Short communication

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Expansion of Sugarcane Production in Ethiopia: Welfare Opportunity or Devastation?

The government of Ethiopia is aiming to boost sugarcane and ethanol production, together with cogeneration. To achieve this goal, enormous sugarcane production strategies have been undertaken without there being concrete evidence as to theirs benefits or detriments to the welfare of households. Here, we used a computable general equilibrium model and SAM dataset to provide useful insights into this story. The results of the study indicate that the average aggregate income and consumption expenditure of households compared to the baseline scenario are negative, although the magnitude of the loss is small. We further find strong evidence that the average aggregate economic welfare of households has deteriorated by 3.43 percent and we conclude that the strategies that the government has been implementing are detrimental to welfare and devastating. Thus, we suggest that the government should cease sugarcane expansion that succeeds at the expense of food crops and policies that favour the use of marginal and barren lands for upcoming sugarcane projects should instead be implemented.

Keywords: Sugarcane, economic welfare, household, general equilibrium, Ethiopia

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Introduction

Ethiopia has traditionally been perceived as the water tower of Africa (Ingebretsen, 2015) and is endowed with a favourable physiographic setting for sugarcane growth and productivity. The country has identified more than half million hectares of land suitable for sugarcane growth with an average productivity of 130 tons per hectare (ESC, 2010). In recent years, the government of Ethiopia has been making considerable investments to boost the sugar sector after observing its immense potential and the dynamic behaviour of domestic demand for sugar and ethanol (USDA, 2015). Between 2009 and 2019, the government has had a plan to expand the area covered with state-run sugarcane cultivations by 333,630 hectares by means of setting aside the land allocated for private farms (ESC, 2010).

This enormous diversion of tracts of land for sugarcane production has been subject of controversy for the last 8 years and will continue to be contentious in the future. Some considered land grabs by the government as a new style of imperialism and appropriation in the name of economic development, while others refer to abuses of the basic human rights of native people. In contrast, advocators of the programme claim that this practice of land use change will not be detrimental and will not lead to the deracination of those indigenous people who were relocated and displaced. They rather argue that those displaced households will have enhanced access to better livelihood and development opportunities (Ingebretsen, 2015).

The shaky argument between proponents and opponents of the programme was lent further support by the contradictory empirical evidence of earlier studies in different countries. Studies by Kennedy and Cogill (1988), Rist *et al*. (2010), Akoth (2016) and Rocca (2016) have found that replacing land for sugarcane cultivation has not jeopardised the income and food security status of households. In contrast, studies by Terry and Ryder (2007), Sparovek *et al*. (2009), Amrouk *et al*. (2013), Hughes *et al*. (2016) and Mwavu *et al*. (2018) reported that land diversion for sugarcane expansion has had detrimental effects on the income and livelihood of households. Similarly, previous studies in Ethiopia by Mengistu *et al*. (2016) and Ingebretsen (2015) predicted adverse results and contradicted the findings of Timkete (2017), who found a positive but small change in GDP.

The mixed results of empirical studies, coupled with human rights abuses reported by different human rights organisations, have led many to ask of whether the policy of reallocating land for sugarcane production should be regarded as an opportunity or instead, a tragedy. This article therefore aims to measure and quantify the impact of the expansion of sugarcane production in Ethiopia by using a computable general equilibrium model, covering the period 2009 to 2019.

The article is structured as follows. The next section briefly reviews the empirical literature on sugarcane production and welfare. Data and methodological issues are described in section three. Section four analyses and discusses the findings, while the conclusions and policy implications are presented in section five.

Review of empirical literature

There is a limited amount of literature about the economic modelling of sugarcane and ethanol production coinciding with cogeneration. Amrouk *et al*. (2013) used an econometric model of a matching technique to analyse structural transformation of sugar market and its implications for smallholder sugarcane farmers in Ethiopia and Tanzania. Their results indicated that a 1% increase in sugar acreage share leaded to a 0.3% reduction in the income of households. Moreover, Mengistu *et al*. (2016) empirically investigated the effects of the public sugarcane growers scheme in Ethiopia and found that participating in these schemes produced significantly negative effects on the income as well as asset stocks of producers and decreased food security in associated villages.

Hughes *et al*. (2016) investigated the effects of large scale sugarcane production on households' food security in El Salvador and their findings implied that farmers involved in commercial sugarcane farming were driven out of business and were vulnerable to food insecurity. A recent study on the expansion of commercial sugarcane production and its impacts on households' food security in Uganda by Mwavu *et al*. (2018) meanwhile found that sugarcane production was among the main causes of food insecurity for households who were engaged in this sector. They also reported that the increased use of land for sugarcane cultivation had reduced the availability of arable fields designated for food crops production. Earlier, Terry and Ryder (2007) also reached the conclusion that converting lands into sugarcane cultivation was the major cause of food insecurity in Swaziland. Similarly, Hartley *et al*. (2018) analysed the economic impacts of developing a biofuel industry in Mozambique using CGE analysis and showed that enlargement of sugarcane farming displacing normal agricultural activities decreased the amount of agricultural food crops produced as well as the welfare of households.

Regarding environmental impacts, Akoth (2016) showed that sugarcane farming reduced grazing fields and forest coverage in Kenya by 12 percent. Similarly, the study by Mwavu and Witkowski (2008) reported that enlarging sugarcane cultivation in Uganda resulted in 8.2% loss of forests. In the study of Sparovek *et al*. (2009), the impact of sugarcane expansion was analysed and a significant reduction of pastures and livestock was reported. Filho and Horridge (2011) estimated the effects of indirect land use change on sugarcane production and found that the expansion of sugarcane cultivation for ethanol production would lead to a fall of pasture land by 0.21%, planted forest land by 0.65% and unused land by 0.02%.

Conversely, some studies reached different conclusions. Akoth (2016), for instance, analysed the socio-economic impacts of sugarcane farming in Kenya and found that sugarcane farming had significantly improved the households' access to income and consequently increased their standards of living. Rocca (2016) meanwhile studied the impacts of commercial sugarcane production in Zambia and found that household income, consumption level and food security of household engaged had improved.

Data and the CGE model

The main dataset generally used in CGE analysis is the Social Accounting Matrix (SAM). This study uses an updated version of 2005/2006 SAM for Ethiopia which was constructed by the Ethiopian Development Research Institute (EDRI). It was updated in 2009. The original SAM disaggregated the economy into 113 activities, 64 commodities and 16 factors. It also has 13 institutions including 12 household groups. Household groups are disaggregated by location as rural zones and urban centres. They are also divided based on poverty status as poor and non-poor households. The rural households are further distinguished based on four main agro-ecological zones (humid, high land cereals, drought prone and pastoralist zones).

In the original SAM, there were no ethanol and cogeneration (bioelectricity) sectors. Ethanol can be produced either from sugarcane through direct conversion or from sugar cane molasses. Ethiopia uses the latter as the sole source of ethanol production yet. Bagasse is another by-product of sugar production used to generate heat and electricity and such technology is known as cogeneration. Thus, omission of these sectors from analysis would understate the aggregate picture of the sugar sector. Therefore, ethanol and cogeneration were included in the SAM and data were collected from four old sugar factories in Ethiopia. By doing so, the SAM has been thoroughly modified to grasp different level of aggregations. It is now disaggregated into 115 activities and 65 commodities, thereby ensuring the originality of the study.

As partial models generally fail to consider the welfare implication of policy changes (Gohin and Moschini, 2006; Hosny, 2013), a multi-sectoral and economy-wide Computable General Equilibrium (CGE) model is used here. The recursive dynamics of the CGE model applied was developed by the International Food Policy Research Institute (IFPRI) as described in Lofgren *et al*. (2002), which is an extension of the IFPRI static model developed by Thurlow (2008). The recursive model basically comprises of two components: the within-period component and the between-period component. The within-period component describes a one-period static CGE model with a total of 46 equations, while the between-period component involves the dynamic part of the model with 6 additional equations. The within-period component consists of four blocks: prices, production and trade, institutions, and system constraints (Lofgren *et al*. 2002). Since the detailed mathematical description of the four blocks would include the description of sets, parameters, variables and equations, we concentrate here on the institutions block for the sake of brevity, and examine how households' income and expenditure equations are specified.

In the CGE model, institutions consists of households, government, enterprise and the rest of the world. Equation 1 represents the total income of each factor. YF_f is total factor income, WF_f is average price of factor, $\overline{WFDIST_{f\alpha}}$ is the wage distortion for factor f from activity a, and $QF_{f\alpha}$ is the quantity demanded of factor f from activity a.

$$YF_f = \sum_{\alpha \epsilon A} WF_f \cdot \overline{WFDIST_{f\alpha}} \cdot QF_{f\alpha} \qquad Eq.(1)$$
$$f \in F$$

The factor income of the institution is divided among domestic institutions in the form of fixed shares after the payment of direct taxes and transfers to the rest of the world.

$$YIF_{if} = shif_{if} \cdot [YF_f - trnsfr_{row\,f} \cdot EXR] \qquad Eq.\,(2)$$
$$i \in INSD;\, f \in F$$

YIF_{if} stands for income for domestic institution i from factor f, $shif_{if}$ represents the share of income by domestic institution i from factor f, and $trnsfr_{row\,f}$ stands for transfers from factor f to the rest of the world.

$$YI_i = \sum_{f\in F} YIF_{if} + \sum_{i\in INSDNG'} TRII_{ii'} + + trnsf_{i\,gov} \cdot \overline{CPI} + trnsf_{i\,row} EXR \quad i \in INSDNG \qquad Eq. (3)$$

Where, $TRII_{ii'}$ denotes transfers from domestic institution i' to institution i, $trnsf_{i\,gov}$ represents transfers from government to institution i, and $trnsf_{i\,row}$ represents transfers from the rest of the world to institution i.

In equation 3, income that households and enterprises received from factors of production and the transfers they obtain from other institutions is included. Households use this income to make consumption, pay taxes, save and transfer to other institutions. Therefore, the total spending of households for consumption is defined as the income difference that remains after taxes, savings and transfers to other non-governmental domestic institutions. We have specified the household consumption expenditure by equation 4 as follows.

$$EH_h = (1 - \sum_{i\in INSDNG} shii_{ih}) \cdot (1 - MPS_h) \cdot \cdot (1 - TINS_h) \cdot YI_h \quad h \in H \qquad Eq. (4)$$

Here, EH_h denotes household consumption expenditure, $shii_{ih}$ denotes the share of net income that household h transfers to institution i, MPS_h stands for marginal propensity to save for household h, $TINS_h$ symbolizes direct tax rate for household h, and YI_h denotes the income of household h.

Household consumption expenditure can be further divided into household consumption demand for marketed commodities and home commodities. In equation 5 and 6, we have specified household consumption demand for marketed commodities and home commodities, respectively.

$$PQ_c \cdot QH_{ch} = PQ_c \cdot \gamma^m_{ch} + \beta^m_{ch} \cdot (EH_h - \sum_{c' \in C} PQ_{c'} \cdot \cdot \gamma^m_{c'h} - \sum_{a \in A} \sum_{c' \in C} PXAC_{ac'} \cdot \gamma^h_{ac'h}) \quad c \in C; h \in H \qquad Eq. (5)$$

$$PXAC_{ac} \cdot QHA_{ach} = PXAC_{ac} \cdot \gamma^h_{ach} + + \beta^h_{ach} \cdot (EH_h - \sum_{c' \in C} PQ_{c'} \cdot \cdot \gamma^m_{c'h} - \sum_{a \in A} \sum_{c' \in C} PXAC_{ac'} \cdot \gamma^h_{ac'h}) \quad a \in A; c \in C; h \in H \qquad Eq. (6)$$

Here, PQ_c stands for composite commodity price, QH_{ch} represents quantity consumption for commodity c by household h, EH_h denotes consumption spending for household h, QHA_{ach} represents quantity for household home consumption of commodity c from activity a for household h, $PXAC_{ac'}$ denotes producer price of commodity c' for activity a, γ^m_{ch} denotes substitute consumption of marketed commodity c for household h, $\gamma^m_{c'h}$ denotes substitute consumption of marketed commodity c' for household h, γ^h_{ach} denotes substitute consumption of home commodity c from activity a for household h, $\gamma^h_{ac'h}$ represents substitute consumption of home commodity c' from activity a for household h, β^m_{ch} symbolises marginal share of consumption spending on marketed commodity c for household h, and β^h_{ach} symbolises marginal share of consumption spending on home commodity c from activity a for household h.

In the baseline scenario, we assumed that the Ethiopian economy continued to grow with its current growth trajectory between 2009 and 2019. We have updated the CGE model for each year to reflect changes in supply of land, population, supply of labour and the productivity of factors. The expansion of land for sugarcane production is assumed to be made on new potential cultivable land (Ferede *et al*., 2013), grazing land (Timkete, 2017) and on lands where different crops are cultivated (Mengistu *et al*., 2016). In our model, total factor productivity (TFP) of all non-agricultural activities is assumed to grow by the rate of 2.9% and for sugarcane activity, by the rate of 5% (Ferede *et al*., 2013; Gebreegziabher *et al*., 2013). Finally, the results of these baseline scenarios are compared with the sugarcane scenario so as to separate the effect of sugarcane production from other effects.

In order to see changes in the welfare of households, the sugarcane scenario was constructed, assuming that large proportions of land was allocated to sugarcane production. In doing so, from 2009 to 2019, we have increased the land allotted for sugarcane cultivation by 6976.96 hectares each year. Given the land assigned to sugarcane production is being utilised, we assume that expansion of sugarcane will influence smallholder farmers in terms of land allocation as they currently account for 95% of the total area suitable for agricultural production.

Results and Discussion

According to the simulation results, diversion of land for sugarcane production can potentially lead to considerable changes in the output of different sectors of the economy. In this regard, Table 1 presents the potential impacts of sugarcane production on sectoral output. Apart from forestry and fishery, the two major agricultural activities, crops and livestock sectors have experienced a reduction in output. Food crop production has reduced by 0.03%, implying that households are more vulnerable in terms of food security as crops account for more than 60 percent of their food items. The overseas studies in El Salvador by Hughes *et al*. (2016), in Uganda by Edward *et al*. (2018) and in Mozambique by Hartley *et al*. (2018) have reported similar negative results. However, results of previous studies in Ethiopia are mixed. The findings of Mengistu (2015) indicate that sugarcane production has threatened the production of food crops. On the contrary, Ferede *et al*. (2013) and Gebreegziabher *et al*. (2013) found a strong positive association between sugarcane production and food crops.

When looking at crops by decomposing into cereals and pulses, again the model predicted that both activities experienced a reduction in output by 0.04% and 0.51%, respec-

Table 1: Sectoral Impacts of Land Use Change.

Sectors	Initial (in billion Birr)	% change from baseline
Crops	122.65	-0.03
Cereals	60.91	-0.04
Pulses	12.75	-0.51
Livestock	49.50	-0.94
Fishing and Forestry	16.64	0.09
Sugarcane	1.02	34.07
Sugar refining	2.79	19.43
Ethanol	0.22	0.59
Food processing industry	29.27	-0.24
Electricity	3.68	0.62
Services	342.88	1.11

Source: Ethiopian Dynamic CGE model simulation results

Table 2: Changes in Agricultural Exports and Imports.

Household Categories	Initial (in billion Birr)	% change from baseline
Agricultural Exports	11.81	-0.74
Agricultural Imports	13.98	0.86
Wheat Import	6.65	2.05

Source: Ethiopian Dynamic CGE model simulation results

Table 3: Impacts of Sugarcane Production on Household Income.

Household Categories	Initial (in billion Birr)	% change from baseline
Rural poor	74.60	-0.72
Rural non-poor	251.16	0.11
Urban poor	3.73	0.33
Urban non poor	31.05	0.32
Total	**360.54**	**-0.04**

Source: Ethiopian Dynamic CGE model simulation results

Table 4: Impact of Sugarcane Production on Household Expenditure.

Household Categories	Initial (in billion Birr)	% change from baseline
Rural poor	70.18	-1.41
Rural non-poor	237.98	-0.60
Urban poor	3.44	-0.58
Urban non poor	27.17	-0.47
Total	**338.77**	**-0.76**

Source: Ethiopian Dynamic CGE model simulation results

tively. This result is consistent with the findings of Terry and Ryder (2007) and Mwavu *et al*. (2018), who also estimated reduction in crops production caused by commercial sugarcane farming. Overall, the reduction in food processing output accompanied with the reduction in cereals and pulses would be detrimental for domestic food supplies and would increase food insecurity and malnutrition for households in Ethiopia.

Our model also show livestock numbers to decrease by 0.94%, which is consistent with the findings of Sparovek *et al*. (2009) and Gebreegziabher *et al*. (2013), indicating that sugarcane production has a negative effect on livestock. Consistent with the finding of Hartley *et al*. (2018), the food processing industry also records a decline in output by 0.24% in our model. Conversely, as presented in Table 1, forestry and fishery, service, sugarcane, sugar refining, ethanol processing, and electricity sectors shows signs of output growth.

As clearly illustrated in Table 1, sugarcane production leads to decline in the two imperative components of agricultural output, crops and livestock. A reduction in agricultural output also leads to a 0.74% decline in agricultural and a corresponding 0.86% increase in agricultural imports as evident from Table 2. It is obvious that a small reduction in agricultural exports would largely exacerbate the trade deficit of the country as more than 90% of the Ethiopian export is generated from agricultural output and livestock products (Asresie and Zemedu, 2015). This result is consistent with the finding of Ferede *et al*. (2013) who find sugarcane expansion (under sugarcane scenario) to have contributed to the worsened trade balance in Ethiopia.

Conversely, the model predicted that the Ethiopian import of agricultural commodities could essentially increase in response to sugarcane production. This could force the country to import agricultural and livestock products to maintain domestic food consumption. The increase in the import of wheat by 2.05%, as presented in Table 2, is a good sign of increased food insecurity. Previous studies by Terry and Ryder (2007), Hughes *et al*. (2016) and Mwavu *et al*. (2018) support our finding that expansion of sugarcane is contributing to the food insecurity of households.

The simulation also brought consequences for households' income, as Table 3 suggests. Our results indicate that the average aggregate household income decreased since crop production and livestock give a significant portion of households' income in Ethiopia (Ayele *et al*., 2003). When looking at the impact by type of households, the adversely impacted households are rural poor (0.72%). However, in consistent with the finding of Akoth (2016), the results of the present study for rural non-poor and urban households are positive.

As reported in Table 3, this study finds an average aggregate deterioration in households' income by 0.04%. This implies that the improvements in the income of the rural non-poor and urban households are not adequate to offset the losses felt by rural poor households. The general deterioration of income by 0.04% is not astonishing as the expansion of sugarcane production is being applied on rural farmers' land, and land is the primary source of rural income. In keeping with the studies of Amrouk *et al* (2013) and Mengistu (2015), we found that expansion of sugarcane cultivation had reduced the income of households in Ethiopia. However, it remains the case that the findings of Akoth (2016) and Rocca (2016) showed that sugarcane production improved the income of households.

Table 4 presents the potential impacts of sugarcane production on households' consumption expenditure. Simulation results show that all categories of households have been adversely impacted with an average aggregate decline of 0.76%. Household expenditure decline was the highest for rural poor households (-1.41%) and lowest for urban non-poor households (-0.47%). The decline in consumption expenditure for rural non-poor and urban poor households are moderate (0.60% and 0.58%, respectively). The average aggregate result implies that massive sugarcane production would force both rural and urban households to remain poor

Table 5: Impact of Sugarcane Production on Household Welfare.

Household Categories	Initial (in billion Birr)	% change from baseline
Rural poor	70.18	-3.94
Rural non-poor	237.98	-3.52
Urban poor	3.44	0.20
Urban non poor	27.17	-1.74
Total	**338.77**	**-3.43**

Source: Ethiopian Dynamic CGE model simulation results

in consumption expenditure terms during the period under consideration. This is mainly due to a decrease in the income of households. This finding contradicts Rocca (2016) but supports the findings of Hartley *et al*. (2018).

As reported in the discussion of Juana *et al*. (2008), the sign of the Equivalent Variation (EV) has different implications for households' welfare. A positive EV represents an improvement in the welfare of households and a negative EV indicates deterioration in the welfare of households. Similarly, the pattern of households' income and expenditure determines the welfare status of households. A rise in the income and expenditure of households represents an improvement in the welfare of households and a fall implies welfare loss. Therefore, in this study, changes in households' income and expenditure considered as the measurements of welfare.

On this basis, we have undertaken a single policy simulation to examine the impacts of sugarcane production on the economic welfare of households in Ethiopia as presented in Table 5. The average aggregate households' welfare has shown deterioration by 3.43% when using equivalent variation as a measure of welfare during the period of the study. Among the household categories, the largest welfare loss was found to have been experienced by the rural poor (3.94%). The only household category that recorded a small improvement in welfare was the urban poor, by 0.20%. This is contrary to the findings of Rocca (2016), while our results support the finding of Mengistu *et al*. (2016), and prove that the expansion of sugarcane production is causing general economic welfare losses to households in Ethiopia.

Conclusions

The article has analysed the potential impacts of sugarcane production in Ethiopia by using a CGE model quantifying the underlying welfare benefits and losses that households would incur using a 2009 updated SAM. According to the results, the diversion of land for sugarcane production brings about considerable changes in sectoral output, agricultural trade and economic welfare. The simulation results have shown that sugarcane expansion decreases crop and livestock production by 0.03% and 0.94%, respectively. Agricultural export is assumed to decrease by 0.74%, household income by 0.04% and households expenditures by 0.76%. All this results in a welfare loss of 3.43%, according to the scenario simulations.

The most important conclusion of the analysis is that there is a strong trade-off between sugarcane plantation and household welfare in Ethiopia, resulting in food insecurity and malnutrition. Consequently, sugarcane production should only be expanded in degraded and marginal lands with prudent planning and implementation. As to future research, it would be interesting to examine the distributional and poverty impact of sugarcane production using micro-simulation models to get more insights into our story.

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