International Journal of Management, IT & Engineering
Vol. 7 Issue 8, August 2017,
ISSN: 2249-0558 Impact Factor: 7.119
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

THE ECONOMIC WIDE IMPACTS OF LAND USE CHANGE FOR SUGARCANE PLANTATION IN ETHIOPIA: A RECURSIVE DYNAMIC CGE APPROACH

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Abstract

In recent years Ethiopia has been implementing multifaceted investment on sugarcane. This massive investment with the aims of producing sugar, ethanol and cogeneration has been undertaking in different regions of the country covering the period of 2009-2019. The most recent and more complicated model that helps us see inter-sectoral impacts of land use change for sugarcane plantation is computable general equilibrium (CGE). This study extends the previous SAM and CGE modeling work in Ethiopia in one step ahead; it incorporates ethanol and cogeneration in an updated version of 2005/06 SAM. And this study made the first attempt to modeled sugarcane collectively with sugar, ethanol and cogeneration into the CGE model. The findings of the study revealed that all macroeconomic variables have shown positive changes except for private consumption. A real GDP at factor cost has grown by 0.35% and real investment increased by 1.68%. With regard to the three dominant sectors of the economy, the largest output expansion is registered by the service sector. It has increased by 1.11%. The agricultural sector is the second with percentage change of 0.16%. The least growth rate has been registered by industrial sector. It declines by 0.69%. With regard to subsectors of the economy, sugarcane, sugar refining, ethanol processing and cogeneration have increased by 34.07%, 19.43%, 1.31% and 0.59%, respectively. Regarding the deleterious impact of land use change for sugarcane plantation, the production of main food stables, pulses, cash crops and livestock have shown reduction in output. It is envisaged that the policy of using degraded and barren lands for sugarcane production will appear as a way out to reverse the adverse effect of land use change on production of cereals, pulses, livestock and agro-processing industries.

Keywords: Land Use Change, Sugarcane, Ethanol, Cogeneration, Recursive DCGE, Ethiopia

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1. INTRODUCTION

Ethiopia has big productive potential vis-à-vis endowed with large areas of suitable arable lands, cheap labor force, abundant water resources and ideal ecological climate for sugarcane growth. The climate and soil types in the country have both proven to be highly conducive for sugar cane growth and productivity (Davison, 2011; Sutton and Kellow, 2010). Sugarcane land expansion accompanied with modern technological breakthrough has been recognized as an overriding source of recent growth in sugarcane sector and should be seen as a main engine of further growth in the sector. On account of these enormous benefits that have been derived from sugarcane production, the Ethiopian government has initiated and endorsed many new sugar development projects so as to culminate the growth of the sector and to give relatively impressive priority to unleash the productive potential of the sector.

According to the survey conducted at a national level, it has been proved that the country has the potential of over 500,000 hectares of land suitable for sugarcane plantation (SC, 2013). The three old states owned sugar factories have a total of 50,370 hectares of land including the expansion programs. The ongoing and the new state owned sugar development projects intended to be established within the growth and transformation plan will have a total of 384,000 hectares of land. This massive investment with the overarching aims of producing sugar, ethanol and cogeneration has been undertaking in different regions of the country. In line with these objectives, after all projects are culminated, sugar production capacity of the country will be sixteen-fold of previous production capacity. The ethanol production capacity will rise by fifty eight-fold, and the country will generate more than eighteen-fold of the previous production of electricity from Bagasse through cogeneration.

These substantial new capital investments for new sugar factories and vigorous expansion of the existing once primarily driven by area expansion seems to have a promising and potential sources of sugar, ethanol, and renewable electricity. As a matter of fact, this sugarcane expansion was made by displacing pasture and other crops. Between 2009 and 2019, the area cultivated with sugarcane in Ethiopia will be expanded by 333,630 hectares. More than three quarters of the expansion was at the expense of other crops and the remaining expansion was mainly on land previously used for grazing cattle. However, such massive land use change must be based on cost and benefit analysis of the projects in the light of economic, social, cultural and ecological values raised by various stakeholders. Despite the projects feasibility study which exhaustively look towards on increasing public employment, sugar production, ethanol and electric power as well as general improvement of infrastructure and services, a number of economic and sustainability concerns remain unanswered, particularly the inter-sectoral impacts of this huge land displacement (diversion) for sugarcane expansion on different subsectors of the economy is not studied yet. To the best of my knowledge, there is no single study conducted to attest the long run and inter-sectoral economic importance of such huge investment. Therefore, the competition between staying at the status quo of being used for pasture and other crops and diverting it for sugarcane cultivation requires economy wide investigation.

The economy wide measurement of land use changes as a consequence of sugarcane land expansion, looking to the past and forecasting the future, is a very dynamic and complex process. The most recent and more complicated model that helps us solve such inter-sectoral maze is computable general equilibrium (CGE). This model by design is able to explain and predict land allocation and land use change caused by the sugarcane expansion over the last years as well as the consequences of future expected expansion. This study therefore presents the first attempt to modeled land use change of sugarcane expansion into the CGE model to forecast its inter-sectoral impacts. It also the first attempt to construct a CGE model of sugarcane sector that can be used to analyze fiscal policy issues in Ethiopia. Hence, the present study is to measure and evaluate the inter-sectoral impacts of changes of land use caused by the sugarcane expansion in Ethiopia by applies the recursive dynamic computable general equilibrium (RDCGE) covering the period between 2009 and 2019 and the outcomes of present study have a grand implication to the concerned policy makers to take the findings as policy instruments to make adjustments and revisions in policies.

2. REVIEWS OF RELATED LITERATURE

There are several areas of the literature that are important to understand in order to proceed and acquaint with developing a methodology for this study.

2.1. Modeling the economy wide impacts of Sugarcane and rationale of CGE approach

In this section, we focus on the comparison between partial equilibrium (PE) and general equilibrium (GE) estimates, for reason that some consider using a computable general equilibrium model for sugar sector as an "overkill" strategy, since contribution of sugar growth to the overall economic growth seems often invisible and the sector is unlikely to be large enough to have significant macroeconomic effects. The fundamental premises of those peoples who argues it is an over killing strategy to include a more specific sector within a broader framework is stemmed from the fact that the feedback effects using such broader models might be insignificant. As result they opt to use partial equilibrium models to undertake a detailed analysis of a more specific sector of the economy, while ignoring interactions with other sectors of the economy.

However, there is no serious impediment to including a more specific sector within a broader framework. Proper modeling of sugar response to policy changes actually requires the interaction of the farm sector with both the processing and the food sector that uses sugar, an issue better dealt with in a general equilibrium (GE) framework (Gohin and Bureau, 2006). The other advantages of using CGE model is the welfare gains computed within it. Comparing with partial equilibrium models, welfare effects are more easily addressed within a general equilibrium framework in the case of second best equilibrium (Gohin and Moschini, 2005). Furthermore, CGE model preferred over the partial equilibrium models on account of its simplicity to undertake a complex interdependencies analysis between sectors. For instance, one can use a policy instruments to estimate the changes in an economic target variable, surprisingly other economic variables than those targeted will be highly affected. Hence, the direct effects predicted by partial equilibrium models may adversely differ with the outcomes predicted by CGE models which may deceive the intention of the policy makers (Thissen, 1998).

The other shortcoming of partial equilibrium model is its inability to consider the feedback effects across interrelated market due to its underpinning assumption of supply is perfectly elastic in each market. In contrast, the general equilibrium demand response takes into account not only own-price and cross-price effects but also feedback effects (Dharmasena et al., 2011). Moreover, CGE models are consistent against partial equilibrium models to assess the economy-wide effects of sugar reform on the account of the fact that in the general-equilibrium framework, production and consumption effects remain much higher than in partial equilibrium models. This might be the reason that explains why commodity price effects are much smaller in CGE models than partial equilibrium models (Elobeid and Beghin, 2005).

Generally speaking, applying CGE framework against other empirical models has at least five good reasons (Hertel, 1990). First, accounting consistency, since CGE models are built upon a social accounting matrix (SAM) which details all the basic identities for a given economy and CGE analysis revolves around the explicit incorporation of these accounting identities into the behavior model. Second, it's treatment of inter-industry effects. Using partial equilibrium models, it is difficult to know where to "draw the line" between the commodities and sectors affected by a given policy. Third, it's theoretical consistency, since CGE framework depicted under the well known Walras' Law, which may be used as a global consistency check.

Fourth, it provides a valuable tool for putting things in an economy-wide perspective. Fifth, it's welfare analysis. One of the salient feature of CGE model is the possibility of conducting welfare analysis in a second-best setting which force us to focus more clearly on households, and, ultimately, on people. This outstanding characteristic of CGE model makes it particularly well-suited for use in agricultural policy analysis (Hertel, 1990). Therefore, in views of all the benefits from using CGE analysis, it is relevant to employ CGE framework in this study against partial equilibrium models.

2.2. Computable General Equilibrium (CGE)

The fundamental conceptual starting point for construction of CGE model is the early work by Leon Walras. Walrasian general equilibrium exists when supply and demand are equalized across all of the interlinked markets in the economy. Computable general equilibrium (CGE) models are simulations that used to combine the abstract general equilibrium structure formalized by Arrow and Debreu with realistic economic data to analyze the aggregate welfare and distributional impacts of policies (Sue Wing, 2004).

Computable General Equilibrium (CGE) model can be defined as a class of economic models that can be used to analysis how an economy might react to changes in policy and other external factors (shocks) that stems from changes in prices and markets. This multi-market model used to model the interactions of individual households and firms on interdependent markets based on actual economic data. This broader model incorporate various institutional and structural characteristics that represents the specific nature of the working economy to identify rigidities and constraints that the simple analysis unable to capture (Bibi et al., 2010). The model is formulated as a set of simultaneous linear and non- linear equations, which define the behaviour of economic agents, as well as the economic environment in which these agents operate (Thurlow, 2004).

According to Virginie (2009) CGE model setting has three stages. The first stage is a general description of the entire economy which consists in building a Social Accounting Matrix (SAM). Depending on the purpose for which the SAM is required, some parts of macro-balance can be disaggregated into sub-accounts to enhance the studied sector. This disaggregation brings more detail and more realism into the model. The base year is chosen so that the economy is close to a general equilibrium at this period. Once such a SAM is determined, it constitutes a benchmarked economy, that is, a steady-state or a long-run equilibrium (Sue Wing, 2004).

The second stage is to specify an equation system in order to account for the relationship between all variables. This system includes macro-balancing equations, functional forms and behavioral equations. The choice of a specific functional form depends on how elasticities are to be used in the model while behavioral equations assumed that representative consumers and producers maximize utility and profit respectively (Virginie, 2009). CGE models always contain more variables than equations. It implies some exogenous variables must be set outside the model. Gillham (2005) described the fact that in order to be able to obtain a solution for a CGE model, the number of equations that need to be solved must equal the number of endogenous variables. To bring such a balance between them, it is necessary to specify macro closure rules, that is, the choice of which variables are to be exogenous. In a nutshell,

"Closure is CGE jargon for assigning causality in a model. The practice often boils down to deciding which variables should be exogenous or endogenous (or which equations should be included or excluded) to make sure the model is 'closed' or has a solution, like a typical problem from high school algebra" (Taylor and von Arnim, 2007).

Indeed, the closure of a CGE model consists in specifying the last element of the model so as all the relationship are compatible. Most of the parameters of the functional forms and behavioral equations are quantified on the basis of existing econometric literature. When such information is not available, some may be chosen idiosyncratically by model builders, who have to estimate a realistic value (Virginie, 2009).

In the third stage, the model is calibrated so that the initial equilibrium reproduces the values from the SAM. Calibration, is the term used to describe parameters that are selected based on non statistical techniques, used as method by model builders to 'test' their parameters and to identify a set of parameter values. Calibration of these parameters of the model is essential in order that the equilibrium reproduces the transactions observed in the SAM (Kehoe, 1996). Calibration usually involves one year's data or a single observation represented by an average over a number of years. It consists in solving the numerical model backwards to determine parameter values that are consistent with the base year data. These values allow, when the model is run right side up, to find the benchmark equilibrium (Virginie, 2009).

2.3. Recursive Versus Intertemporal Dynamic CGE Models

Initially CGE models can be subdivided into static and dynamic models. Static models can be described as looking the behaviour of economic agents at one point in time. Dynamic models, on the other hand, consider the behaviour's of economic agents' overtime. In line with this subdivision, the broader literature on CGE further distinguishes two kinds of dynamic general models. These are: intertemporal and recursive (sequential) dynamic models. The equilibrium concepts and the expectations formation hypothesis raised under these models are quite different (Mabugu, 2005). The behaviour of economic agents under intertemporal (clairvoyant) dynamic models is characterized by perfect foresight and rational expectations which is based on the optimal growth theory. In intertemporal dynamic models economic agents know all about the future and react accordingly for the changes in prices to the future. Households maximized their intertemporal utility subject to constraints to determine their consumption schedule overtime. Correspondingly, firm's decision towards investment is the results of cash flow maximization over the whole time horizon (Annabi et al., 2005).

However, the application of this kind of model is not straightforward in a number of circumstances and it is difficult to apply this model particularly in a developing countries due to its underpinning assumption of economic agents have perfect foresight, which is hard to assume in these countries. In addition, household savings is not endogenously determined using an inter-temporal utility function, and so it does not smooth consumption over time. Therefore, as capital accumulation cannot be defined inter-temporally, the dynamics in CGE model is defined as a recursive process. This means that we can separate the model into "within-period" and "between-period" components (Diao and Thurlow, 2011). For these reasons we opt to the second strand of dynamics specification in CGE models known as recursive (sequential) dynamics, a much more appropriate model for developing country. This kind of dynamics implies that the behaviour of its agents is based on adaptive expectations (myopic expectations), that is, people expect current relative prices to persist in the future. Unlike intertemporal dynamics, sequential dynamics is not the result of intertemporal optimization by economic agents (Annabi et al., 2004).

A recursive dynamic model is basically a series of static CGE models that are linked between periods by behavioural equations for endogenous variables and by updating procedures for exogenous variables. Though it is possible to add updating mechanism for other variables, updating capital stock endogenously with a capital accumulation equation and population (total labour supply) exogenously between periods remains essential (Annabi et al., 2004). To obtain a solutions in recursive dynamic models it require shocking of stock variables, such as capital stock and population, in each period by their historically determined changes on a year-on-year basis (known as momentum simulation) (Pant, 2002). Analogously, Morley and Piñeiro **(**2011) described recursive dynamic CGE model as a dynamics that has been solved in two stages. The first stage aims to find a solution for a one-year equilibrium using a static CGE model. In the second stage, a model between periods is used to create the dynamic linkages that update the variables that drive growth. Though the model does not incorporate future expectations, it is solved forward in a dynamically recursive fashion, with each static solution depending only on current and past variables. Incorporating sugarcane into a more broad and muti-sectoral model is a disaggregated and most recent phenomenon. It is therefore hard to find an extensive empirical works to support our arguments based on practical results. Hence, the following are some of empirical studies we found in the vast literature.

Filho and Horridge (2011) analyzed the effects of indirect land use change (ILUC) on ethanol production from sugarcane in Brazilian economy. They used a multi-period computable general equilibrium model for the Brazilian economy. The results of the study show that, due to the expansion of land for sugarcane plantation to produce ethanol, pasture land would fall by 0.21%, planted forest land by 0.65%, and unused land by 0.02%. In physical terms this would account for an extra 530 thousand hectares of crops, and a reduction of 380 thousand hectares of pastures, 30 thousand hectares of planted forests, and 120 thousand hectares of unused land. Consequently, the model results show that each extra sugarcane hectare was associated with a 0.14 hectares fall in unused land, and with a 0.47 hectares fall in pastures.

Lee et al. (2009) analyzed the economy wide impacts of increasing ethanol production from sugarcane in Taiwan. In their study, they used a CGE model to estimate the impacts of boosting ethanol production on the Taiwanese economy. The results of simulations revealed that the positive macroeconomic effect in the event of the raise the production of ethanol is achieved. The model predicted increase in real GDP from 0.136% to 0.853%, consumption increase from 0.150% to 0.940%, employment increase from 0.094% to 0.588%, export increase from 0.045% to 0.284%, import increase from 0.027% to 0.172%, and investment increase from 0.07% to 0.437%. The result also shows the raise of ethanol production will reduce carbon dioxide emission from -0.259% to -1.618% and also energy density from -0.086% to -0.531%. Arndt et al (2010), in their part, used dynamic CGE model to investigate the relationship between bioenergy development and its contribution to enhance economic growth and poverty reduction in Tanzania. They have been used ten scenarios. Of which the first six scenarios refers to ethanol production from sugarcane feedstock and the results indicated that establishing a bioenergy industry in Tanzania can help to achieve the country's development objectives of enhancing economic growth and reducing poverty. They further noted that national GDP rises and new employment opportunities are created in bioenergy sectors which lead to welfare gains.

2.4. Conclusion and Knowledge Gap

Some considered using a computable general equilibrium model for sugarcane sector is just like attempting to cross an ocean through swimming, since contribution of sugarcane growth to the overall economic growth seems often invisible and the sector is unlikely to be large enough to have significant macroeconomic effects. As result they opt to use partial equilibrium models to undertake a detailed analysis of a more specific sector of the economy. However, it is very difficult to look about inter-sectoral effects of sugarcane by ignoring interaction of the sector with other sectors of the economy. In this regard, computable general equilibrium model assumed to be the most appropriate model against the caveats of partial equilibrium models. For these reasons, this study presents the first attempt to modeled land use change of sugarcane expansion into the CGE model to forecast its inter-sectoral impacts. To the best of the researcher knowledge and belief, this study brought the first attempt to collectively modeled sugarcane with ethanol and cogeneration. Therefore, this research filled the literature gap of modeling a more specific sector in to a broader model and of course a starting point in modeling sugarcane with its byproducts in CGE model using GAMS software.

3. DATA AND METHODOLOGY

3.1. The Social Accounting Matrix (SAM)

The source of data used in this particular study is a Social Accounting Matrix (SAM). The standard CGE model explains all of the payments recorded in the Social Accounting Matrix. The model follows the SAM disaggregation of activities, commodities, factors and institutions (Lofgren et al, 2002). The SAM is a comprehensive, disaggregated, consistent and complete data system that captures the interdependence that exists within a socioeconomic system. More technically, a SAM is a square matrix in which each account has its own row and column. The payments (expenditures) are listed in columns and the receipts are recorded in rows. As the sum of all expenditures by a given account (or subaccount) must equal the total sum of receipts or income for the corresponding account, row sums must equal the column sums of the corresponding account (Decaluwé et al., 1999; Thorbecke, 2001).

With regard to the structure of the standard SAM, it has a number of accounts such as activities, commodities, institutions, factors of production and saving-investment accounts. It also incorporates the three macro balances: government deficit, trade deficit and savings-investment balance. The activity accounts (the entities that undertake production) show the value of commodities (goods and services) produced by each activity and the cost of inputs into each production activity consisting of intermediate input purchases along with payments to primary factors of production. Commodity accounts show the components of total supply in value terms (domestic production, imports, indirect taxes and marketing margins) and total demand (intermediate input use, final consumption, investment demand, government consumption and exports). Factor accounts describe the sources of factor income and how these factor payments are further distributed to the various institutions in the economy. The institution account summarizes payments among government, households, enterprises, and rest of the world. The savings-investment(S-I) account should be seen a representing the" loanable funds" market. The account collects savings from various sources (government, private, and foreign) and spends the accumulated savings on capital goods (EDRI, 2009).

The 2005/2006 Ethiopia SAM is the first comprehensive economy wide dataset constructed by Ethiopian Development Research Institute (EDRI). As the current structure of the Ethiopian economy is different from 2005/2006 on which the existing SAM is based, it was updated in 2009. There are initially no ethanol and cogeneration sectors both in 2005/2006 and in the updated version of 2005/2006 social accounting matrix used to calibrate the dynamic computable general equilibrium model. It is not a simply task to a person to make any modification on SAM because it requires time, money and intellectual skills so as to make even a slight modification. However, it is too inconclusive to analysis land use change without incorporation of ethanol and cogeneration. We therefore opted to create these new sectors in the model to make this study more sound and consistent with the Ethiopian sugar program. We used information from the existed three sugar factories to draw the input -output table (the main data used to construct the social accounting matrix) of ethanol and cogeneration.

The modification has been made on the updated version of 2005/2006 SAM. The author incorporated the input-output data that has been drawn from the aforementioned three sugar factories in to the updated version of 2005/2006 SAM. After the author made the SAM to be scientifically balanced, then the author successfully culminated the maze of crucibles to link the modified SAM with the CGE model. The Author's modified SAM is produced in different level of aggregations. It is disaggregated into 115 activities (2009 updated SAM consists 113 activities), 65 commodities[2] (2009 updated SAM consists 64 commodities), 16 factors, and 13 institutions including 12 households. More specifically, it is disaggregated into 77 agricultural activities by four main agro ecological zones (humid, high land cereals, drought prone and pastoralist zones). The SAM also has different taxes, saving investment, inventory, and rest of the world accounts to show the interaction of different economic agents.

3.2. The Dynamic CGE Model and the Model Scenario

Some have used partial equilibrium analysis as the alternative method to address similar sector but slightly different issue (Elobeid and Beghin, 2005; Beghin et al., 2003). Moreover, others have used general equilibrium analysis to deal with related issues (Filho and Horridge, 2011; Lee et al., 2009; Arndt et al, 2010). Since, the sugar sector is closely interrelated with other sectors of the Ethiopia economy; sugarcane investment and production have economy-wide effects that desperately need multi-sectoral analysis.

This study used two activities to produce commodity electricity over the updated version of 2005/2006 SAM. The reason that we have two activities and one commodity emanated from the fact that electricity is produced from two activities (from the hydropower and cogeneration) but we have single commodity, electricity.

Hence, in this study, to estimate economy wide effects of ongoing and planned sugar investments in Ethiopia, the analytical approach used here is a computable general equilibrium. This is mainly because the interactions between the sugar industry and the rest of the economy can be quite significant and the effect of sugarcane sector considered as economy wide in nature. Furthermore, the income distribution and poverty related effects can easily captured by CGE analysis through micro level analysis that uses household level data. In a nutshell, as it has been already stated by Rendleman and Hertel (1993), I did not choose the general equilibrium approach because of large anticipated general equilibrium feedback effects. Certainly, I expect such effects to be quite small. Rather, I had the following advantages in mind: (i) exhaustive treatment of inter-sectoral relationships, (ii) ease of incorporating econometric estimates of key elasticities, (iii) straightforward welfare analysis in a second-best setting, and (iv) the availability of state of- the-art simulation software.

As it has been explicitly explained in the literature section, the model presented in this paper is the conventional recursive dynamic CGE model used by the International Food Policy Research Institute (IFPRI) as described in Lofgren et al. (2002). This model is an extension of the IFPRI static model developed by Thurlow (2008). Since a recursive model is solved one period at a time, it is possible to separate the **within-period component** from the **between-period component**, where the latter involves the dynamics part of the model (Thurlow, 2008). The within-period component describes a one-period static CGE model and it can be divided it into four major blocks: production and trade, price, institutions and system constraint blocks for the purpose of description of the structure of the model.

The within-period component represents an economy within a particular time-period. Its inability to account the second period effects limits its assessment of the full effect of policy and non-policy changes. However, as investments in sugarcane and its byproducts spread out over several of years, the static model is extended to a recursive dynamic model in which selected parameters are updated based on the modeling of inter-temporal behavior and results from previous periods. The model is dynamized by building a set of capital accumulation and updating rules for capital stock, labor force growth by skill category and productivity growth. Growth in total supply of each labor category and land is specified exogenously. In addition, growth in land supply by agro-ecological zones to sugar sector is specified exogenously (Thurlow, 2008). The detailed mathematical description of the model can be found in Lofgren et al (2002). For the purpose of investigating the inter-sectoral land use change, one scenario is designed to capture the effect of such direct production shock. The simulation has been performed to see the fourteen fold increase in land for sugarcane production and its consequential inter-sectoral effects. However, here the expansion of land for sugarcane plantation is assumed to be made on arable land used to produce other agricultural products and grazing of animals.

4. RESULTS AND DISCUSSION

4.1. Description of simulation

In this section, we introduced the baseline scenario and sugarcane scenario. The baseline scenario is established to serve as a reference in absence of any policy shocks and is used as the benchmark value so as to compare the values of sugarcane scenario after the policy shocks. Therefore, examining the differences between the sugarcane scenario and the baseline scenario allows one to obtain clear and analytically tractable comparisons about the impacts of different policy interventions. For this reason, we have developed and performed one set of simulation to achieve the research objective.

Simulation-I: sugarcane scenario, the first simulation is performed by increasing the land in the sugarcane sector that fully financed through increased government saving rate + increase in TFP of sugarcane sector shock. Consequently, we performed a fourteen fold increase in land for sugarcane production going from 30,000 to 459,370 hectares. The expansion of land for sugarcane cultivation was at the expense of arable land used to produce other agricultural crops and on land previously used for animal grazing.

4.2. Interpretation of Results

In this section, we present the detailed results of our simulation and their corresponding interpretation. Before we go pass to interpret our results, it is essential to make a general statement about the results of our CGE model. Given the previous restricted due attention for sugarcane plantation in Ethiopia, the contribution of the sector is a quite small to the Ethiopian economy, both as a share of agricultural GDP and of total agricultural production. Modeling of such more specific sector within a broader framework is often invisible and is unlikely to be large enough to have significant macroeconomic effects. Therefore, our model scenario results provide an indicative direction and should not be considered as a perfect forecast. Furthermore, in a sector such as sugarcane, which is at an early stage of development and very little information is available; the results should be interpreted with caution. Keeping these caveats into consideration, our analysis is essentially made on major issues; such as, changes in agricultural production, impacts on macroeconomic indicators, economic sectors and impacts on land and livestock.

4.2.1. Macroeconomic and Sectoral Impacts

4.2.1.1. Impacts on Macroeconomic variables

In Table 5.1 we present the summary of the results from our simulation projection for the major macroeconomic variables. These variables are real GDP at factor cost (GDPFC2), fixed investment (FIXINV), private consumption (PRVCON), and government consumption (GOVCON). From our results, the first general statement we can formulate is that the impact on macro variables is relatively small. This is not surprising as the sugarcane sector of interest is relatively small at the reference period. In simulation 1, all macroeconomic variables have shown positive changes except for private consumption, as depicted in Table 5.1. A real GDP at factor cost grows by 11.53%. Compared to the baseline, real GDP at factor cost grows by 0.35%. This growth would largely driven by rising in real investment. Real investment increase by 1.68% compared to the baseline simulation. In totality, the annual growth rate of GDP at factor cost grows by 11.53%. Compared to baseline simulation, GDP at factor cost has increased by 0.35% in simulation 1.

Table 5.1: Impact on macroeconomic variables

Average percentage (%) change per year

Variables	Initial	Sim0	Sim1
ABSORP	457.94	9.61	9.82
PRVCON	338.78	10.11	9.98
FIXINV	85.49	8.92	10.60
GOVCON	31.86	5.70	5.70
GDPFC2	355.12	11.18	11.53

% Change compared to the Baseline

Variables	Initial (In billion Birr)	Sim1
ABSORP	457.94	0.21
PRVCON	338.78	-0.13
FIXINV	85.49	1.68
GOVCON	31.86	-
GDPFC2	355.12	0.35

Source: DCGE simulation result

4.2.1.2. Sectoral Impacts of Land Use Change

In this subsection, we are going to analyze investment on sugarcane sector and its effect on the sectoral output using GDP at factor cost disaggregated by activity. The three dominant sectors that have substantial effect on the overall growth rate of the economy are agriculture, industry and service. The growth of each sectoral output and their corresponding average percentage change in output from baseline simulation is depicted in Table 5.2. Output of all activities in the agricultural, industrial and service sectors are aggregated to get the total output of the sectors for the years 2009 to 2019. Then average percentage change in output for each sector is calculated from aggregate output growth. Of the three sectors, the largest expansion is registered by the service sector. Compare to the baseline simulation, it has increased 1.11%, in simulation 1(for details see appendix A).

This substantial expansion is due to the fact that the service sector is one of the major users of sugar, ethanol and cogeneration as an intermediate input for further processing to produce its final output. The major users of sugar from service sector are hotels and restaurants. Most recently, ethanol used as substitute for petroleum by blending with gasoline. This practice will help to reduce the cost incurred associated with imported petroleum. This in turn improves the productivity of the transportation sector. Cogeneration is used by all activities of service sector. From this one can noted the fact that the land use change for sugarcane plantation significantly improves the total factor productivity of service sector. This improvement in factor productivity in turn enhances the output of the aforementioned sector. In terms of percentage change of sectoral output, the agricultural sector is the second with percentage change of 0.16% in simulation 1 compared to baseline simulation. Though there has been a reduction on output of agricultural crops, the overall growth rate of agricultural sector showed a positive growth rate. The largest output growth rate, actually, recorded by sugarcane sector. Compared to the baseline simulation, it increased by 34.07% in simulation 1 (Appendix B).

The least growth rate, in terms of percentage change of sectoral output, has been registered by industrial sector. It declines at 0.69% in simulation 1 compared to base line simulation. This negative growth rate may be due to the fact that the industrial sector in Ethiopia characterized by agro-processing (dairy, vegetable products, grain milling, milling services, tea processing, other food processing, beverages and tobacco processing), that is, the industrial sector mainly obtain its intermediate inputs from agriculture. As discussed earlier, there is a reduction on agricultural output as a result of land use change for sugarcane plantation. This reduction might have been adversely translated in to the performance of industrial sector. To put differently, this negative percentage change registered by industrial sector directly related to the decline in agricultural output. Though, the overall growth rate of industrial sector portrayed a decline in output, there are subsectors that registered the highest growth rate of output. Among the subsectors sugar refining, ethanol processing and cogeneration recorded higher growth rate (Table 5.3). The largest output growth rate is, as expected, registered by the sugar refining. It increased 19.43% in simulation 1 compared to base line simulation. By the same token, cogeneration has increased by 1.31% in simulation 1 compared to base line simulation. The lowest growth rate is, however, registered in ethanol processing which increased by 0.59% in simulation 1 compared to baseline simulation (Appendix C). This larger growth rate registered by the aforementioned subsectors is not as such surprising results rather it is the expected growth rate of output.

Table 5.2: Sectoral impact of land use change (Average % change per year)

Sectors	Sim0	Sim1
Agriculture	5.67	5.83
Industry	8.80	8.11
Service	11.94	13.05

Average % change from base line simulation

Sectors	Sim1
Agriculture	0.16
Industry	-0.69
Service	1.11

Source: DCGE simulation result

Table 5.3: Intra-sectoral impacts of land use change (percentage change)

Sub-sectors	Initial	Sim0	Sim1
Sugar cane	1.02	6.46	40.53
Sugar	2.79	7.49	26.92
Ethanol	0.22	12.73	13.32
Cogeneration	0.1	17.42	18.73

Average % change from base line simulation

Sub-sectors	Sim0	Sim1
Sugar cane	6.46	34.07
Sugar	7.49	19.43
Ethanol	12.73	0.59
Cogeneration	17.42	1.31

Source: DCGE simulation result

4.2.2. Changes in Agricultural Production

The fourteen fold expansion of land for sugar cane production requires: (1) increase the land supply of the country that can be used for cultivation of sugarcane without making any land adjustment; (2) displacement of the existed land that has already been used for other agricultural crops. Since there is no change on the land supply, this huge amount of land expansion for sugar cane cultivation comes at the expense of other land uses. In other words, the increase in land demand for sugarcane is accommodated by a fall in agricultural land for other uses, as shown in appendix B.

Imposing the projected land extensions on sugarcane sector in Ethiopia leads to a largest negative impact on other agricultural crops. For instance, as shown in appendix B, the production of main food stables like Teff, Barley, Maize, Sorghum, and Enset have declined by 0.06 %, 0.27%, 0.14%, 0.19%, and 0.01%, respectively. The production of Pulses has also been reduced by 0.04%. Moreover, the production of cash crops like Vegetables, Fruits, Cotton, Tea, and Coffee have declined by 0.11%, 0.35%, 0.01%, 0.01%, and 0.01%, respectively. Similarly, the production of Cattle, Milk, Poultry, Animal products and Fisheries have declined by 0.07%, 0.02%, 0.06%, 0.06%, and 0.62%, respectively. However, the only sectors that stand to gain from this huge amount of land expansion are sugarcane (about +34%), wheat (+0.26%), forestry (+0.1%) and other crops (+0.07%).

The increment in domestic production of sugarcane is necessarily followed by a reallocation of land resources. Displacement of land that has been previously used for production of other agricultural crops towards sugarcane cultivation brought a substantial reduction in the production of other agricultural crops. The simulation results show that the current sugarcane plantation has a significant impact on agricultural and food production. The production and land allocation of the relevant crops undergo remarkable changes. Such tremendous changes associated with reallocation of agricultural land may have dramatic consequences on food prices.

In this regard, Sorda et al., 2009, in his part, has been argued that the recent increase in the prices of staples has been partly caused by increased biofuel production. The main feedstock that can be used for the production of biofuel is sugarcane. The consequent higher demand for this feedstock together with a reallocation of land that previously used for production of other agricultural crops has been claimed as a relevant factor in the current surge in food prices in Ethiopia. Therefore, the land extensions on the sugarcane sector reduce the availability of land for other agricultural crops. This reduction might have adverse impacts on the household income and consumption. Since the contribution of agriculture in general and cereals in particular have a significant magnitude to the overall the economy, a displacement of land on the aforementioned sector would have negative consequences on some of macro variables and sectors of the economy.

4.2.3. Impacts on Land and Livestock

The aggregate returns of land have shown the lowest growth rate. Compared to the base line, it declines by 1.51%, 0.70% and 1.64% in simulation 1, 2 and 3, respectively. The main reason for deterioration of return from factor land is due to the decline in the production of other agricultural activities. The fall of output in agricultural sector emanated from diversion of land previously used for staples production towards sugar cane cultivation.

The aggregate returns of livestock have registered negative growth. It has decreased by 0.94%, in simulation 1compared to baseline simulation. The reduction in return for livestock might be associated with expansion of lands for sugarcane cultivation. Since there is land displacement for sugarcane plantation at the cost of grazing lands and other agricultural crops, which resulted from limited land supply, lead to a significant reduction in the production of livestock. To the country like Ethiopia, which highly dependent on grazing lands for improvement of livestock production, reallocation of this lands for other purpose will caused a significant reduction in the production of livestock.

Table 5.4: Average annual percentage changes in factor income

Variables	Initial	Share	Sim0	Sim1
Land	39.76	11.2%	8.19	6.68
Livestock	30.85	8.7%	10.61	9.67

Average annual percentage changes in factor income from the baseline

Variables	Initial	Share	Sim1
Land	39.76	11.2%	-1.51
Livestock	30.85	8.7%	-0.94

Source: DCGE simulation result

5. CONCLUSIONS AND POLICY IMPLICATION

In Ethiopia there is a substantial new capital investment for new sugar factories and vigorous expansion of the existing once primarily driven by area expansion seems to have promising and potential sources of sugar, ethanol, and renewable electricity. However, the inter-sectoral impacts of this huge land displacement for sugarcane expansion on different subsectors of the economy are not based on an investigation through using multi-sectoral models. In this paper we developed a recursive dynamic CGE model to quantitatively assess the economy wide impacts of land use change for sugarcane plantation in Ethiopia. The study used an updated version of the 2005/2006 EDRI Social Accounting Matrix with a necessary modification. The dynamic CGE model is developed so as to capture the impact of land use change for sugarcane plantation by agro-ecological zones.

Our model results indicate that the impact of land use change on macro variables is relatively small. This is not surprising as the sugarcane sector of interest is relatively small at the reference period. All macroeconomic variables have shown positive changes except for private consumption. A real GDP at factor cost grows by 11.53%. Compared to the baseline, real GDP at factor cost grows by 0.35%. This growth would largely driven by rising in real investment. Real investment increased by 1.68% compared to the baseline simulation. With regard to the three dominant sectors of the economy, the largest expansion is registered by the service sector. Compare to the baseline simulation, it has increased by 1.11%. In terms of percentage change of sectoral output, the agricultural sector is the second with percentage change of 0.16% compared to baseline simulation. The least growth rate, in terms of percentage change of sectoral output, has been registered by industrial sector. It declines by 0.69% compared to base line simulation.

With regard to subsectors of the economy, sugarcane, sugar refining, ethanol processing and cogeneration recorded higher growth rate. The largest output growth rate is registered by sugarcane. Compared to the baseline simulation, it has increased by 34.07%. The second largest output growth rate is registered by sugar refining. It increased by19.43%. Cogeneration has increased by 1.31% and the lowest growth rate is, however, registered in ethanol processing which increased by 0.59%, compared to baseline simulation.

Regarding the deleterious impact of land use change for sugarcane cultivation in the Ethiopian economy, the production of main food stables like Teff, Barley, Maize, Sorghum, and Enset have declined by 0.06 %, 0.27%, 0.14%, 0.19%, and 0.01%, respectively. The production of Pulses has also been reduced by 0.04%. Moreover, the production of cash crops like Vegetables, Fruits, Cotton, Tea, and Coffee have declined by 0.11%, 0.35%, 0.01%, 0.01%, and 0.01%, respectively. Similarly, the aggregate returns of livestock have registered negative growth. It has decreased by 0.94%, compared to baseline simulation, particularly the production of Cattle, Milk, Poultry, Animal products and Fisheries have declined by 0.07%, 0.02%, 0.06%, 0.06%, and 0.62%, respectively.

Overall, the most useful lesson learnt from land use change for sugarcane plantation in Ethiopia is the land use change promotes sugar and energy security and appears relatively substantial effects on the level of real GDP and macro indicators, but it has an adverse effect on production of cereals, pulses, livestock and agro-processing industries. However, major negative macroeconomic effects on the other sectors of the economy are not recorded.

In line with the analysis made using the policy simulation, the study has come up with the following policy implication:

Our study clearly shows that is there is a possible trade-offs between sugarcane and other crops production, that is, land use changes caused by higher sugarcane feedstock production have been substantial and brought to a reduction in the production of other crops. The effect at the end might rest on downward shift in wellbeing of the society. Therefore, the policy of using degraded and barren lands for sugarcane production should be considered as a way out to reverse the adverse effect of land use change on production of cereals, pulses, livestock and agro-processing industries.

6. RECOMMENDATION FOR FUTURE RESEARCH

As our model results clearly showed that a fourteen fold expansion of sugarcane produces a slight negative effect on other agricultural sectors as the sector competes for land. And this adversity may and may not deteriorate the welfare of the society. However, performing welfare analysis using dynamic CGE model presents important challenges as one needs to determine who will benefit from the growth and depreciation of production factors. A further extension of this model is required by introducing some endogeneity in the agricultural households' behavior which allow them to switch from one crop to the other. But, the exogenous land endowment limits this type of behavior. Therefore, this type of application will require some further investigation on the household behavior at the micro level for which we lack adequate databases.

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Appendices

Appendix A: Impacts on real output of service sectors (percentage change)

	Initial	Sim0	Sim1	Sim1-Sim0
aelec	3.58	11.29	11.89	0.6
awatr	3.92	11.1	11.31	0.21
acons	85.1	9.73	11.17	1.44
atrad	90.02	12.71	16.34	3.63
ahotl	40.9	10.07	9.86	-0.21
atran	24.6	22.61	20.78	-1.83
acomm	4.03	16.11	16.44	0.33
afsrv	10.5	12.7	12.94	0.24
absrv	1.41	54.59	45.67	-8.92
areal	37.01	13.3	13.15	-0.15
aosrv	6.86	12.12	11.59	-0.53
apadm	20.64	5.81	5.8	-0.01
aeduc	11.08	6.87	6.85	-0.02
aheal	3.23	7.66	7.51	-0.15

Appendix B: Impacts on real output of agricultural sectors (percentage change)

	Initial	Sim0	Sim1	Sim1-Sim0
ateff	14.24	7.23	7.17	-0.06
abarl	8.48	8.78	8.51	-0.27
awhea	15.45	3.62	3.88	0.26
amaiz	14.72	6.05	5.91	-0.14
asorg	8.02	8.03	7.84	-0.19
apuls	12.75	5.22	5.18	-0.04
aoils	4.95	4.95	4.95	0
avege	5.04	6.66	6.55	-0.11
afrui	0.94	9.07	8.72	-0.35

anset	6.04	7.2	7.19	-0.01
acott	1.66	6.09	6.08	-0.01
asugr	1.02	6.46	40.53	34.07
ateal	0.11	7.54	7.53	-0.01
achat	7.15	4.49	4.49	0
atoba	0.05	1.89	1.89	0
acoff	13.78	5.82	5.81	-0.01
aflow	0.36	5.34	5.34	0
aocrp	8.91	3.92	3.99	0.07
acatt	18.07	6.01	5.94	-0.07
amilk	23.34	4.8	4.78	-0.02
apoul	1.43	6.32	6.26	-0.06
aaprd	6.66	4.11	4.05	-0.06
afish	0.18	-1.89	-2.51	-0.62
afore	16.46	5.47	5.57	0.1

Appendix C: Impacts on real output of industrial sector (percentage change)

	Initial	Sim0	Sim1	Sim1-Sim0
Aomin	2.57	3.26	3.26	0
Adair	12.05	2.77	2.93	0.16
Avprd	0.02	10.09	9.73	-0.36
agmll	2.05	7.3	6.67	-0.63
amsrv	2.32	10.97	10.33	-0.64
apsgr	2.79	7.49	26.92	19.43
aptea	0.41	9.15	8.84	-0.31
afood	6.66	7.7	7.69	-0.01
abeve	5.12	11.48	10.52	-0.96
aptob	0.64	13.29	11.48	-1.81
atext	4.6	6.01	5.46	-0.55
aclth	1.17	12.88	9.77	-3.11

aleat	2.69	-4.26	-4.38	-0.12
awood	0.32	5.08	3.5	-1.58
apapr	2.06	14.37	13.41	-0.96
achem	3.16	8.5	2.95	-5.55
anmet	2.29	0.15	-4.62	-4.77
ametl	7.08	22.76	15.91	-6.85
amach	0.03	8.84	9.76	0.92
avehe	0.81	12.4	12.84	0.44
aeequ	0.81	15.59	13.68	-1.91
aoman	6.12	12.69	11.78	-0.91
aeth	0.22	12.73	13.32	0.59
aelec-cog	0.1	17.42	18.73	1.31