439% and 0.14461%.

One main policy implication recommended by the study is that any policy for expanding Jatropha plantations should coincide with another policy for promoting the biodiesel industry to take the full advantage of both sectors. Finally, the study recommends the expansion of Jatropha plantations, while at the same time asserting that the environmental impacts have to be evaluated.

Keywords: Gtap, CGE, Wastewater, Economic impacts, Egypt, Orani-G, Jatropha, Biodiesel

JEL Classification: Q00, Q01, Q16, Q18, Q23, Q24, Q25, Q43, Q53

Highlights:

- A new production nest of Wastewater-marginal land is introduced to the model.
- Two new sectors are introduced to the model database.
- Biodiesel and related byproducts are evaluated.

1. Introduction:

Given that all sustainable development programs should take into consideration the reuse of available resources, the Egyptian government started "*The National Program for Safe Use of Treated Sewage Water for Afforestation,*" which encompasses a wide range of new projects that aim to expand the green stretch in the desert by introducing forest plantations (manmade forests), making use of treated sewage water, and producing trees of high economic value (Ministery of State for Environmental Affairs, the Egyptian Environmental Affairs Agency (EEAA), 2012). The Jatropha experiment started on a small scale in Egypt in 1997, using Jatropha curcas seed imported from India. Promising results prompted the Egyptian Government to plant this species using seed from India on a wider scale, including the establishment of 42 hectares of Jatropha in 2001 that were irrigated by treated sewage water "drip irrigation". All desert areas of Upper Egypt governorates and in the New Valley are considered potentially suitable for Jatropha plantations. This marginal land, presently planted with Jatropha in Egypt, covers 844 hectares (Hayder & Rakotondramanga, 2011). Since then, just a few preliminary studies have discussed the economic value of these projects, but none of these studies—as we will see in the next section—measured the potential macroeconomic impacts.

Egypt is a lower- to middle-income country with a population of about 82 million and a GDP estimated to be $272 billion in 2013 (World Bank, 2013). Egyptian agriculture is almost entirely dependent on irrigation. More than 90 percent of Egypt is desert. The agricultural land base totals about 3.5 million ha, which represented about 3.5% of the total area in 2007. Of this agricultural land, about three million ha lie within the Nile Basin and Delta, and the remaining 210,000 ha are rain fed or in the oases. Of the total area of the Nile Basin and Delta, about two million ha are old land; the remaining one million ha are new, reclaimed land (El-Nahrawy, 2011). The River Nile is the main source of water for Egypt, with an annual allocated flow of 55.5 km3/yr., under the Nile Waters Agreement of 1959. Internal renewable surface water resources are estimated at 0.5 km3/yr. This brings the total actual renewable surface water resources to 56 km3/yr., with total water withdrawal in 2000 estimated at 68.3 km3. This included 59 km3 for agriculture (86%), 5.3 km3 for municipalities (8%), and 4.0 km3 for industry (6%) (AQUASTAT, 2009).

The current amount of collected Wastewater in Egypt is about 6.5 Billion m3/yr., of which about 56% (3.65 Billion m3/yr.) is treated, and the rest of the Wastewater, which is around 2.85 Billion m3/yr., is not treated. Only 0.7 Billion m3/yr. of treated Wastewater is being used in irrigation to cultivate forests and some crops. The rest of the treated Wastewater, which is about 2.95 Billion m3/yr., is pumped to drains and canals in Cairo and the Delta. The use of treated Wastewater has become increasingly important in water resource management for both environmental and economic reasons (Wahaab, 2012) and (Rifaat & Mohy El-Din, 2011). More than 67,200 ha are available for plantations that could make use of Wastewater (Ronald S. Zalesny & John A. Stanturf, 2011). Almost all of this area is marginal desert land, and for now, as a start, around 36,960 ha are allocated to the Holding Company for Water and Wastewater for reuse projects in different governorates, and around 4,620 ha of the total allocated area are already cultivated with various plantations (Wahaab, 2012). The crops currently growing using treated Wastewater are mainly Jatropha, Jojoba, Flowers, Flax, Mulberry, Sorghum, Olives and Wood Trees (Swanberg, 2009).

While there are a number of studies that have analyzed the economic value of Jatropha plantations in Egypt, only a few estimate the plantations' impacts on the wider economy. El-Gamassy (2008) performed a cost-benefit analysis study on Jatropha plantations in Luxor. He found that the plantation's payback period is approximately four years, with about 1.85 benefit/cost ratio at a

25% discount factor, and an internal rate of return of 47%. Consequently, he concluded that the results indicate a promising investment opportunity in these plantations and plans to promote Jatropha use should be taken seriously (Gamassy, 2008). A similar finding is also reported by Swanberg (2009), who carried out a financial feasibility study of alternative crops with potential for the use of treated Wastewater in Egypt. He found that new Jatropha plantings at Luxor and Abu Rawash look extremely promising, with earlier than expected yields. With the higher and earlier yields, Jatropha has become an economically viable crop. In-country processing of biodiesel is projected and highly recommended in order to capture the full value-added processing income of this crop (Swanberg, 2009).

In this paper, our focus is on measuring the expected wider economic impacts that would occur by implementing such expansion of Jatropha plantations. In addition, since Jatropha plantations' sole purpose is producing oil, which is used in the biodiesel industry, we added biodiesel production to our analysis. Hence, we pose the following question: What are the expected impacts on the Egyptian economy of expanding these plantations? For our empirical analysis, we used the applied general equilibrium model ORANI-G, which has been applied to many countries (CoPS, 2015). To better contextualize this question, the next section provides a brief overview on available resources and literature concerning Jatropha Plantations in Egypt. Then, the second section presents our model framework, in which we discuss the methods, assumptions, and model aspects. This is followed by a section detailing data sources used by the model, then the empirical analysis and results, and finally a section about the policy implications and conclusions.

2. Methods:

This study is a comparative-static analysis that uses a multi-sector, single country, static computable general model to measure the impacts of large-scale expansion of Jatropha plantations and biodiesel production. For this purpose, we used the generic version of ORANI, the applied general equilibrium (AGE) model of the Australian economy (Horridge, 2014). In order to represent the production flow of Jatropha in the model, it is first necessary to introduce both Wastewater and marginal land as production factors into the production structure of the model. The question, then, is into which nest of the production structure should they be incorporated and what functional form should be used? The approach adopted in this study is to interpret the existing primary factor of the model "Land" variable as "Old Land," which is assumed to be all of the land around or near the Nile River or in the desert area that is irrigated or planned to be irrigated with fresh water or occupied for any other purpose.

As it is assumed that Jatropha plantations will only take place on unused "empty" marginal desert land, the existing "land" variable of the model is not appropriate; instead, another production factor is introduced called "Marginal Land." Since this type of land cannot be used without water, specifically wastewater, the study chose to incorporate "Wastewater" into the production structure by adding a Wastewater-Land nest at the bottom of the production structure, which seems like the most appropriate solution for Egypt, as land in Egypt cannot be used for agricultural production without irrigation water. Wastewater land is assumed to be a function of Marginal land and Wastewater, which are used in fixed proportions to produce Wastewater land. Because both of them are required and needed for the production to take place and neither could substitute for the other, both of them are combined through the Leontief production function.

The new structure of the primary factor nest includes Wastewater land composite (Wastewater and Marginal Land), Labor composite (Skilled and Unskilled labor), Capital, and Land combined through a CES production function, as shown in Figure (1).

Now, let Wastewater be (WWR) and let Marginal Land be (MLD). Therefore, the resulting Wastewater land (WLD) Leontief composite will be:

$$WLD = \min\{\alpha WWR, (1-\alpha)MLD\} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (1)$$

As Horridge (2014) proved, to minimize the cost $\sum_{i=1}^{n} P_i X_i$ for inputs Xi (i = 1 to N), in producing given output Z, subject to the CES production function:

$$Z = \sum_i \left(\delta_i X_i^{\rho}\right)^{-1/\rho} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (2)$$

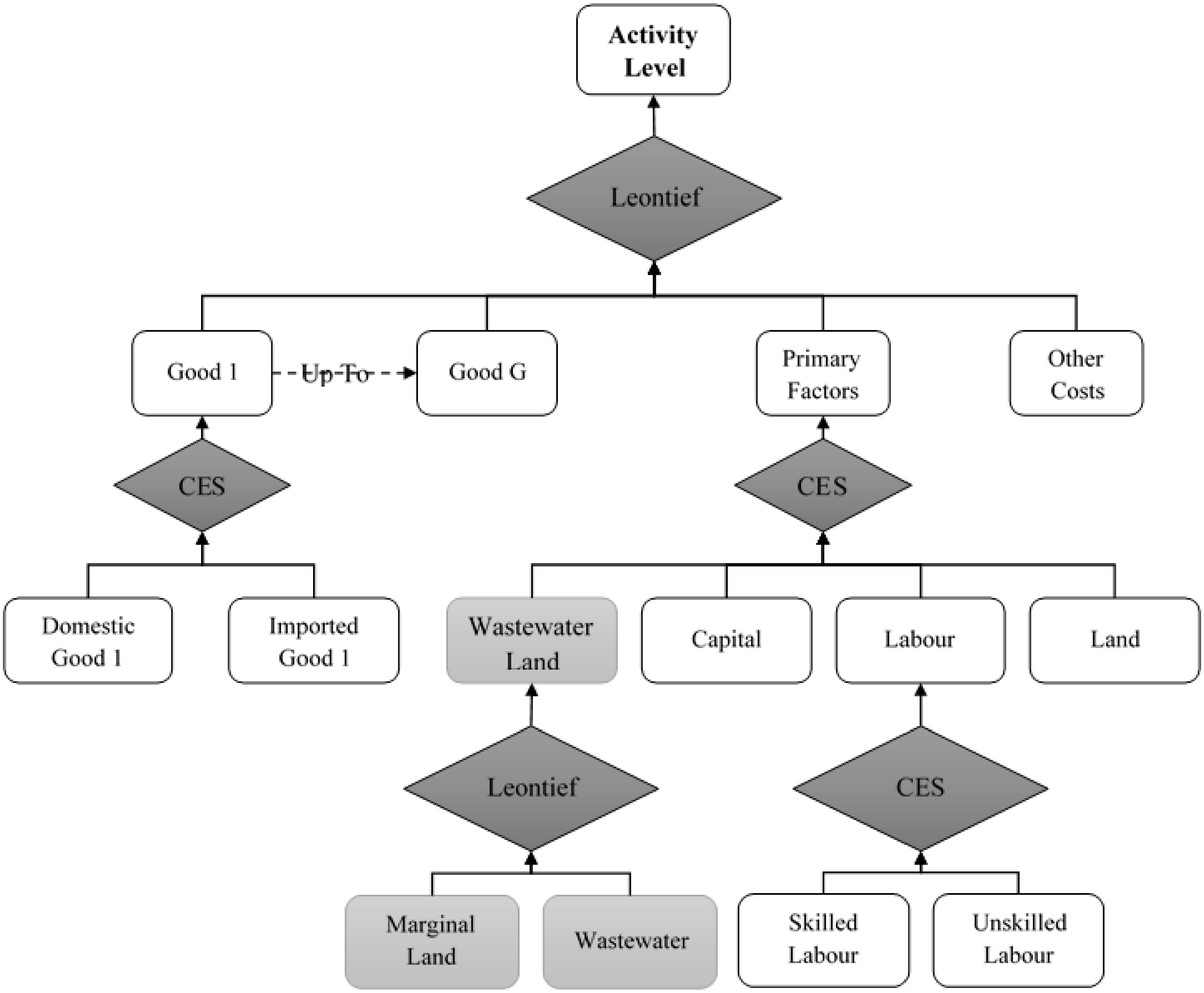
Transforming to percentage changes to get:

$$X_k = Z - \sigma(P_k - P_{ave}) \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots .. \dots (3)$$

Where X_k is the input and Z is the output, P_k is the input price and Pave is the average price. In addition, as the Leontief production function is a special case of the CES production function, where just the elasticity of substitution is ($\sigma = 0$), then the percentage change form will be as follows:

$$X_{WWR} = WLD \quad , \quad X_{MLD} = WLD \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (4)$$

Figure (1) Modified Production Nest of the Model



This means that the percentage change in both Wastewater and Marginal land will change with the same ratio as the percentage change of the composite (Wastewater Marginal land). Finally, the final primary factor aggregate will be:

$$X1PRIM\ (i) = CES\left[\frac{X1WLD(i)}{A1WLD(i)}, \frac{X1LAB\_O(i)}{A1LAB\_O(i)}, \frac{X1CAP(i)}{A1CAP(i)}, \frac{X1LND(i)}{A1LND(i)}\right] \ldots \ldots . . \ldots (5)$$

Additional modifications to the aggregates, such as GDP have been done. Also, a full block of pre/post simulation equations is added to the end of model to report the changes that occurred in the resulting solution file. An excerpt of the related equations in Tablo language can be found in Appendix (A).

In addition to the introduction of the new production nest, the model is limited to some assumptions, which make it more appropriate for implementation in Egypt. These assumptions are as follows:

- The entirety of the Jatropha plantations and their related biodiesel production will take place on the new marginal desert land. This means no use at all for the old land, which is already occupied by other plantations or production activities or even free land. Enacting this assumption will cause the minimum possible rental price impact on the current land price.
- The only source for irrigation of Jatropha plantations is treated sewage water. That is, the plantations will not use other water sources, such as underground water or the Nile River's water.
- The Government will provide the Wastewater treatment plants and pipes network. That is, the study treats Wastewater as an available resource ready to be used as a production factor, rather than as an intermediate commodity.
- Jatropha plantations are the only sector that will make use of Wastewater, at least for the current industries in the economy.
- The study assumes no taxes, subsidies, or any other margins costs.

The previous assumptions are likely to be implemented through enforcing government policies. Additionally, there are more assumptions related to the model database, which will be discussed in the next section.

2.1. Model Database:

The process of building the model database mainly involved fitting the data of the new sectors (Jatropha plantations and Biodiesel industry) and their related commodities into the ORANI-G database, which was extracted from the GTAP database version 8.0.

The resulting database contains 39 industry × 39 commodity, two types of labor (Skilled labor and Unskilled labor), and three primary factors (Land, Labor, and Capital), with no sub-regions or margins, and all the prices are measured in 2007 US dollars in millions. As this database does not have the suitable sectors to be updated with the new sectors data, a special program named "DAggHAR," which is a command line GEMPACK program that enables very rapid data splitting of sectors (or regions or households) into parts, is employed. It attempts to provide a successor to the venerable DAGG program, which is also mainly used for disaggregating HAR files (Horridge, 2012). Instead of constructing a new sector from scratch, the splitting practice itself is used to retain the base production technology and elasticities from the old sectors to be used in the new ones. The splitting existing sectors technique has been used before, for example, by Taheripour et al. (2008) to introduce liquid biofuels into the GTAP Data Base, and for the same purpose used by Tariq et al. (2012) to incorporate a biofuels sector of Pakistan into the GTAP database (Taheripour, et al., 2008) and (Tariq, et al., 2012).

The selected old sectors for the splitting process are (OilSeeds and VegOilFats), and the study chose them because they have similar production technology to the new sectors, Jatropha and

Biodiesel, respectively. The splitting is done in two steps. First, (OilSeeds) is split into (JatOilSeeds and OthOilSeeds), while at the same time (VegOilFats) is split into (Biodiese and OthOilFats). The sectors that start with "Oth" represent the same old sectors, and they weighted to 100, which means they will retain the whole flow value. In order to have the elasticities in both of the new sectors, the special character (|) is used to override the default action. The second step is to split the newly created (Biodiese) into (Biodiesel, Glycerol, and Seedcake), and this step is rather straightforward.

Now, the resulting database has 41 Industry × 43 Commodity. Because the biodiesel industry has 3 commodities, the next step is to add the new production factors (Wastewater and Marginal Land). To do this, a program called "ViewHar" is used to create new headers in the database file with the names (1WWR and 1MLD) for Wastewater and marginal land, respectively.

Now, the database file is ready for the new sectors data, which was collected from various sources. First, data related to the (Jatropha seeds) sector was collected from a data survey that the researcher conducted to gather needed costs and revenue data at the plantation location in Luxor city in Upper Egypt. Some other secondary data was collected from the Published Reports of the USAID program "Life - Integrated Water Resources Management Project" (The Ministry of Water Resources and Irrigation, 2015). As for the second sector, (Biodiesel), the data is based on Michael, et al. (2006) and Guzine, et al. (2012). However, the data itself needed some work, as it came from many sources. So first, the production data of Jatropha and Biodiesel is organized in two tables, and then the unit of measure is unified to be (USD per Hectare) for both of them. Finally, the values are adjusted for inflation to equal the 2007-dollar value.

The next step is mapping the production costs for both sectors to the appropriate existing input-output database related factor or intermediate commodity. Table (1) illustrates the production costs mapped to the appropriate sector or production factor. The final step is to update these sectors and production factors in the database prepared earlier with the values from the table above. The resulting sectors data in the database is illustrated in Table (2), and the data related to Biodiesel byproducts is illustrated in Table (3).

As the database is ready for the analysis, the last step is to include some assumptions, which could potentially be enforced through government policies, to ensure that the model database fully represents current consumption behavior within the Egyptian economy. As there is no local market for both Jatropha Seeds and Biodiesel, the study assumes the following:

- Almost all of Jatropha seeds production will be directed toward the biodiesel industry. Only a small proportion will be used in expanding the plantations, as a source of Jatropha seedlings.
- Any byproducts of Jatropha plantation are neglected.
- Apart from using a small amount of biodiesel and its byproducts, such as Glycerol in ElecGas and Chemicals, it is directed for export accounts.

Table (1) Mapping Production Costs to the Related Database Sectors - USD

Item	I / O Database Sector	Group Value	%
Mapping Jatropha Production Costs			
Land	Marginal Land	72.43	9.90
Wastewater for Irrigation (M3)	Wastewater	57.13	7.81
Land leveling	Construction	7.24	0.99
Irrigation system Irrigation pump Irrigation System Maintenance	OthEquip	222.15	30.37
Jatropha seedling (tree)	Jatropha Seeds	29.20	3.99
Planting (man) Irrigation Labor (man) Holes Improvement(man) Pruning(man) Collecting seeds (man)	Labor	229.09	31.32
Fertilization	Chemicals	63.88	8.73
Pumping power (hour)	ElecGas	50.43	6.89
Total		**731.54**	**100.00**
Mapping Biodiesel Production Costs			
Storage Facilities Process equipment Utility equipment	ElectronicEq	9.26	0.82
Loading/Unloading Stations	Construction	0.15	0.01
Jatropha seeds	Jatropha Seeds	979.27	86.62
Labor installation	Labor	45.37	4.01
Chemicals	Chemicals	80.90	7.16
Electricity	ElecGas	2.42	0.21
Water	Water	13.12	1.16
Total		**1130.49**	**100.00**

Source: own calculations.

Table (2) Final Input- Output Table for Jatropha & Biodiesel - Thousands USD

	JatOilSeeds	Biodiesel	ElecGas	Chemicals	Export	Total
JatOilSeeds	0.02920280	0.9792720				**1.0084748**
Biodiesel & Byproducts			0.0528402	0.1447786	1.7422772	**1.9398960**
Construction	0.00724276	0.0001491				
OthEquip	0.22214950					
ElectronicEq		0.0092616				
ElecGas	0.05042520	0.0024150				
Chemicals	0.06387975	0.0808989				
Water		0.0131186				
Taxes						
Labor	0.22908840	0.0453709				
Capital	0.27693114	0.8094099				
Marginal Land	0.07242757					
Wastewater	0.05712768					
Production Tax						
Other Costs						
Total	**1.0084748**	**1.9398960**				

Source: own calculations.

Table (3) Make Matrix of Biodiesel Byproducts

	ElecGas	Chemicals	Export	Total
Biodiesel			1.1926000	1.1926000
Seedcake	0.0528402	0.1047786	0.5064814	0.6641002
Glycerol		0.0400000	0.0431958	0.0831958
Total	**0.0528402**	**0.1447786**	**1.7422772**	

Source: own calculations.

2.2.Model Closure:

Once the CGE model is fully specified, it provides a mechanism for measuring the potential economy-wide effects of a hypothetical change in economic policy or other shocks to the economy. Simulating a policy change in a CGE model is a "what if" comparison of two equilibrium states of the economy (Kenneth, et al., 2002). Thus, to be able to conduct a proper analysis based on a CGE modeling approach, some major decisions about "Closure" and "Shock" are required. In the next subsections, these terms are discussed in more detail.

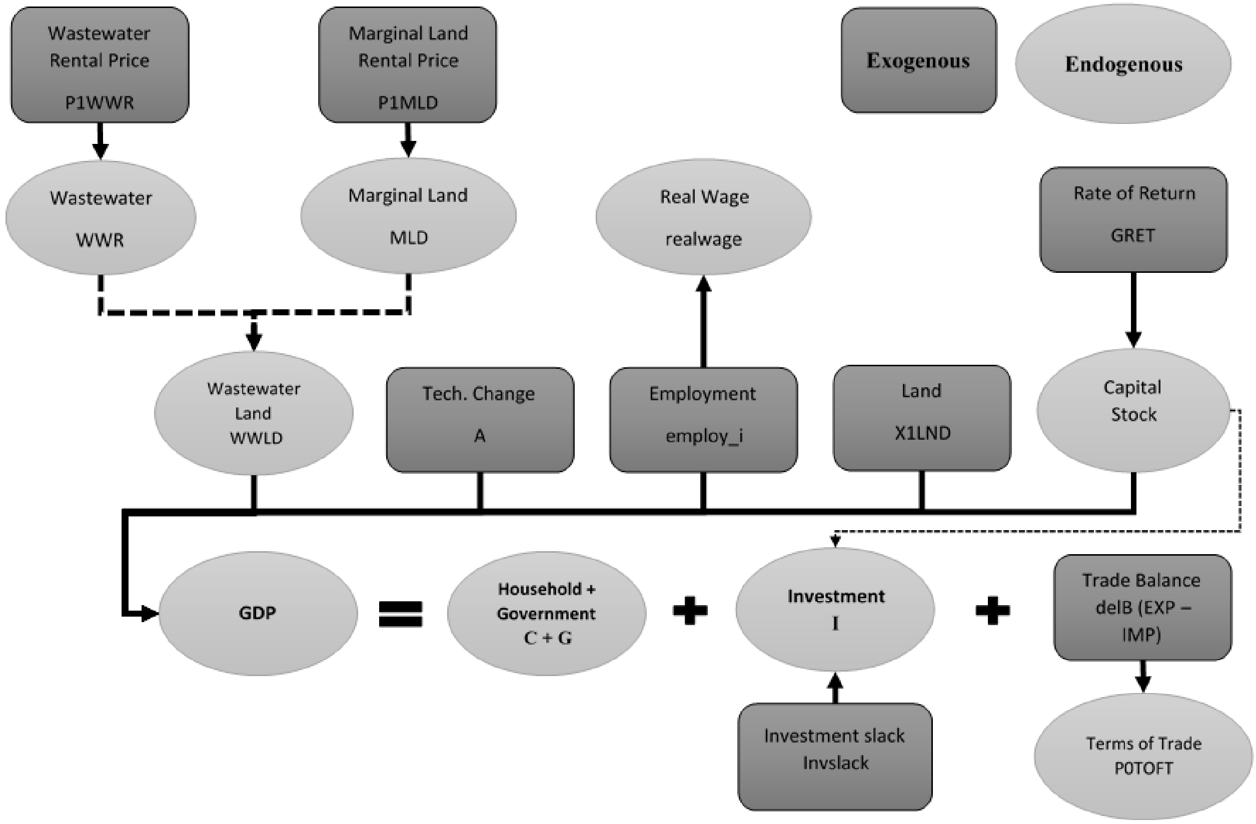
In a comparative static CGE model, the reaction of the economy to an exogenous shock occurs at only one point in time. Hence, the solution path over time is unknown; rather, time is represented in the terms of the short run and the long run. In this model, closure is distinguished between short-run and long-run closure, based on the exogenous variables in the factor market. The study starts from the ORANI-G default closure, in which the differences between short-run and long-run closure can be divided into three main areas concerning (Capital, Employment, and Expenditures) as follows:

- Capital Stocks (x1cap) are fixed in the short-run. Because there is not enough time for the capital stock to adjust, there is no new investment. Capital is sector-specific; that is, it is fixed for each industry and cannot move between sectors, while in the long-run, they are free to adjust in such a way that the sectoral gross rates of return (gret) are maintained as it is fixed. Therefore, aggregate investment follows the aggregate capital stock.
- Aggregate employment (employ_i) is free to move in the short-run, as the time frame is not long enough for contractual labor to adjust. Thus, the real wage shifter (f1lab_io) is fixed. On the other hand, in the long run, aggregate employment is fixed, and the real wage adjusts to

keep the economy in the full-employment condition. That is, both the labor force and the rate of unemployment are, in the long run, determined by mechanisms outside of the model. Moreover, Labor can move between sectors and different types of occupations.

- In the long run, the balance of trade (DelB) is fixed, because in the long run the rest of the world might be reluctant to fund an increased trade deficit. Thus, to accommodate a balance of trade constraint, household and government expenditure move together because (f5tot2), which links both of them, is kept fixed.
- Variables that are assigned as exogenous in the short-run and long-run simulations are tax rates, foreign prices of imports, transfers between institutions, and all technological changes. Finally, because the model shock that will be discussed later would likely have a massive impact on the new sectors, especially their production factors (Wastewater and Marginal Land), their prices (p1wwr, p1mld) are kept fixed (Horridge, 2014). As Figure (2) shows.

Figure (2) Long Run Closure of the Model



Source: *(Adams, 2014)***.**

2.3.Model Shock:

A typical CGE model to expand an industry first increases the demand on the products. To do that in our model there are two new industries. One is (Jatropha Seeds), which produces only "seeds." Its production is generally used by the second industry (Biodiesel), which in turn produces "biodiesel" and other byproducts "Glycerol & Seed Cake," and by our assumption is primarily exported.

Therefore, our shock was started by increasing the export basic demand (x4) on biodiesel commodities (Biodiesel, Glycerol, and Seedcake), but the export demand is by default an endogenous variable. In addition, exports of particular commodities may be fixed or shocked by exogenoising the corresponding elements of the vector (x4) while at the same time endogenising matching elements of the vector (f4q) (Horridge, 2014). Thus, we started our shock by doing a "Swap" between the export basic demand and the quantity (right) shift in export demands (f4q) for these three commodities.

The last step in determining the model shock is to determine the shock value. We were willing to significantly shock the final demand of biodiesel commodities because we know that industry is rapidly expanding. For example, the European Union—the world's largest biofuel market—has a target to reach 10% of renewable energy in road transport fuels by 2020 (GLOBE-Net, 2011). Another report claimed that the global second-generation biofuels (advanced biofuels) market would reach $23.9 billion by 2020, registering a compound annual growth rate (CAGR) of 49.4 percent from 2014-2020 (Allied Market Research, 2014). Finally, Egypt is one of the African countries with preferential access to EU markets, which have excellent potential to increase its biofuel exports (Johnson, et al., 2012).

Thus, we freely decided to do a huge shock to our variables by increasing the export demand by around one million times. In addition, in order to have relatively accurate results, we chose to do this shock on more than one step; every step shocks the demand by around 1000 times, and then we use the updated database to serve as the base for the next step.

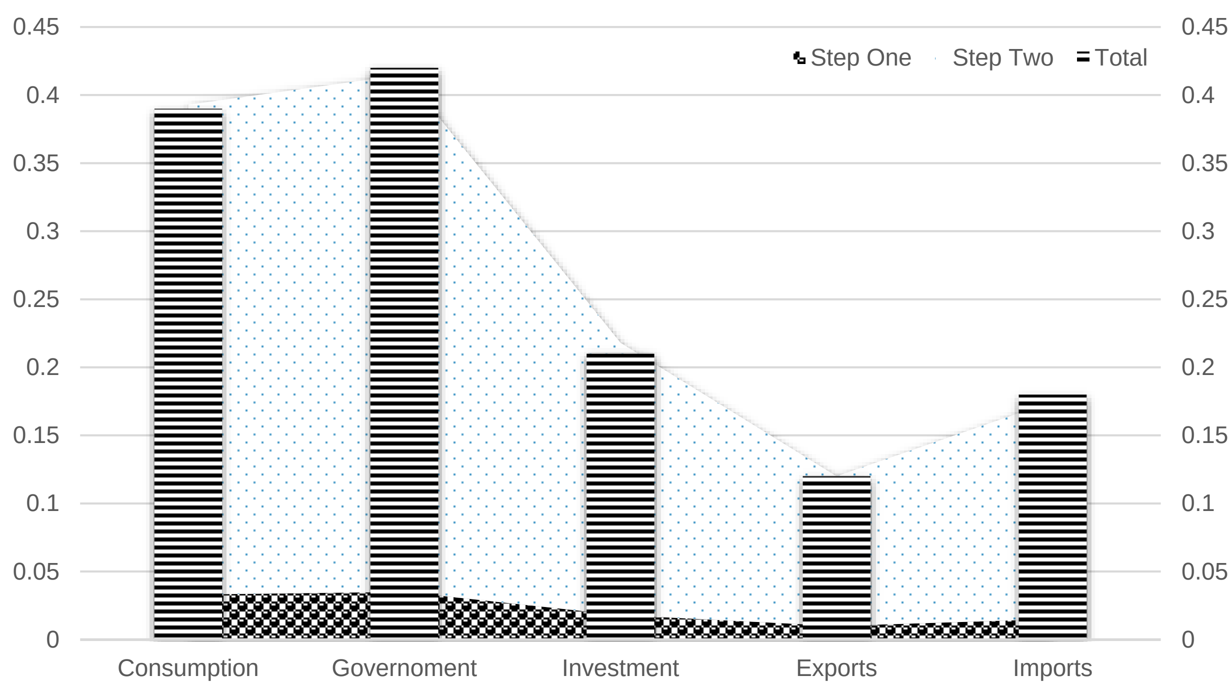
Lastly, we use the (Euler) method for the solution method, with (14, 16, 18) steps. Appendix (B) shows an excerpt of the command file used in this study.

3. Results:

3.1. Long-run Closure:

The explanation of macro effects begins with the impacts on the Nominal GDP. In general, nominal GDP—expenditure side—increased around $40 million after the first step and about $429 million after the second step, which totals around $468 million in increase after the two-step shock, representing approximately 0.36% of the base GDP. Furthermore, as Figure (3) shows, the increase in the GDP caused by the different changes occurred in GDP key components.

Figure (3) Percentage Changes in GDP Components in long run



As the closure is a typical long run closure, we have Household and Government expenditure move together to accommodate a balance of trade constraint. DelB (the balance of trade as a fraction of GDP) is fixed. The idea here is that, in the long run, the rest of the world might be reluctant to fund an increased trade deficit. Aggregate investment follows the aggregate capital stock (Horridge, 2014).

A major percentage change occurred in Government demand, which increased by about 0.42%, followed by about a 0.39% increase in Household consumption. As for Investment, the increase was about 0.21%, mostly induced by capital stock movement. Finally, unequal percentage changes occurred in exports and imports, where exports increased by about 0.12%, while imports increased by about 0.18%.

Moreover, the model distinguishes two different values of GDP—the one mentioned earlier, "Nominal GDP," and another GDP value, which is "Real GDP." As Table (4) shows, the total increase in real GDP was about $206 million, which represents about 44% of the total increase in Nominal GDP. Thus, the increase in Nominal GDP was about 56% due to the increase in the Price index, which was about $262 million.

Table (4) Real EXP. GDP & GDP Price Index Shares In Nominal GDP

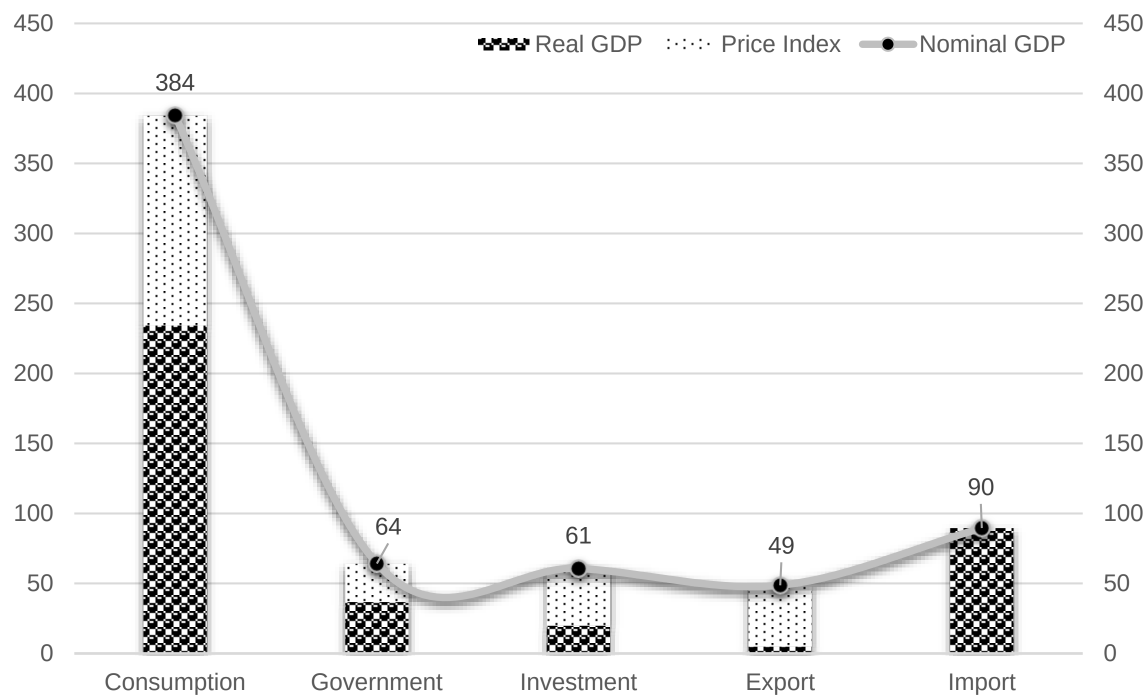
		Consumption C	Government G	Investment I	Inventories N	(Export X	Import) M	Total GDP
Real GDP	**Step One**	19.60	3.07	1.67	0.00	0.34	-7.47	17
	Step Two	214.60	33.59	18.08	0.00	4.45	-81.96	189
	Total	234.20	36.66	19.75	0.00	4.79	-89.44	206
	% GDP	**61**	**57**	**33**	**0.00**	**10**	**100**	**44**
GDP Price Index	**Step One**	12.47	2.28	3.41	0.00	3.71	0.00	22
	Step Two	137.35	25.03	37.50	0.00	39.99	0.00	240
	Total	149.83	27.31	40.91	0.00	43.70	0.00	262
	% GDP	**39**	**43**	**67**	**0.00**	**90**	**0**	**56**

As visualized in Table (4), 61% of the increase in Household consumption is due to the increase in quantities demanded; the other 39% is because of the increase in the prices. In general, price index causes changes in Government demand, Investment, and Export by 43%, 67%, and 90%

respectively. However, for imports, the price index has no effect because the imports price is a fixed variable in the closure as exogenous variable, as Figure (4) shows.

Terms of trade (TOT) here reflects changes in the exports price, which increased about 0.11% in the two-step shock, indicating that there is an improvement in the country's TOT. This means that the ability to purchase more imports will increase. Additionally, real devaluation is the ratio of imports price to the GDP price index. Again, the imports price fixed, so it is the inverse of the GDP price index, which totaled around 0.20%; therefore, real devaluation decreased by 0.20%, which generally means that imports become cheaper.

Figure (4) Changes in Real EXP. GDP & Price Index – Expenditure Side



The other side of GDP is factor cost. GDP from factor cost is a function of Wastewater land rent value (WWLD), land rent value (LND), capital usage (CAP), and labor wages (EMPLOY), with allowance for technical changes.

In our long-run closure, technical change and quantity of used land is kept fixed. Moreover, the aggregate employment is fixed as well, and the real wage adjusts. This would be consistent with the idea that both the labor force and the rate of unemployment (NAIRU) in the long run are determined by mechanisms outside of the model. In addition, the model solves the value of Wastewater land internally as an endogenous variable, so we have displayed the results in Table (5).

As seen in the table below, capital increased by about $280 million from $65266 million to reach about $65546 million in the two-step simulation, which means a percentage change estimated to be about 0.43% from the base value. As for labor, the wage bill increased by about $176 million to reach about $53249 million, with a percentage change from its base value estimated to be about 0.33%. As employment is fixed, all of this increase is likely due to an increase in real wages. Furthermore, value of land decreased by about $8 million from about $7709 million to reach about $7701 million, and, as mentioned before, quantity of land is kept fixed, so this decrease is likely due to a fall in land price.

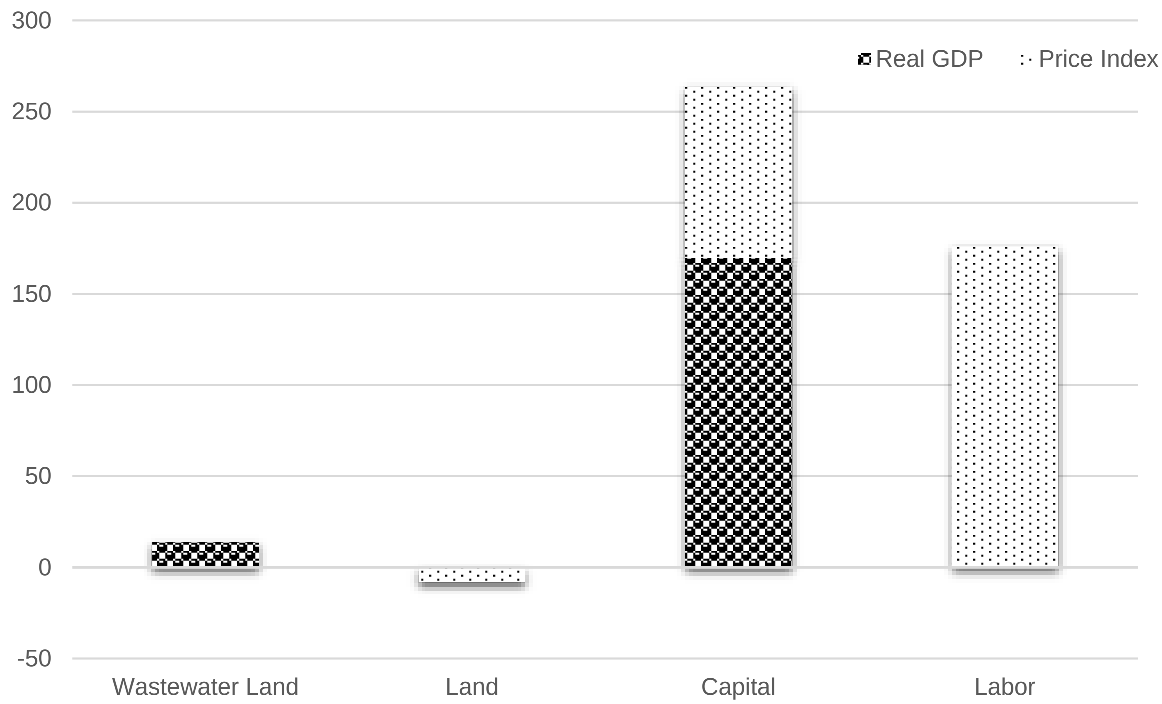
Table (5) Nominal GDP from Income Side

		WWLD	**LND**	**CAP**	**EMPLOY**	**TAX**	**Total**
		V1WWLD	**V1LND_I**	**V1CAP_I**	**V1LAB_IO**	**V0TAX_CSI**	**V0GDPINC**
	Pre	0.13	7709	65266	53073	4558	130606
Step One	**Post**	1	7708	65289	53087	4560	130646
	Change %	**920**	**-0.01**	**0.04**	**0.03**	**0.03**	**0.03**
	Pre	1	7708	65289	53087	4560	130646
Step Two	**Post**	14	7701	65546	53249	4566	131075
	Change %	**995**	**-0.10**	**0.39**	**0.30**	**0.13**	**0.33**
Total Change	**Quantity**	**14**	**-8**	**280**	**176**	**8**	**469**
	Change %	**1915**	**-0.11**	**0.43**	**0.33**	**0.17**	**0.36**

As for Wastewater land, which represents a composite of the marginal land and Wastewater and is an endogenous variable determined by the model, its value changed dramatically from $0.13 million to reach about $14 million, indicating an increase estimated at about $14 million. Lastly, an increase estimated at about $8 million occurred in tax value, as it is moved from about $4558 million to reach about $4566 million. Although the amount of changes occurring in capital and labor seems enormous, if these changes are compared relative to base values, it can be found that they only represent minor changes, except for Wastewater land, where the value relative to the base value increased by about 1915% in the two-step simulation.

In addition, approximately $199 million, which represents around 43% of the total increase in GDP, is due to an increase in Real GDP. Whereas the 57% that represents about $262 million occurred due to an increase in the GDP price index, as Figure (5) shows, almost 100% of the increase that occurred in Wastewater Land value is due to an increase in the quantity demanded, which is estimated to be $14 million. On the other hand, around 100% of the increase in Labor income is due to the increase in labor price, which is about $176 million. Moreover, 100% of the decrease in Land value is due to a decrease in its price, which is about $8 million. Lastly, around $185 million, which represents around 66% of the increase in Capital value, is due to an increase in Real GDP; the other 34%, which is about $94 million, is due to an increase in prices.

Figure (5) Changes in Real INC. GDP & Price Index – Factor Cost



There is no production factor named "Wastewater land" in the model database. Instead, it has two production factors: one is "Wastewater," and the other one is "Marginal Land." Wastewater income increased from $0.06 million to approximately $6.4 million in the two-step simulation. Because they are combined together through the Leontief function, the same goes for the Marginal land, which increased from $0.07 million to reach about $8.1 million. As Table (6) shows, this totals an approximately $14 million change in Wastewater land income composite.

Table (6) Wastewater & Marginal Land Changes - Millions $

	Step One			**Step Two**			**Total**
	Pre	**Post**	**Change**	**Pre**	**Post**	**Change**	
Wastewater	0.06	0.58	0.53	0.58	6.38	5.80	6.32
New Land	0.07	0.74	0.67	0.74	8.09	7.35	8.01
Total							**14.34**

Finally, it is worth pointing out that the increase that occurred in both Wastewater & Marginal land is due to the increase in quantities demanded, as the prices are kept fixed for both factors in the model closure.

3.2. Short-run Closure:

Results shows that in the short-run closure, aggregate employment increased by about 0.09% in total for the two-step shock, moving from $53.07 billion to reach $53.11 billion, with an estimated change of approximately $35 million.

As expected, results show that the most affected industries from the model shock are Jatropha seeds and Biodiesel. While Jatropha increased by 11060% from $0.23 million to around $26 million, Biodiesel increased by 11040% to reach around $5 million. This clearly shows that the Jatropha sector is much more labor intensive than biodiesel. In addition, as real wages are kept fixed as exogenous variables in the model closure, all of the labor changes were caused by real employment demand rather than wages prices.

In the short-run closure, exports in general increased by about 0.45%, which represents around $175 million. The major source for this increase is the shock of the model, which caused Biodiesel, Seedcake, and Glycerol to increase by about $175, $38, and $1.5 million, respectively. On the other hand, some sectors, such as TCF, Transport, Metals, CoalOilGas, Chemicals, and OthEquip, witnessed a decrease estimated at $1.71, $2.58, $2.59, $4.76, $5.42, and $18.63 million, respectively.

In contrast, imports increased by a tiny ratio, estimated at 0.02%, representing around $8 million. The major imports increases occurred in sectors that have close interaction with Biodiesel and

Jatropha, such as Chemicals, OthEquip, CoalOilGas, and ElectronicEq, with increases estimated at $2.13, $2.10, $1.10, and $0.73 million, respectively. Alternatively, import decreases occurred in some other sectors, such as OthOilFats, Transport, TranspEquip, and MVP, with values estimated at $0.04, $0.10, $0.21, and $0.24 million, respectively.

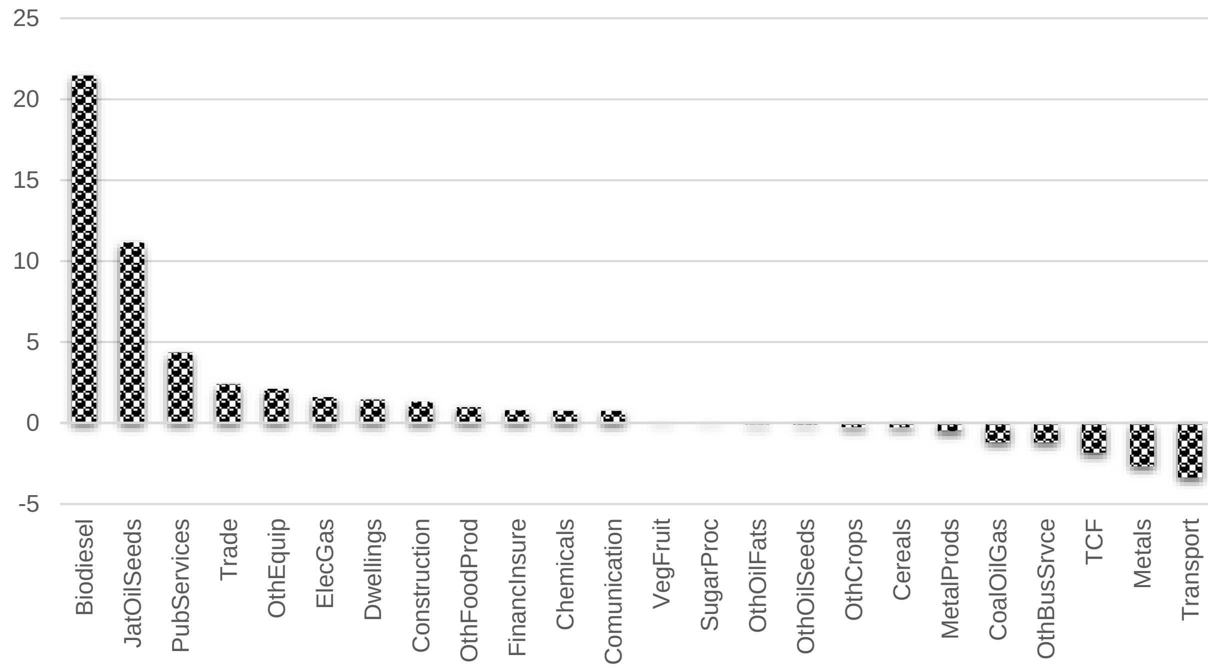
3.3. Fan Decomposition

Long-run results show some minor changes occurring in commodities' consumption behavior. However, the local market demand increased for some sectors, such as Water, Dwellings, and OthServices, estimated at 2.03, 0.27, and 0.22, respectively. On the other hand, the increase in consumption demand in the OthEquip sector was caused by the shift from imported Equipment to locally produced equipment, with a ratio reached of 1.8.

3.4. Winners & Losers:

The percentage change in industry output is reported by the variable (x1tot). However, a large percentage of the change in (x1tot) may occur in a relatively small-sized sector, so the results may be unreliable in such cases. A better way of ranking is by some approximation to the CHANGE (not percentage change) in industry activity. A good measure of that can be obtained by multiplying the pre-simulation level of activity (V1TOT) in each industry by the percentage change (x1tot) in industry activity (Jill, et al., 2014).

Figure (6) Winners & Losers of Industries Ranked by their Actual Change Value.



As the review of the benefits from the expansion of the new sectors to the overall economy shows, certain sectors gain more benefits (winners) than others do. Consequently, some other sectors are set back (losers).

As Figure (6) shows, the top 10 winners in the economy-wide sectors are Biodiesel, JatOilSeeds, PubServices, Trade, OthEquip, ElecGas, Dwellings, Construction, OthFoodProd, and FinancInsure. All of these industries operate in close relation to Biodiesel & Jatropha, which explains why they gain more benefits than others do. The results show that the actual value of change in these sectors is $21.46, $11.16, $4.36, $2.41, $2.11, $1.60, $1.45, $1.33, $0.98, and $0.79 million, respectively.

In addition, the top 10 losers in the economy-wide sectors, ordered from the smallest loss to the largest loss, are OthOilFats, OthOilSeeds, OthCrops, Cereals, MetalProds, CoalOilGas, OthBusSrvce, TCF, Metals, and Transport, with the actual value of change as follows: $0.08,

$0.10, $0.26, $0.27, $0.50, $1.19, $1.20, $1.83, $2.67, and $3.36 million, respectively. One possible reason for transport to place as the biggest loser is that the analysis takes into consideration the transport margin in the model database. The full list of actual changes in industries value can be found in Appendix (C).

3.5. Sensitivity Analysis:

While the study introduces two new sectors, the most critical part of the assumptions is related to these sectors' elasticities. Because their data is not precisely known, the study chose to question these elasticities through the sensitivity analysis. For this purpose, three main elasticities were selected: Individual Export Elasticities (EXP_ELAST), Intermediate Armington (SIGMA1), and Primary Factors Sigma (SIGMA1PRIM). This sensitivity analysis is based on the data from the second-step of the long-run closure because it has a major portion of the total model results.

The above parameters during sensitivity analysis are varied using type (P), which is a percentage variation, while the variation value is 100% for each of them. Moreover, the default triangular distribution is selected rather than the uniform distribution. Finally, Liu's quadrature is selected as the analysis quadrature type.

As Table (7) shows, four scenarios were set. Through all of them, the parameters will vary independently, with the first one varying EXP_ELAST over biodiesel industry commodities (Biodiesel, Glycerol, and Seedcake). As these are the only export commodities for the new sectors, they represent the final demand, which induces growth in these sectors, so any uncertainty related to this parameter should be evaluated. The second scenario varies SIGMA1 over the two industries (Jatropha OilSeeds and Biodiesel). Because these new industries are introduced into the existing economy and would interact and use the current commodities, the uncertainty related to the use of the intermediates should be evaluated as well. The third scenario evaluates the uncertainty related to introducing new primary factors of production (Wastewater and Marginal Land) into the economy through varying SIGMA1PRIM over the new sectors (Jatropha Oilseeds, and Biodiesel), which are using these new primary factors. Finally, the fourth scenario is simultaneously varying both EXP_ELAST and SIGMA1PRIM to measure the composite impacts.

Table (7) Sensitivity Analysis Scenarios

Scenario No.	Name	Sims Num.	Parameter	Actual Value	Actual SD	Min Param	Max Param
1	Individual Export Elasticities	8	EXP_ELAST(Bio)	-6.6	2.69	-9.29	-3.91
2	Intermediate Armington	16	SIGMA1(Jat)	2.45	1	1.45	3.45
			SIGMA1(Bio)	3.3	1.35	1.95	4.65
3	Primary Factor Sigma	8	SIGMA1PRIM(Jat)	0.25	0.1	0.15	0.35
			SIGMA1PRIM(Bio)	1.12	0.46	0.66	1.58
4	Export Elasticities & Primary Factor Sigma	16	EXP_ELAST(Bio)	-6.6	2.69	-9.29	-3.91
			SIGMA1PRIM(Jat)	0.25	0.1	0.15	0.35
			SIGMA1PRIM(Bio)	1.12	0.46	0.66	1.58

Two important endogenous variables were selected to report the sensitivity analysis results, which are Real GDP from the expenditure side (x0gdpexp) and Wastewater Land Aggregate Rental weights (x1wwld_i). Results shows that the first and second scenarios have no impact on the real GDP, while the third and fourth scenarios have a minor impact estimated at 0.000011 for the standard deviation. This indicates that, under this specific case, the primary factor sigma is the most likely to affect real GDP, rather than the other selected elasticities. Moreover, applying Chebyshev's inequality with 99% confidence assures that whatever the distribution of real GDP, it will always lie between 0.14439 and 0.14461 percent, as shown by Figure (7).

As for Wastewater Land Aggregate Rental weights, results shows that export elasticities don't have any impact on it, while varying intermediate Armington has a minor impact that is estimated to be 0.0015 of standard deviation. Finally, the third and fourth scenarios equally influence Wastewater land aggregate by around 0.1197 of the standard deviation. Thus, primary factor sigma is the most likely to affect Wastewater land aggregate. Moreover, with 99% confidence, the value of Wastewater land will have a minimum value of 993.57 percent and a maximum value of 995.97 percent, as shown in Table (8).

Figure (7) Real GDP Sensitivity Analysis Result – 99% Confidence Level

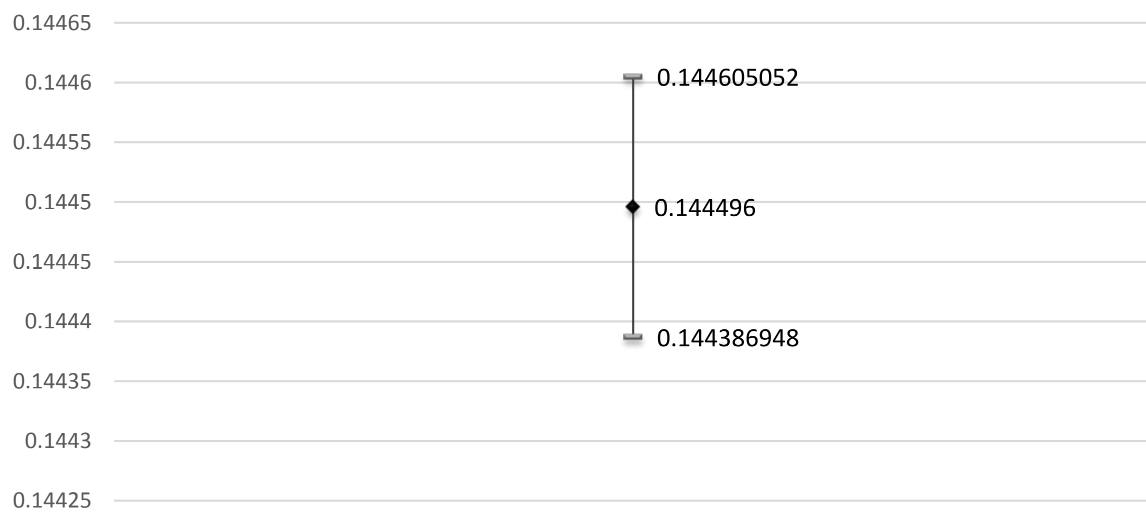


Table (8) Wastewater Land Aggregate under Different Scenarios

			99% Confidence Level	
Scenario No.	**Mean**	**Standard Deviation**	**Lower**	**Upper**
1	994.7700	0	994.7700	994.7700
2	994.7700	0.0015	994.7554	994.7847
3	994.7700	0.1197	993.5726	995.9674
4	994.7700	0.1197	993.5726	995.9674

4. Conclusion & Policy Implications:

In this paper, we tried to illustrate the expected impacts of expanding Jatropha plantations and biodiesel production on the Egyptian economy, in order to help the decision makers. We did that by using a CGE model based on data collected from various resources and a survey conducted exclusively for this research.

The insight brought out by the analysis is that the expansion of Jatropha plantations and biodiesel production will positively impact the economy in general. As was discussed earlier, for example, if household consumption is considered as a simple indicator of welfare, results showed that household consumption increased 0.39% from its base value. In addition, Wastewater and marginal land become a source of income to the country's GDP, as the value of Wastewater increased by about $15 million, while the marginal land increased by about $21 million. Furthermore, the results showed that wages increased by about $176 million, which, according to one way of thinking, puts the money into the hands of consumers, boosting demand for goods and services. However, at the same time, the results showed some negative impacts on certain sectors that are vital to the Egyptian economy, such as cereals and metals.

From a policy perspective, the study highlights the following requirements:

- As the results show, the biodiesel industry represents the biggest winner, so any policy for expanding Jatropha plantations in Egypt should be made in conjunction with a policy promoting the biodiesel industry in order to take the full advantage of both sectors, as the former serves as the latter's intermediate input.
- Analysis of the results shows that there is some spillover effect impacting old land prices. That is, even if, according to the model assumption, the sectors only take place on new land, it still

affects the price of old land. To control such impacts, a policy should be created to control the expansion of the new sectors and ensure that it will only take place on new marginal land.

- The Jatropha plantations sector, as results show, is a labor-intensive sector, and it is very dependent on unskilled labor; therefore, the plantation locations (marginal land) should be near the concentrated population in poor areas.
- Biodiesel plants should be located within the same locations as Jatropha plantations, and it is recommended that they be small- to medium-sized plants.

5. Future Research:

The study did not cover the environmental impacts of the expansion of these new sectors. Therefore, a separate study to investigate such impacts on the ecological system is recommended. In addition, a social study covering labor and the social impacts is needed.

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Appendix A – Excerpt of Tablo Language Modification

```
!   Excerpt Wastewater / Marginal land Leontief Production Nest     !
!$  X1WWLD(i) = Min(X1WWR(i)/A1WWR(i), X1MLD(i)/A1MLD(i))          !

Coefficient (all,i,IND) V1WWLD(i) #Total Wastewater Land input(i)#;

Formula  (all,i,IND) V1WWLD(i) = V1WWR(i) + V1MLD(i);

Variable
 (all,i,IND) p1wwld(i)  # Effective price of Wastewater Land#;
 (all,i,IND) x1wwld(i)  # Wastewater Land composite #;
 (all,i,IND) a1wwr(i)   # Wastewater-augmenting technical change #;
 (all,i,IND) a1mld(i)   # Marginal Land-augmenting technical change #;
(change)(all,i,IND) delV1WWLD(i)
                      # Ordinary change in cost of Wastewater Land #;

Equation
 E_x1wwr  # Industry demands for Wastewater #
   (all,i,IND)  x1wwr(i) - a1wwr(i) = x1wwld(i);

 E_x1mld  # Industry demands for Mrginal Land #
    (all,i,IND)  x1mld(i) - a1mld(i) = x1wwld(i);

 E_p1wwld  # Effective price term for Wastewater Land demand equations
#
  (all,i,IND)  [TINY + V1WWLD(i)]*p1wwld(i) =
               V1WWR(i)*[p1wwr(i) + a1wwr(i)]
             + V1MLD(i)*[p1mld(i) + a1mld(i)];

 E_delV1WWLD
     # Ordinary change in total cost of Wastewater Land composite #
(all,i,IND) 100*delV1WWLD(i) = V1WWR(i)  * [p1wwr(i) + x1wwr(i)]
                             +  V1MLD(i)  * [p1mld(i) + x1mld(i)];
```

Appendix B - Excerpt of the Command File

```
! Closure: "!*!" indicates difference from shortrun

! Exogenous variables constraining real GDP from the supply side
exogenous  gret              !*! sectoral gross rates of return
           x1lnd               ! all sectoral agricultural land
           p1wwr               ! all sectoral Wastewater Price
           p1mld               ! all sectoral Marginal Land Price
           a1cap a1lab_o a1lnd a1wwr a1mld
           a1prim a1wwld a1tot a2tot  ! all technological change
           employ_i ;        !*! total employment - wage weights

! Exogenous settings of real GDP from the expenditure side
exogenous
      delB               !*! balance of trade/GDP
      invslack           !*! investment slack variable
      f5tot2             !*! link government demands to total household
      delx6 ;              ! real demands for inventories by commodity

!jmhmod Shock!
swap  f4q("BioDiesel") = x4("BioDiesel");
swap  f4q("Seedcake") = x4("Seedcake");
swap  f4q("Glycerol") = x4("Glycerol");
shock x4("BioDiesel") = 1000;
shock x4("Seedcake") = 1000;
shock x4("Glycerol") = 1000;
```

Appendix C - Winners & Losers

Sector	Change
Biodiesel	21459.35
JatOilSeeds	11156.45
PubServices	4360.834
Trade	2409.613
OthEquip	2110.725
ElecGas	1604.713
Dwellings	1451.533
Construction	1325.564
OthFoodProd	975.4397
FinancInsure	785.4608
Chemicals	753.0681
Communication	745.7104
BevTobacco	562.7656
OthServices	550.0421
WoodPaper	462.0158
MVP	435.2902
ElectronicEq	222.8045
Fishing	205.5182
Animals	159.9458
Water	151.0838
RawMilk	86.42153
Sugar	35.73083
MeatProds	11.12125
Forestry	-0.18442
OthManuf	-18.8322
TranspEquip	-21.1594
DairyProd	-35.0397
OthMinProds	-43.2423
OthMinerals	-47.7905
VegFruit	-57.0695
SugarProc	-67.5779
OthOilFats	-84.6905
OthOilSeeds	-98.0781
OthCrops	-261.004
Cereals	-269.604
MetalProds	-503.414
CoalOilGas	-1187.46
OthBusSrvce	-1198.74
TCF	-1829.65
Metals	-2672.69
Transport	-3355.04