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National and Regional Implications of Agricultural Efficiency Improvement in Sudan

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Abstract

Agriculture in Sudan has three main farming systems: (a) traditional rain-fed sector; (b) mechanized rain-fed sector; and (c) irrigated sector. The traditional rain-fed sector, which is the focus of this paper,occupies an average of 60% of the total cultivated land and employs about 65% of the agricultural population during the last ten years. Nevertheless, this sector is characterized by low crop productivity mainly driven by low technical efficiency; therefore, it has contributedonly an average of 16% to the total agricultural GDP during the last decade.This paper is an attempt to assess the national and regional effects of improving technical efficiencies of the crops produced in this sector.The Global Trade Analysis Project (GTAP) and the GTAP Africa Database that includes the newly constructed Sudanese Input/Output Table are employed for this purpose. Technical change parameters of the value-added functions of the model are augmented to reflect the intended simulations. Results indicate that improving the technical efficiencies of the major crops in the traditional rain-fed sector of Sudan would improve the country's overall GDP and welfare. Moreover, it increases the domestic output and improves the trade balances of the crops in the traditional rain-fed sector, for which efficiency improvement is simulated. Results also indicate that the efficiency improvement scenario would have slight regional effects as it increases the domestic demand for imported grain crops and oilseeds from Sudan into the Middle East and North Africa, Congo and Ethiopia.

الآثار المحلية والإقليمية لتحسين الكفاءة الزراعية في السودان

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ملخص

تشكل الزراعة في السودان ثلاثة نظم زراعية، أهمها قطاع الزراعة البعلية التقليدية (محور هذه الورقة) الذي يشكل حوالي 60% من مجموع الاراضي المزروعة، ويوظف نحو 65% من إلسكان الزراعيين خلال السنوات العشر الماضية ومع ذلك، فإن هذا القطاع يتميز بانخفاض إنتاجية المحاصيل فيه مدفوعا بإنخفاض الكفاءة الفنية، وبالتالي فإنه كان يسهم فقط بحوالي 16% من الناتج المحلي الإجمالي الزراعي خلال العقد الماضي. هذه الورقة هي محاولة لتقييم الآثار الوطنية والإقليمية لتحسين الكفاءة التقنية للمحاصيل المنتجة في هذا القطاع. وقد استخدمت لهذا الغرض بيانات المدخلات/المخرجات السودانية التي تم بناؤها حديثا والتي تضمنتها قاعدة بيانات المشروع التحليلي التجاري الدولي لافريقيا. ومن اجل ان تعكس المحاكاة المقصودة، فقد تمت زيادة معاملات التغيير التقني لمعادلات القيمة المضافة للنموذج. تشير النتائج إلى ان تحسن الكفاءة التقنية للمحاصيل الرئيسية في قطاع الزراعة البعلية التقليدية للسودان من شانه ام يحسن من رفاه الدولة وناتجها المحلي الإجمالي. وعلاوة على ذلك، فإنها ستزيد من الإنتاج المحلي وتحسن الموازين التجارية للمحاصيل في قطاع الزراعة ألبعلية التقليدية. كما تشير النتائج إلى ان سيناريو تحسين الكفاءة سيكون طفيفا على المستوى الإقليمي.

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1. Introduction

Sudan is an agrarian country endowed with enormous amount of resources including arable land, animal resources, fresh water sources and different types of climate. These factors qualify it to contribute significantly to the Arab world food security issues. Moreover, petroleumextraction, peace establishment in southern Sudan, and the assignation of a separate Ministry for Investment have created a suitable investment climate that led to considerable increases in the volume of foreign investment particularly from Arab countries (MFNE, 2009).

The volume of agricultural investment in Sudan was only US$5.1 million in 2004, of which Arab countries' share was 75%. In 2008, it showed a considerable increase and reached US$300 million. The average share of Arab countries during the period 2004-2008represents about 80% and in 2008 alone,it reached 98% (MFNE, op cit.).

Despite the deterioration in the share of agriculture in the total Sudanese exports from 73% in 1998 to 6% in 2007 and 5% in 2008 due to increasing oil exports,agriculture remains an important sector in the Sudanese economy. Its importance evolves from its annualcontribution of an average of 45% to the country's GDP during the last ten years (CBOS, 2009).It also employs about 80% of the total labor force including agricultural-related activities (Siddig, 2009a). Furthermore, it derives activity in the industrial, trade and service sectors such as transportation, agro-industries and commerce, which account for a large part of the rest of the economy.

Despite the high growth rate of the Sudanese economy during the period between 2000 and 2006, poverty has increased within the agricultural population. Abadi and Ahmed (2006)explain this by the decreasing share of the traditional sector in the total agricultural GDP and the growing population within the sector. Theaverage contribution of the traditional sector to agricultural GDP during this period accounts to 15%, the irrigated subsector to 28%, and the mechanized sector to 4%, while forestry and animal production accounts for the remaining 53%. However, the proportions of population depending on these subsectors during the same period were 70%, 12% and 0.7%, respectively. This means that the contribution of the traditional sub-sector to agricultural GDP falls short relative to the proportion of the population depending on it. Hence, strategic action has to be undertaken to enhance the efficiency of production in the traditional sector, in order to improve the livelihood of the population. Efficiency improvement is necessary to produce higher quality goods in a more efficient manner, which results in lower costs to consumers, and raises per capita incomes over time (Abadi and Ahmed, op cit.).

This paper focuses on the major crops grown in the traditional rain-fed sector of Sudan, namely cereals and oilseeds. Cereals grown in the traditional rain-fed sector are sorghum and millet, while wheat is mainly grown in the irrigated sector. In this paper, sorghum and millet are allocated to a GTAP sector called 'grains and crops'and henceforth, it will be referred to as 'grains and crops'. The selection of cereals and oilseeds in this paper is important as the first represents a major staple food in Sudan, while the second are major agricultural exports in Sudan.

More specifically, this paper simulates the situation where labor skills in the traditional rain-fed sector is improved based on an assumed additional allocation of capital to the sector introduced in terms of extension services, advanced technology, improved seeds and rational use of inputs. The findings of the paper are important as it appeals to tackling recent national and regional interests, especiallyin relation to the recent increase in international food demand and prices.

2. Agricultural Sector Efficiency in Sudan

Agriculture in Sudan has three main farming systems namely: (a) traditional rain-fed sector; (b) mechanized rain-fed sector; and (c) irrigated sector. The traditional rain-fed sector, which is the focus of this paper, occupies an average of 60% of the total cultivated land and employs about 65% of the agricultural population during the last ten years. Nevertheless, this sector continues to be characterized by low crops' productivity that is mainly driven by lower technical efficiency. Therefore, it has contributed only an average of 16% to the total agricultural GDP during the last ten years.

Efficiency literature in the Sudanese context reveals that productivity in the overall Sudanese agriculture is low. This is especiallytrue in the traditional sector that provides staple food for the majority of the subsistence farmers and other domestic consumers besides its contribution to the export sector. In a global comparison, TruebloodandCoggins (2001) used the Malmquist index approach to examine inter-country agricultural efficiency and productivity. They carried out an inter-country agricultural productivity and efficiency survey, in which they studied 151 countries including Sudan covering the period between 1961 and 1991.The Malmquist approach can distinguish between two sources of productivity growth, which are changes in technical efficiency and technical change.Their results show that developing countries'productivity declined over the study period.

Table 1 shows the productivity weighted growth rates for aggregated groups of countries and regions according to economical and geographical bases, throughout the period between 1963 and 1990.

Table 1: Productivity Weighted Growth Rates, by Group and Region (1963-1990)

Region	1963-1965	1966-1970	1971-1975	1976-1980	1981-1985	1986-1990
World	-2.3	-1.9	-2.4	-1.6	0.0	0.2
Economic Groups:						
Developed Countries	0.1	1.6	0.7	1.8	2.6	2.4
Developing Countries	-3.0	-1.9	-1.4	-1.1	0.4	0.7
Central Planned Econ	1.6	-0.2	-1.4	-0.2	2.5	3.2
Geographic regions:						
N. America / Oceania	-0.4	1.4	0.7	2.8	2.6	2.7
Latin America	-3.2	-1.6	0	-0.7	0.0	0.9
Western Europe	1.6	2.5	1.3	1.5	2.9	2.4
E. Europe and Soviet Union	-1.1	0.2	-0.8	-1.4	0.4	2.6
North Africa / Mid East	-1.5	-1.7	-1.2	-2.2	1.3	1.5
Sub-Sahara Africa	-2.8	-2.3	-2.8	-1.1	0.5	2.1
Asia	-3.4	-1.9	-1.8	-1.2	0.6	-0.1
People>s Rep. of China	6.1	-0.8	-2.3	1.2	4.7	3.9

Source: Truebloodand Coggins (2001).

Sudan's decrease in agricultural productivity — among other countries like Afghanistan, Korea, Nicaragua, Nigeria, and Turkey-has been due to decreases in both efficiency and technology adoption. Thestudy of TruebloodandCoggins (2001) reveals thatthe average technical efficiency scores by scale assumption during the period between 1961 and 1990was 0.67. The productivity profile of Sudan in their study shows the multifactor productivity to be -1.21, an efficiency change of -1.21, and technical change to be -0.10. Table 2A of the Appendix shows a comparison between the productivity profiles of selected 24 countries including Sudan, several African countries, and countries from the Middle East, Europe and the United States.

At the cropslevel, several studies have addressed the efficiency of producing various crops in Sudan. For instance, Mohamed et al.(2008)estimate the technical efficiency of producing sorghum in western Sudan. Their results show that the mean technical efficiency of sorghum production is 0.65, which is quite similar to the global study of Truebloodand Coggins (2001) showinga technical efficiency of 0.67 for Sudan. Mohamed et al.(2008a) carried out a similar study to measure technical efficiency of sesame production in the Kordofan state. Their results show that the average technical efficiency of sesame production is 72%. This indicates that sorghum and sesame farmers can increase their level of production by 35% and 28%, respectively at the given set of inputs and technology.

In a single country computable general equilibrium modeling framework, Siddig (2009a) has studied the effects of agricultural efficiency improvement in Sudan. His results reveal that improving the efficiency would improve GDP, private income and consumption, government income and trade balance. He explainedthese positive effects of efficiency improvement on the macroeconomic indicators by the resultingincrease in the domestic output of the agricultural crops thatin turn increasesthe income of production factors and hence private household.He further analyzed combining the increase in agricultural efficiency with exchange rate devaluation, where his results show that exports and welfare levels would improve, while imports would decline(Siddig, op cit.).

It is obvious from this literature survey that agricultural production in Sudan and particularly in the traditional rain-fed sector, is technically less efficient. Therefore, introducing advanced technologies in the agricultural practices, improved seeds and improving the extension services could improve the sector's performance. Obviously, these strategies would consequently enhance the livelihood of the people.Accordingly, this paper tries to simulate this exercise of improving efficiency using a global modeling approach in order to improve the awareness about its impact not only at the national level, but also on the regional level.

3. Research Methodology

This paper employs the model of the Global Trade Analysis Project (GTAP) and its new Africa Database Source (Siddig, 2009a).The global Computable Equilibrium (CGE)modeling framework of the GTAP is one of the most popular modelsfor analyzing the impact of trade policy.

There are various advantages of employing GTAP model in this study. Firstly, since it is a multi-regional model of world production and trade, it can take into account the overall trade implications of agricultural efficiency changes in Sudan taking into consideration all the countries and regions likely to be affected. Secondly, it contains a database for different sectors and thus, can explore the trade implications for various sectors of interest.(1) Moreover, it has a detailed representation of the technological change within the production factors that support the idea of employing it in this research.

The GTAP model is a comparative static, global CGE model based on neoclassical theories. It is a linearized model assuming perfect competition in all markets, constant returns to scale in all production and trade activities, and profit and utility maximizing behavior of firms and households respectively. It is solved using the GEMPACK software.(2)

Because the GTAP model is complex, it may be useful to provide a simplified graphical representation of the basic structure of the model. Figure 1 presents the basic flows for one region model, focusing on an open-economy without government intervention.(3) For simplicity, there is no depreciation in this figure, and government intervention in the form of taxes and subsidies is also omitted. However, all will be considered in the explanations. At the top of the figure is the so-called regional household, which has a fixed endowment with primary factors of production (land, labor and capital). Labor without government intervention—the only source of income for the regional household — is sales of endowment factors to producers. Therefore, factor payments flow from producers to the regional household. The regional household has an aggregate utility function which allocates regional income across three broad categories: (a) private expenditure; (b) government expenditure; and (c) savings. As regional income rises, the regional utility function takes changes in private expenditures into account, as well as savings and government purchases (Hertel and Tsigas, □□□□).

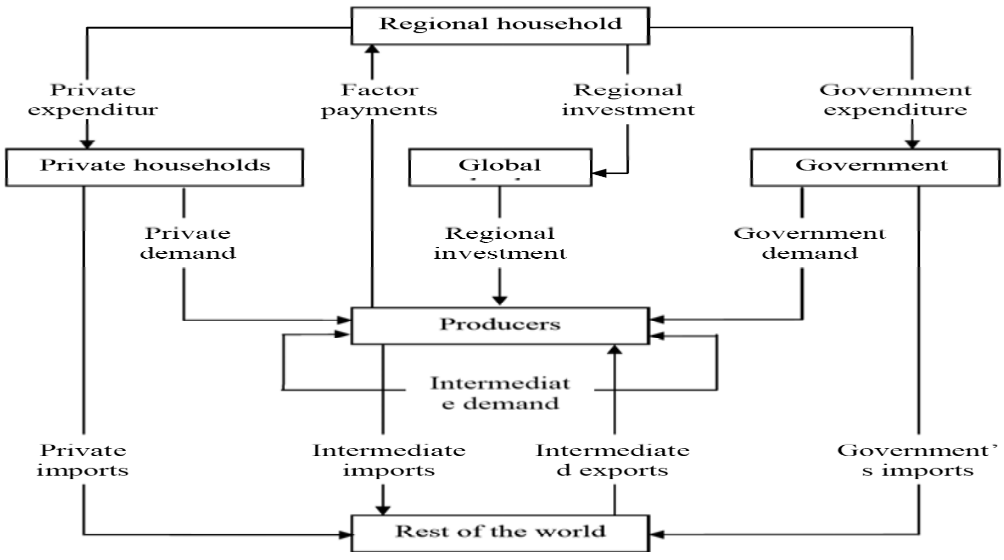

Figure 1. Flows in an open economy model without government intervention. (Adapted from Brockmeier, □□□□□

Producers' Behavior

Producers receive their income from selling consumption goods and intermediate inputs to consumers in the domestic market and/or to other regions. This income must be spent on domestic intermediate inputs, imported intermediate inputs, factor payments and taxes paid to regional household (taxes on both domestic and imported intermediate inputs and production taxes net of subsidies) in order to satisfy the zero profit assumption employed in the model.

For production, a nested production technology is considered assuming that every industry produces a single output, constant returns to scale (CRS) prevail in all markets, and the Leontief production technology is assumed for industries output. As shown in Figure 2, producers maximize profits by mixing composite of factors — value added (qva) — and composite intermediate inputs (qf). Value added itself is a Constant Elasticity of Substitution (CES) function of labor, capital, land and natural resources (qfe). Intermediate composite is a Leontief function of material inputs, which are in turn, a CES composition of domestically produced goods and imports. Imports are sourced from all regions following the CES function (Brockmeier, 2001). Furthermore, laboris disaggregated to skilled and unskilled.

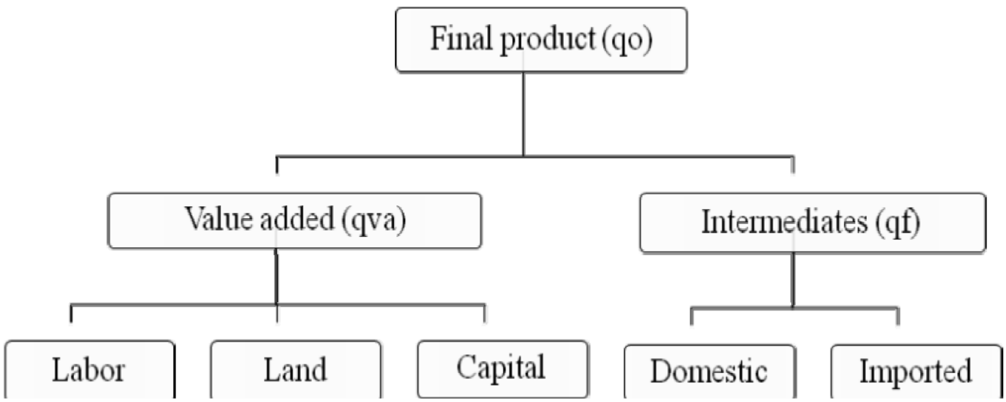

Figure 2.The production tree in the GTAP model

Source: Hertel and Tsigas, (1997)

The technology tree of Figure 2 provides a visual display of the technology for firms in each of the industries in the model. It represents separable, constant returns-to-scale technologies. At the bottom of the inverted tree are the individual inputs demanded by the firm, where the primary factors of production in the model are land, labor and capital in addition to natural resources. Their quantities are denoted qfe(i,j,s), where i is the production factor (endowment commodities), j is the industry (production sector), and s is the region.

The manner in which the firm combines individual inputs to produce its output —qo(i,s) — depends largely on the assumptions of separability in production. Firms are assumed to choose their optimal mix of primary factors independentlyof the prices of intermediate inputs. Therefore, the elasticity of substitution between any individual primary factor, on the one hand, and intermediate inputs, on the other, is equal.

Within the primary factor branch of the production tree, Equations 1 and 2 describe the value-added nest of the producers' technology tree. In particular, they explain changes in the price of composite value-added (pva) and the conditional demands (qfe) for endowment commodities in each sector. The coefficient SVA(i,j,r) refers to the share of endowment commodity i in the total cost of value-added in sector j of regionr(Equation 1).

In addition to the price variables —pfe(i,j,r) — these equations include variables governing the rate of primary factor augmenting technical change afe(i,j,r). More specifically, this is the rate of change in the variable afe(i,j,r), where afe(i,j,r)⋆qfe(i,j,r) equals the effective input of primary factor i in sector j of region r.

Therefore, a value of afe(i,j,r) > 0 results in a decline in the effective price of primary factor i. For this reason, it enters the equations as a deduction from pfe(i,j,r). This has the effect of: (a) encouraging substitution of factor i for other primary inputs via the right-hand side of Equation 2; (b) diminishing the demand (at constant effective prices) for i via the left-hand side of Equation 2; and (c) lowering the cost of the value-added composite via Equation 1 thereby encouraging an expansion in the use of all primary factors.

Equation 1 $\forall j \in$ production sectors and r $\in$ regions

Equation 2 $\forall i \in$ production factors, j$\in$ production sectors and r $\in$ regions

Consumers' Behavior

Each region has a single representative household, termed as the regional household, the income of which is generated through factor payments and tax revenues net of subsidies. Expenditure categories include private household expenditure, government expenditure and savings according to a Cobb Douglas per capita utility function. The private household buys commodities to maximize utility subject to its expenditure constraint represented by a Constant Difference of Elasticity (CDE) as an implicit expenditure function. They spend their income on consumption of both domestic and imported commodities and pays taxes. This consumption is a Constant Elasticity of Substitution (CES) aggregate of domestic and imported goods where the imported goods are also CES aggregates of imports from different sources (regions). Taxes paid by the private household are commodity taxes for domestically produced and imported goods and the income tax net of subsidies.

The government also spends its income on domestic and imported commodities and pays taxes. For the government, taxes consist of commodity taxes for domestically produced and imported commodities. Like the private household, government consumption is a CES composition of domestically produced goods and imports, but Cobb Douglas sub-utility function is employed to model the behavior of government expenditure (Hertel, 1997).

Savings and Investment

In the multiregional setting, the model is closed by assuming that regional savings are homogenous and contribute to a global pool of savings (global savings) and the demand for investment in a particular region is savings-driven. These savings are then allocated among regions for investment in response to the changes in the expected rates of return in different regions. If all other markets in the multiregional model are in equilibrium and all firms earn zero profits while all households are on their budget constraint, such a treatment of savings and investment will lead to a situation where global investment must equal global savings, and the Walras'Law will be satisfied (Kelali, 2006).

Database and the Aggregation of Regions and Sectors

The GTAP Africa Database (GAD)is a special version based on GTAP 6 Database. It includes data for 39 regions (30 African regions and 9 other aggregated regions) covering the 57 sectors(4)of the GTAP 6 Data Base. The Sudanese Input/Output Tables

(IOT) is one of the newly contributed IOTs among other six African countries that have been contributed by African economists. Detailed documentation of the Sudanese IOT is available in Siddig(2009b)Furthermore, the missing bilateral trade flows for the African regions have been econometrically estimated, using the gravity approach, which is documented byVilloria (2008).

The GAD is helpful in assisting African policy makers to quantitatively assess different trade agreements and other economic issues. A more specific and disaggregated policy analysis in Africa has been constrained by data limitation and this special database is expected to loosen such constraints.

The Aggregation of GTAP Database

Region Aggregation.The database has been aggregated in special way to suit the objectives of this paper. Regions are aggregated from the 39 regions of GAD to 11, including Sudan, Middle East and North Africa (MENA)and Common Market of East and Southern Africa (COMESA).Moreover, other COMESA members are excluded to be represented separately including Egypt, Ethiopia, Kenya, and Uganda.Hence, the region COMESA in this context is a modified region, which doesnot include the four aforementioned countires.The rationale of this disaggregation is to allow the observation of the implications of the simulated scenarios on these closely related countries and regions to Sudan. The rest of the world countries are also disaggregated to East Asia, the European Union, and Rest of the World, in order to monitor possible changes in the amounts and directions of oilseed trade with the EU and EastAsian countries. The idea of separating East Asia from the rest of the world emanates from the strong trade linkages between Sudan and the region's countries like China, Japan, Korea and Indonesia.

Sector Aggregation.A similar exercise was also followed in the aggregation of the database sectors. It was aggregated in a way that allows representing oilseeds and grain crops, each in a separated sector. Wheat is separated from other grain crops because it is mostly grown in the irrigated sector, while other grain crops are mainly traditional sector's crops. The rest of the sectors in the database were aggregated to ten in order to allow monitoring any possible intersectoral shifts in terms of resources and intermediate use as a result of the improving the efficiency of grain crops and oilseeds. Hence the 57 sectors of GAD are aggregated to 14 new sectors. Table 2 shows the complete list of sectors and regions considered in this research.

4. Simulation Set up and Discussion of Results

This section highlights the setup of the scenarios simulated in this paper and discusses its results.Three scenarios are considered as follows:

Scenario 1: Efficiency Improvement. This scenario increases the labor and capital augmenting technology change parameter ofgrain crops and oilseeds by 5%, while assuming everything else is constant;

Scenario 2: Efficiency Improvement and Subsidy Removal.This scenario increases the labor and capital augmenting technology change parameter of grain crops and oilseeds by 5% and removes the base rate of subsidy;

Table 2: Sectors and Regions Aggregation

No.	Sectors Aggregation	No.	Regions Aggregation
1	Wheat	1	Sudan
2	Grain crops	2	Egypt
3	Oilseeds	3	Ethiopia
4	Sugar	4	Uganda
5	Forestry	5	Congo
6	Meat and livestock	6	Kenya
7	Extraction	7	Rest of the Middle East and North Africa (MENA)
8	Processed food		
9	Textile and wearing apparels	8	East Asian countries
10	Light manufactories	9	The European Union (EU – 25)
11	Heavy manufactories	10	Rest of Common Market for Eastern and Southern Africa (COMESA)
12	Utility and construction		
13	Transport and communications	11	Rest of the World
14	Other services		

Scenario 3: Efficiency Improvement and Taxation. This scenario increases the labor and capital augmenting technology change parameter of grain crops and oilseeds by 5% and imposes a targeted tax rate of 5% on the same sectors.

The rationale of setting the scenarios in this specified way is to assess the significance of improving the agricultural efficiency in the traditional sector of Sudan under different possible assumptions. Therefore, the first scenario augments labor and capital with 5% for grain crops and oilseed in the status quo, in which case, the likely impact of efficiency improvement in the two sectors maybe noted.The second and third scenarios have similar objectives. However, they investigate the sensitivity of the obtained gains from the efficiency improvement by removing the base rate of subsidy, which is 0.05% in the second scenario and by imposing a 5% targeted tax on production in the third. The last two scenarios represent a kind of sensitivity analysis that reduces the positive impact of improving the efficiency and leaves room for some cost-related issues of efficiency improvement in the selected sectors to be covered.

The remaining part of this section discusses the response of the economy to the three scenarios. It shows the impact on the macroeconomic indicators, trade variables, sectoral output, and welfare measures. Moreover, it shed lights on the possible changes in the country's trade with some neighboring countries as well as investigating any possible impacts on the economies of the region.

5. Effects of Efficiency Improvement on Sudan's SectoralOutput and Trade

As reported in Table 3 which shows percentage changes from the base values of the sectoral output, improving the efficiency of oilseeds and grain crops production would lead their output to increase by 5% and 3%, respectively. Other related sectors such as livestock production, processed food and services would also slightly improve, indicating the importance of the two sectors as intermediate inputs for the agro-industries in Sudan. Adversely, there are some contractions in the output of other competing sectors that could be due to resource competition and specifically reallocation of the limited production factors across sectors.

Grain crops and oilseeds'output would improve only in the scenarios where tax rate doesnot increase. This means that the removal of the small subsidy of the baseline data will slightly lead the change in output to vary from that of Scenario 1. On the other hand, the imposition of a 5% tax on production will absorb all the gains achieved from improving the efficiency and will lead the output of the selected sector to deteriorate instead of improving it.Private incomeanddomestic demand for commodities would also improve due to the first two scenarios and falls due to the third.

Sectoral trade balance, which measures changes in the trade balance of the commodity (i) in the region (r) inUS$ millions, follows almost a similar trend as that of the output. Grain crops trade balance increases by US$12 million and US$11million due Scenarios 1 and 2 respectively, while oilseeds increases by US$9 million and US$8million for the same scenarios. On the other hand, Scenario 3 reduces the sectoral trade balance by US$3 million for grain crops and US$1 million for oilseeds (Table 3). These are due to increased exports in the case of oilseeds and decreased imports of grain crops.

As reported in Table 4, the trade balance of sectors — other than grain crops and oilseeds — has negative signs under the first two scenarios. This is justified by similar shifts of production factors and specifically land to be grown with the grains and oilseeds; hence, production and exports of other crops will decline. On the other hand, the enhancement of income due to efficiency improvement would result in an increased demand. Consequently, thisincreases imports which, together with deteriorated exports, will explain the resultant negative change in the trade balances. The results of Scenario 3 confirm this justification as imports contrast due to the lesser income; hence, trade balance improves.

Table 3: SectoralOutput's Effects of Improving the Agricultural Efficiency

Sectors	Percentage change from the base values		
	Scenario1	Scenario2	Scenario3
Wheat	-1.42	-1.17	1.51
Grain crops	2.72	2.46	-0.35
Oilseeds	4.77	4.30	-0.56
Sugar	-0.97	-0.83	0.71
Forestry	-0.51	-0.42	0.56
Meat and livestock	0.02	0.07	0.55
Extraction	-0.60	-0.53	0.19
Processed food	0.25	0.25	0.26
Textile and wearing apparels	-1.95	-1.70	0.94
Light manufactories	-2.67	-2.34	1.32
Heavy manufactories	-0.97	-0.83	0.63
Utility and construction	0.68	0.64	0.21
Transport and communications	0.13	0.14	0.32
Other services	0.17	0.19	0.37

It should be noted that commodities' balance of trade reflects the direction of producers' preferences either towards the local market or to the international market, given the comparative advantage that each sector has and its ability to compete. In this regard, the improvement in the trade balances ofgrain crops and oilseeds confirms that the producers and consumers of grain crops in Sudan prefer domestic grain crops, while producers prefer the international oilseeds market.

6. Effects of Efficiency Improvement on Sudan's Macroeconomic Indicators

As shown in Table 5, improving the efficiency of oilseeds and grain crops production in Sudan will lead the GDP quantity index to increase by 0.3% and GDP value index by 1.2%.This improvement in the GDP is mainly due to the increase in the output of the two crops as well as other related sectors such as food industries and livestock as mentioned previously.

Under the tax scenario, the GDP value index will slightly deteriorate affectedby the production side more than the consumption side as output will apparently deteriorate. In addition, the levels of household income and consumption wouldalso deteriorateas results of the higher tax rates.

Table 4: Trade Effects of Improving the Agricultural Efficiency of Grain Crops and Oilseeds

Sectors	Change from the base (US$ Millions)		
	Scenario1	Scenario2	Scenario3
Wheat	−0.77	−0.71	−0.03
Grain crops	11.90	10.66	−2.60
Oilseeds	8.63	7.78	−1.20
Sugar	−1.66	−1.46	0.63
Forestry	−0.02	−0.02	0.01
Meat and livestock	−3.28	−2.84	1.89
Extraction	−5.27	−4.78	0.26
Processed food	−4.89	−4.41	0.70
Textile and wearing apparels	−2.30	−2.09	0.13
Light manufactories	−5.82	−5.30	0.39
Heavy manufactories	−18.77	−17.15	0.18
Utility and construction	−0.04	−0.04	0.02
Transport and communications	−1.57	−1.41	0.23
Other services	−1.64	−1.47	0.41

Equivalent variation (EV) — which measures the changes in the welfare levels resulting from the simulation scenarios in US$ millions —would increase by more than US$40 millionunder the first two scenarios due to the improvement in the allocative efficiency components of the EV.(5)However, trade balance will deteriorate by an average of US$23 million under the same two scenarios. This deterioration in trade balance can be explained by the corresponding improvements in the welfare levels and the import oriented household demand, whichincreases imports. Adversely, the higher tax rates of the third scenario reduce household income, decrease the consumption of imported commodities, and hence, improve trade balance.

Regional Implications of Efficiency Improvement in Sudan

Scenario 2.Figure 3 summarizes the effects of improving the efficiency of Sudanese grain crops and oilseeds on theirexports by destination. Only the second scenario is selected for this exercise.It shows the impact of improving the agricultural efficiency in the two selected sectors, while removing their baseline level of subsidies. The rationale of this selection is that,it is a moderate scenario in terms of examining the sensitivity compared to the third scenario, while it has the same improvement in efficiency compared to the first. Therefore this sub-section reflects the regional implications of moving from subsidizing agriculture to improving efficiency in the Sudan. Results reveal that exports of the two selected sectors fromSudan to the ten selected regions would increase by an average of 9%.This, in turn, justifies the improvement of these sectors trade balance by US$11 million and US$8 million, respectively.

Table 5.Macro-effects of Improving the Agricultural Efficiency in Sudan

Macro-indicators	% change (or absolute change*)		
	Scenario1	Scenario2	Scenario3
Trade balance* (X-M US$ million)	-25.51	-23.23	1.02
Equivalent variation* (US$ million)	41.2	40.39	30.94
GDP quantity index	0.29	0.29	0.28
Volume of merchandize imports	0.94	0.86	0.03
Volume of merchandize exports	0.11	0.11	0.14
GDP value index	1.16	1.05	-0.06
Value of merchandize imports	0.94	0.86	0.03
Value of merchandize exports	-0.02	-0.01	0.13
Household income	1.20	1.09	-0.04
Household consumption expenditure	1.18	1.08	-0.04

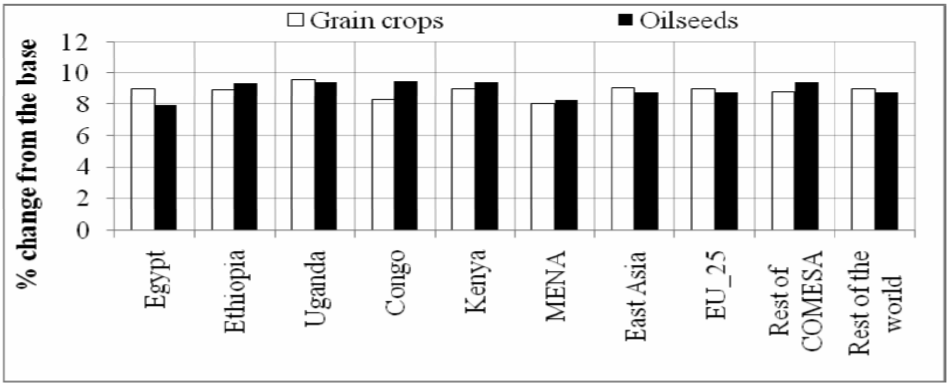

Figure 3. Regional exports' effects of improving agricultural efficiency in Sudan.
Source: Authors' Model's Results

Regionwise, the higher increase will be in grain crops exports to Uganda, which would increase by 10%. Moreover, considering the average increases in the exports of the two sectors, Uganda would also receive the highest share.

As a result of the same scenario, the levels of domestic demand for imported grain crops and oilseeds in the receiving countries would slightly increase. This is depicted in Figure4, where consumption demand for imports isshown. More specifically, it shows the domestic demandfor imported grain crops and oilseeds in Egypt, Ethiopia, MENA and the Congo, as the GTAP model differentiates between the private and government demand for commodities.

Figure 4 shows both components, where Egypt and MENA witnessed higher demand for oilseeds compared to Ethiopia and Congo, and Ethiopia shows the highest increase in grain cropsdemand.

The response of oilseeds tothe selected scenario in terms of domestic demand of imports in all regions is more than grains because oilseedsare export- oriented products while grains are domestically consumed goods.Oilseeds show an average percentage increase of 0.3. With respect to regions, Egypt is the most respondingregion showing an average increase of 0.4% in the domestic demand for imports of the two commodities, followed by MENA with 0.2% increase. Oilseeds alone show a 0.7% increase in the domestic imports demand in Egypt, while it shows 0.5% increase in MENA.Generally, the percentage increase is small. However, it confirms the importance of improving the efficiency by deriving positive changes in their domestic demands for imports inother regions.

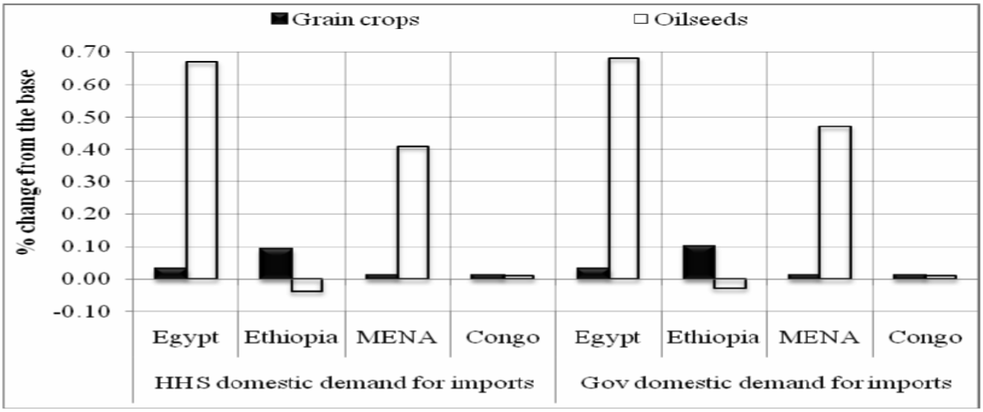

Figure 4. Effects of efficiency improvement on the regional domestic demand for imports.
Source:Authors' Model's Results

Adversely, Ethiopian domestic demand for imported grains will increase by 0.1%, while surprisingly, oilseeds demand will decrease by 0.03%. The rise in demand for imported grains in Ethiopia isin accordance with the higher prices of domestic grains after the removal of their subsidy by the Ethiopian government compared with the imported ones. However, this is not captured by this model, as the Ethiopian subsidies in the model donot change.(6)

7. Conclusion

In this paper, an attempt has been made to show the likely impact of improving the efficiency of selected traditional agricultural commodities in Sudan, namely oilseeds and grain crops.It employs the new GTAP Africa database, which includes the newly produced Sudanese Input/output Table (IOT) and GTAP standard model and closure. The GTAP model is implemented in RunGTAP, which is an advanced, user-friendly simulation interface that puts together the underlying mathematical representation of the CGE model and the global economic database.

Both oilseeds and grains arespecifically represented in the GTAP Africa database that includes the standard 57 sectors of GTAP database.(7)Oilseeds compriseimportant commodities grown in the rain-fed sector of Sudan —the most important of which are sesame, groundnuts, and sunflowers. Moreover, this paper exempted wheat from grain crops because it is mostly grown in the irrigated schemes rather than in the rain-fed sector; hence, grain crops include mainly sorghum and millet.

Labor and capital augmenting technical change parameter has been simulated to increase by 5% in the status quo with subsidy removal, and with 5% output targeted tax rate. Results reveal that the Sudanese economy will apparently benefit from increasing agricultural efficiency even if subsidies are removed.

Results of the simulation indicate that improving the efficiency of the major crops in the traditional rain-fed sector of Sudan would increase thetotal agricultural output and enhance the overall country's GDP and welfare levels of the people.In addition, the output of the crops where agricultural efficiency is simulated to improve would apparently increase leading their trade balance toimprove. The welfare implications of the simulation are important as the three scenarios show that welfare will improve. The welfare decomposition module of the GTAP model allows decomposing the welfare changes caused by the simulation. In this regards, the major welfare changes are due to allocative efficiency gains, which indicate that the efficiency improvement in the Sudanese agriculture could lead to better use of the domestic resources.

Technical efficiency could be improved by improving labor skills that requiremore effective extension services besides employing more advanced farming practices including agricultural machinery and improved seeds. This could be a better utilization of thehugeagricultural land occupied by the traditional sector. Moreover, improving the productive capacity of the subsistence farmers based on public investments in the rural infrastructure could crowdin additional private and foreign investments.Accordingly, the continuation in adopting more favorable environment for investment in the agricultural sector is crucial, and particularly the recent investment flows needto be fairly distributed among areas in the country, especially in the rural areas.

Statistics show that the majority of investments are concentrated in the central part of Sudan, where infrastructure is developed. Therefore, investors should be given special preferences when they invest in rural areas.This would encourage improving the rural infrastructure, and consequently,rural agricultural production, rural industries and export oriented rural farming.Finally, the provision of support to research, extension and technology transfer should be fairly representedin the annual government budget contrary to itscurrent embarrassing presence.

Footnotes

(1) See more details in Hertel (1997). A graphical presentation of the GTAP model with particular emphasis on the accounting relationships is given by Brockmeier (2001). A more rigorous approach is presented by Hertel and Tsigas (1997).

(2)For more details about Gempack and its related software packages, see Harrison and Pearson (1996).

(3) For an extended graphical representation of GTAP model, see Brockmeier (2001)

(4)The GTAP database comprises the international commodities classification of the United Nations into 57 sectors, which are the standard GTAP sectors. For details on this including the mapping between ISIC sectors and GTAP sectors, see Dimaranan (2006). For details on the mapping between this paper's sectors and GTAP sectors, see Appendix Table 1A of this paper.

(5)The allocative efficiency is a measure showing the welfare gains due to the reallocation of resources after the introduction of a certain shock in the model. The GTAP model has a very comprehensive welfare decomposition module that differentiates between several components of the welfare measures.

(6)Details about the implications of the Ethiopian government policies on grain subsidies are addressed in the study of Woldie and Siddig (2009).

(7)Details about the mapping between GTAP 57 sectors and the sectors of the paper are shown in the Appendix, Table 1A.

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Appendix

Table 1A: Mapping between the GTAP 57 Standard Sectors andAggregatedSectors

No.	Aggregated Sectors	Detailed Sectors Comprised in the Aggregated Sector
1	Wheat	Wheat
2	Grain crops	paddy rice,cereal grains nec[1],processed rice
3	Oilseeds	oil seeds
4	Sugar	sugar cane, sugar beet.Sugar
5	Forestry and other crops	vegetables, fruit, nuts; plant-based fibers; crops nec; fishing.
6	Livestock and Meat Products	cattle, sheep, goats, horses, animal products nec,raw milk,wool, silk-worm cocoons,meat: cattle, sheep, goats, horse,meat products nec
7	Mining and Extraction	forestry,coal,oil, gas,minerals nec
8	Processed Food	vegetable oils and fats,dairy products, food products nec,beverages and tobacco products
9	Textiles and Clothing	fextiles,wearing apparel
10	Light Manufacturing	leather products,wood products,paper products, publishing,metal products,motor vehicles and parts,transport equipment nec, manufactures nec.
11	Heavy Manufacturing	petroleum, coal products,chemical, rubber, plastic products,mineral products nec; ferrous metals,metals nec,electronic equipment, machinery and equipment nec
12	Utilities and Construction	electricity,gas manufacture and distribution,water,construction
13	Transport and Communication	trade,transport nec, sea transport, air transport,communication
14	Other Services	financial services nec,insurance, business services nec,recreation and other services,public administration /defense/health/education,dwellings.

Table 2A: Productivity Profiles of Selected Countries

Country	Multifactorproductivity	Efficiency change	Technical change
Angola	−0.4	−0.3	−0.1
Argentina	−2.8	−2.5	−0.3
Bangladesh	−2.6	0.0	−2.6
Brazil	2.6	−0.1	2.8
Canada	4.1	0.5	3.7
China	1.3	0.9	0.4
Egypt	1.0	1.0	0.0
Ethiopia	−0.6	−1.3	0.7
France	−1.5	1.7	−3.3
Germany	−13.9	0.0	−13.9
Ghana	−0.5	−0.2	−0.4
Jordan	0.6	1.1	−0.5
Kenya	−1.5	0.0	−1.5
Malaysia	1.4	0.5	0.9
Netherlands	1.6	0.2	1.3
South Africa	2.7	1.2	1.4
Sudan	1.6	0.6	1.0
Syria	3.7	0.6	3.2
Tanzania	−0.4	−0.5	0.0
Thailand	−0.6	0.0	−0.6
Turkey	0.2	0.0	0.2
Uganda	0.3	−0.7	0.9
United States	−1.0	−1.0	0.0
Zimbabwe	3.1	−0.3	3.4

Source: TruebloodandCoggins (2001).