# Food Self-sufficiency versus Foreign Currency Earnings in the Sudanese Irrigated Agriculture

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## 1 Background and Motivation

The Sudan is a vast country endowed with sizable land and natural resources. Agriculture occupies a pivotal position in Sudan's economy because of its sizable contribution to the national income. It generated an average of 40% of the GDP during the period between 1998 and 2003, over 90% of the national food requirements and accounted for almost 50% of the employment opportunities, and supplied about 60% of raw material needed by the manufacturing sector (Mubarak et al., 2011). The contribution of agriculture to the GDP remains at about 31% in 2009 and 2010 (CBoS, 2011)

Agriculture in Sudan has three main farming systems: (a) traditional rain-fed sector; (b) mechanized rain-fed sector; and (c) irrigated sector. The irrigated sector has occupied between 5 and 7% of the total cultivated land during the last seven years. However, despite its small share in the annual cultivated area in Sudan compared to the other two farming systems, it contributes more than half of the total volume of the agricultural production (CBoS, various issues).

Sudan has the largest irrigated area in sub-Saharan Africa and the second largest in the whole of Africa, after Egypt. Irrigated agriculture has become more and more important over the past few decades as a result of drought and rainfall variability and uncertainty. It remains a central option to boost the economy in general and increase the living standard of the majority of the population (FAO, 2011).

The irrigated agricultural public enterprises in Sudan are under the direct control of the state, which decides about the different agricultural and administrative activities. This implies that, the decision about the cultivated crop mix, agricultural operations, crop share, financing arrangement, input supplies, setting of prices of crops and the management, supervision and control of the production activity is a centralized one and applied to all. Therefore, the Gezira scheme could exemplify the pattern of production relations applied to the entire irrigated parastatals.

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The Gezira Scheme is Sudan's largest irrigation project. It lies on land between the Blue and White Nile, with a command area of 504,000 hectares (2.1 million feddan). It covers about 80% of Public Agricultural Schemes' (PAC) area. It also employs some 400,000 - 500,000 workers, while about 1.5 to 2 million persons depend upon the Gezira Scheme for their livelihood. The Gezira Scheme is said to be the largest organization in the world under one management (Abdalla, 1987). Four agricultural tradable crops namely cotton; groundnut, sorghum, and wheat are grown in the scheme. These crops contribute 60% to the country production of cotton crop, 50% of wheat, 25% of groundnuts, and 15% of sorghum.

The agricultural production potential of the public irrigated schemes has been streamlined upon controlled institutional, technical, and economic systems. An important institutional characteristic is the lack of tenant contribution in decision-making, particularly concerning the selection of crops mix and the allocation of areas among them. Because crop rotations were based on research findings, tenants allocated fixed area of their tenancies to specific crops. However, scheme management was able to change crop areas at the scheme level due to changes in political and economic conditions.

The Sudan's government started adopting food self-sufficiency policy during the 1940s by establishing the mechanized rainfed schemes. However, it further focused on it during the 1990s due to economic sanctions. Accordingly, the area cultivated by wheat and sorghum was enormously increased particularly, in the irrigated schemes. A peak of the subsidized wheat area was reached in 1991 when over 600,000 feddans were planted in Gezira Scheme (Mubarak, 2011).

By 1998, a removal of wheat subsidy and allowance of flours imports lowered prices, production, and led to continuous deterioration in area and output. In 2003, the food Self-sufficiency phenomenon was once again stressed due to the high annual import bill of wheat of over US$ 250 million when the Gezira scheme was anticipated to cultivate more of wheat to secure the strategic goal.

Based on this background and for the purpose of assessing the impact of different government policies this study focuses particularly on the Gezira scheme, which is the largest irrigated scheme in Sudan. It simulates the situation in a multimarket model, which is built and calibrated for Sudan's irrigated agriculture. The simulation considers switching portions of cultivated land between cash and food crops in order to reach a suitable mix where both self-sufficiency in food and foreign currency earnings are considered.

## 2 Objectives

This study tries to assess the impact of policies related to land allocation among crops in the Gezira scheme on the related variables including output, self-sufficiency from sorghum and wheat, and tenants' welfare. Two simulation scenarios are considered with the idea of switching portions of cultivated land between cash and food crops. They are specifically designed as follows:

1. Simulating the area grown by wheat to increase from about 70 thousand feddans to 300 thousand feddans, at the cost of other crops. However, the area grown by cotton, groundnut, and sorghum are set be always greater than zero. This increase is plausible as it is still lower than that of 1990/91, when it reached 6000 thousand feddans.
2. Simulating the area grown by cotton to increase from 219.14 thousand feddans to 400 thousand feddans, at the cost of other crops. However, the area grown by wheat, groundnut, and sorghum are set be always greater than zero. It is worth mentioning that, the designed cotton area in the crop rotation of the Gezira Scheme is 420 thousand feddans.

## 3 Method of Analysis and Data

This paper applies a model belonging to the group of Multimarket models of the Static World Policy Simulation Modeling Framework" (SWOPSIM), which are developed by the U.S. Department of Agriculture. It is helpful in analyzing both the international and domestic policy reforms. Furthermore, the SWOPSIM database provides the needed elasticities and parameters for the development of equations of the model (Abdel Karim, 2002). An overview about the mathematical structures of the model major components is provided in the following sections.

### 3.1 Supply and Demand Systems

The supply and demand systems for each commodity covered by the study are derived from a reduced form of Cobb-Douglas function constant elasticity (Kirschke, et al., 1996; Jechlitschka, 1997). The supply (production) quantity of the commodity is set to depend on its own price and the prices of competing products to allow for substitution between products.

In order to incorporate the effect of farmer decision on commodity production concerning his production capacity, the supply function has to be specified to include variables that constrain production. Given the rigid institutional and technical structure of the Gezira Scheme and the need to allocate the farmer's resources to different crops, the response of the scheme to the economic incentive is limited. The response to price is a behavioral response while the technical response is assumed to be represented by changes in the area allotted administratively to different crops. Increasing area allotted to one crop necessitates decreasing areas on other crops given fixed farmer resources of area, labour, and capital (seeds, fertilizer, pesticide, access to credit, etc). Land is used in the model to capture all other non-price variables since an increase in the area cultivated would necessitate an increase in those resources assuming constant technology. Accordingly, the supply function is specified as follows:

$$q_i^{\ s} = c_i \cdot (p_i^s)^{\varepsilon_i} \cdot \prod_{j \neq i} (p_j^s)^{\varepsilon_{ij}} \cdot A_i^{\ \varepsilon_{ai}} \qquad (1)$$

Where $q_i^{\ s}$ represents quantity supplied, $P_i^s$ represents the own price of the product, $P_j^s$ is the price of a competing product, $A_i$ is proportion of irrigated area of the product, and the term $c_i$ is a constant. The exponential terms $\varepsilon_i$, $\varepsilon_{ij}$ and $\varepsilon_{ai}$ are own supply price elasticity, cross price elasticity and area proportion elasticity, respectively.

On the other side, the demand (consumption) quantity of the commodity is defined as a function of consumer prices of own and close consumption substitutes and consumer per capita income as follows:

$$q_i^{\ d} = k_i \cdot (P_i^c)^{\eta_i} \cdot \prod_{j \neq i} (P_j^c)^{\eta_{ij}} \cdot Y_i^{\alpha_i} \qquad (2)$$

Where $q_i^{\ d}$ is quantity demanded, $P_i^c$ represents own product consumer price, $P_j^c$ is price of competing product, $k_i$ is the constant factor, while $\eta_i$, $\eta_{ij}$ and $\alpha_i$ are own demand price elasticity, cross price elasticity and income elasticity, respectively. $Y_i$ represents the consumer income per capita, which is defined as follows:

$$Y_i = \frac{GDP}{N} \qquad (3)$$

Where, $GDP$ is the gross domestic product and $N$ is the total population. Therefore, domestic prices for one market affect the quantity supplied and demanded not only in that market but also in the other markets through cross-market price linkages.

The differences between supply and demand quantities determine the model net trade or surplus for each commodity accruing to Gezira Scheme. This difference represents export availability (if positive) or import requirement (if negative) as represented by equation (4).

$$Nt_i = q_i^{s} - q_i^{d} \qquad (4)$$

Where, $Nt$ is net trade and *i = 1, 2, 3, and 4.*

## 3.2 Prices in the Model

The producer and consumer prices of each commodity are determined by the border price, the country's border policies that affect the domestic price (pd) and the domestic policies (tax and/or subsidy) as shown in the following equations:

$$P_i^d = P_i^w (1 + r_i) \qquad (5)$$

$$P_i^s = P_i^d (1 + t_i^p) \qquad (6)$$

$$P_i^c = P_i^d (1 + t_i^c) \qquad (7)$$

Where, *i = 1, 2, 3, and 4*.

By substituting equation (5) in equation (6) and equation (7) the following equations are obtained:

$$P_i^s = P_i^w (1 + r_i)(1 + t_i^p) \qquad (8)$$

$$P_i^c = P_i^w (1 + r_i)(1 + t_i^c) \qquad (9)$$

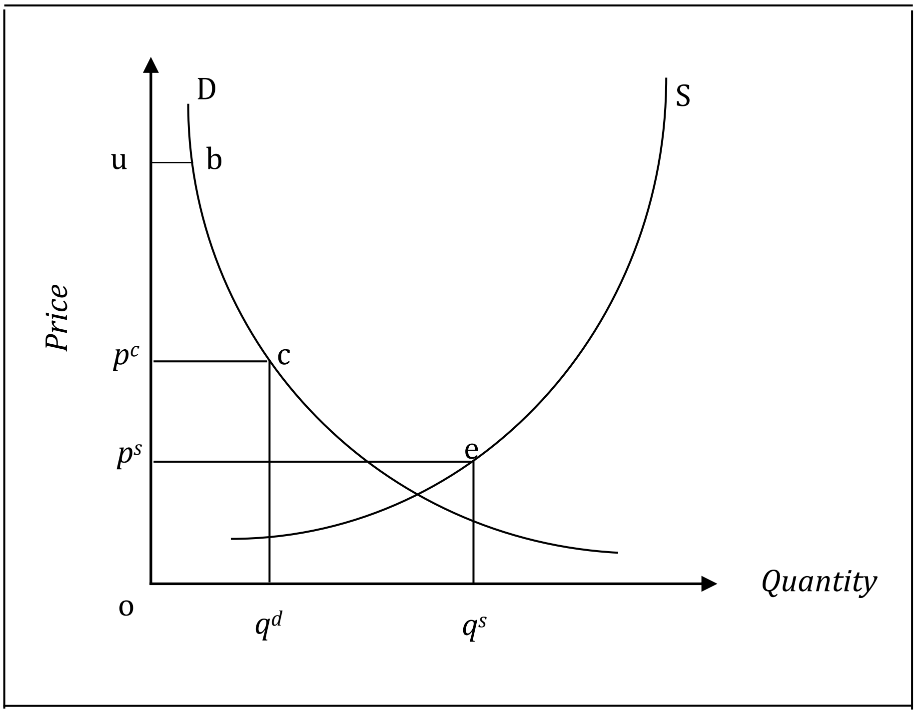
Where, i = 1, 2, 3, and 4. $P_i^s$ is producer price for export and import substitute crops. $P_i^c$ is the consumer price. $P_i^d$ and $P_i^w$ are the domestic and world prices, respectively. $r_i$ is the rate of protection on export and import–substitute commodities. If $r_i$ is less than zero, this means producer is taxed, and if $r_i$ is greater than zero, the producer is subsidized. $t_i^s$ and $t_i^c$ are the domestic tax/subsidy rate on producer and the domestic rate of taxation on consumer, respectively.

### 3.3 Welfare Analysis

Changes in policies necessitate a look at the relative welfare of producer and consumer and the income distribution impacts of changes in relative prices. The welfare of producer and consumer are measured by producer and consumer surpluses. The welfare levels are derived from the individual supply and demand functions incorporated in the model.

For simplicity, let us consider the welfare implications of changes in the world price in Figure (1). Consumer surplus can be measured by the area above the price line and below the demand curve, while producer surplus corresponds to the area below the price line and above the supply curve. Let S and D represent supply and demand for a particular commodity, and $p^s$, $p^c$, $q^s$, $q^d$ are producer price, consumer price, quantity supplied, and quantity demanded, respectively. u represents the upper boundary, which is required in nonlinear models to facilitate a feasible solution for the problem (Brooke *et al*. 1988).

**Figure 1: Surpluses of Producer and Consumer**




The producer surplus is the area $oep^s$, which is equal to the area $oq^sep^s$ minus the area under the supply curve $oeq^s$. Because the supply curve measures the marginal cost of each unit produced, $oeq^s$ is the total cost. Area $oq^sep^s$ is the gross revenue. Therefore, producer surplus for non-linear supply equation is:

$$PS_i(p^s) = R_i(p^s) - C_i(p^s) \quad (10)$$

where,

$$R_i(p^s) = p_i^s \cdot q_i^s \quad (11), \text{ and}$$

$$C_i(p^s) = p_i^s \cdot q_i^s - \int_0^{p^s} q^s(p)\, dp$$

$$= p_i^s \cdot q_i^s - \frac{1}{\varepsilon_i + 1} \cdot c_i \cdot (p_i^s)^{\varepsilon_i + 1} \cdot \prod_{j \neq i} (p_j^s)^{\varepsilon_{ij}} \quad (12)$$

Where, $P^s$ is the producer surplus and the terms $R$ and $C$ are producer revenue and cost, respectively.

On the other side, the consumer surplus as depicted in figure (1) is the area $p^ccbu$. The demand curve measures up to a scalar (λ), which is the marginal utility offered by each unit in the good. The difference between marginal utility, which indicates the maximum price consumer would be willing to pay for that unit and the price actually paid (the market price) is a measure of surplus and, hence, of consumer welfare (Sadoulet, et al. 1995). The area $p^ccbu$ thus measures the difference between money value of total utility (area $oq^dbu$) and the cost of achieving this utility (area $oq^dcp^c$). By applying this definition, consumer surplus can be measured as follows:

$$CS_i(p^c) = B_i(p^c) - E_i(p^c) \quad (13)$$

where,

$$E_i(p^c) = P_i^c \cdot q_i^d \quad (14)$$

and

$$B_i(p^c) = p_i^c \cdot q_i^d + \int_{pc}^{\lambda} q_i^d(p)\, dp$$

$$= p_i^c \cdot q_i^d + \frac{1}{\eta_i + 1} \cdot k_i \cdot (\lambda^{\eta_i + 1} - (p_i^c)^{\eta_i + 1}) \cdot \prod_{j \neq i} (p_j^c)^{\eta_{ij}} \cdot Y_i^{\alpha_i} \quad (15)$$

Where, CS is the consumer surplus, the terms *B* and *C* are consumer benefit and expenditure, respectively, and λ is the scalar (maximum price).

Finally, the welfare function is determined by the sum of net producer and consumer surpluses plus government budget, as represented by equation (17). Whereas, the net government budget in the model is expressed by equation (16).

$$GB_i = q_i^{\,s} (P_i^{\,w} - P_i^{\,s}) + q_i^{\,d} (P_i^{\,d} - P_i^{\,w}) \quad (16)$$

$$i = 1, 2, 3, .and 4$$

$$W_i = PS_i + CS_i + GB_i \quad (17)$$

Here *GB* represents the government budget and the *W* is the welfare measures. The calculation of foreign exchange is represented by equation (18). It can also be calculated in another way by equation (19), where the welfare function is determined by the difference between consumer benefit and producer cost plus the foreign exchange (Just et al., 1982).

$$F_i = (q_i^s - q_i^d) P_i^w \quad (18)$$

$$W_i = B_i - C_i + F_i \quad (19)$$

With is = 1, 2, 3, or 4 and *F* is foreign exchange earnings. Aggregate welfare effects can then be measured by:

$$W(aggregate) = \sum_{i=1}^{N} W_i \quad (20)$$

### 3.4 Food Security Indicators

To analyze the effect of policy changes on the contribution of Gezira Scheme to food security, two indicators are measured, which are the self-sufficiency ratio and the per capita consumption of sorghum and wheat. Self-sufficiency ratio is measured by the ratio of domestic supply to domestic demand (equation 21);

while the per capita consumption is measured by the ratio of domestic demand to total population (equation 22).

$$SSR_i = \frac{q_i^s}{q_i^d} \tag{21}$$

$$PCC_I = \frac{q_i^d}{N} \tag{22}$$

With i=1 and 2, SSR is the self-sufficiency ratio, and PCC is the per capita consumption.

### 3.5 Specification and Calibration of the Model

A base model is constructed to serve as a yardstick to measure variations that are going to be considered in this study. The calibration of the model to the base period data is an important step before the policy scenarios can be simulated. The parameters of supply and demand are calibrated to reproduce the given base period. The calibration procedure of supply and demand function has been carried out in two steps. First, the supply and demand elasticities are calibrated under the assumption of symmetry and homogeneity for both supply and demand as microeconomic constraints. Adding up is also considered in the case of demand function.

Symmetry means that the second order derivatives of the profit function for commodity (i) with respect to the prices is symmetric. This can be expressed as in equation (23) for supply and equation (24) demand function.

$$\frac{\partial q_i^s}{\partial p_j^s} = \frac{\partial q_j^s}{\partial q_i^s} \tag{23}$$

$$\partial \frac{q_i^d}{\partial p_j^c} = \frac{\partial q_j^d}{\partial p_i^c} \tag{24}$$

The symmetry constraint can be expressed in term of elasticities as in equations (25) and (26) for supply and demand functions, respectively.

$$\varepsilon_{ij} = \varepsilon_{ji} \frac{q_j^s}{p_i^s} \cdot \frac{p_j^s}{q_i^s} \qquad (25)$$

$$\eta_{ij} = \eta_{ji} \frac{q_j^d}{p_i^c} \cdot \frac{p_j^c}{q_i^d} \qquad (26)$$

For homogeneity, if a profit function is homogenous of degree (1) in prices it follows that the supply and input demand functions are homogenous of degree (0), which is a regulatory condition imposed on Cobb-Douglas functions. In term of elasticities, it means that the sum of elasticities for a commodity with respect to its own price and all cross prices is zero for supply.

The adding-up condition for total food expenditure is also ensured during the calibration process of demand function (Kirschke and Echlitschka, 2002). This is expressed as follows:

$$\sum a_1 . W_1 = 1, \qquad (27)$$

Where, i= (1, 2, 3 and 4), and $W_1 = \frac{q_i^d - p_i^c}{y}$ is the expenditure share of product (i).

In order to make reasonable supply reaction to price changes and reasonable demand reaction to price and income changes, upper and lower boundary on individual elasticities have been defined in the model. They have been entered into the calibration procedure as ranges in percentage terms $b_{ij}^s$ , $b_{ij}^d$ and $b_{ij}^c$ around the initial elasticities of supply, demand, and income elasticity, respectively.

$$\varepsilon_{ij}^0 (1 - b_{ij}^s) \le \varepsilon_{ij} \le \varepsilon_{ij}^0 (1 + b_{ij}^s)$$
$$\eta_{ij}^0 (1 - b_{ij}^d / 100) \le \eta_{ij} \le \eta_{ij}^0 (1 + b_{ij}^d / 100)$$
$$\alpha_i^0 (1 - b_i^c / 100) \le \alpha_i \le \alpha_i^0 (1 + b_i^c / 100)$$

Where $\varepsilon_{ij}^0$, $\eta_{ij}^0$, $\alpha_i^0$ are the initial elasticities of supply, demand and income elasticity; $\varepsilon_{ij}$ , $\eta_{ij}$ and $\alpha_i$ are calibrated elasticities of supply, demand and income respectively.

The supply, demand, and income elasticities set are then calibrated in a way to minimize the deviation from the initial sets and to satisfy the above-mentioned constraints using Excel solver.

The parameters of the supply and demand are calibrated to reproduce the given base period (average of 1999 - 2001). In the calibration procedure, equation (1) and (2) are solved for the constant terms by using initial values of prices, quantities, proportion of grown area of the crop, and elasticities. Once the equations are calibrated, they can be used in further analysis for deriving price and quantity effects as well as welfare changes.

All the equations in the model are simultaneous and the model is solved consequently for all the endogenous variables. When the objective function is solved for zero value, the model generates optimal values for all prices, factors of production and outputs of commodities included in the model at the point where the market is in equilibrium (Abdel Karim, 2002).

This paper focuses on the Gezira irrigation project as the area of the study. The data were collected from different institutional sources representing both national and international institutions. The selected crops are cotton, groundnut, sorghum, and wheat representing the major crops grown in the scheme based on the cultivated land.

# 4 Results and Discussion

The two simulation scenarios considered in this paper and presented as two different government policies with opposite objectives. Scenario1 is setup to be a food security oriented promotion policy, where the area grown by what expands at the cost on the other three crops. Therefore, it would be referred to as food security policy during the discussion of the results. On the other hand, scenario 2 is setup to promote the earning from the foreign exchanges represented by cotton. It assumes that cotton area to expand at the cost of the other three crops. Accordingly, it would be referred to as a foreign exchange oriented policy from this point and on.

## 4.1 Land Reallocation

The simulation results with respect to the cultivated area by the four crops and after the two policies are shown in Table (1). The food security scenario shows that 47% of the land being moved to wheat is originated to sorghum. Moreover, 30% of the cotton area and 23% of the groundnuts area would be grown by wheat as well according to this scenario. The relocation of land seems to be more governed by the baseline data than specific substitutability issues, which is found be valid also for the second scenario of the foreign exchange.

**Table 1: Changes (000 feddan) and (%) in area cultivated due to the two policies**

| Crops | Baseline area | Food security | | Foreign exchange | |
|---|---|---|---|---|---|
| | | 000 feddan | % | 000 feddan | % |
| Cotton | 218.7 | -69.1 | -31.6 | 180.4 | 82.5 |
| Groundnuts | 123.5 | -53.6 | -43.4 | -53.5 | -43.3 |
| Sorghum | 486.8 | -107.1 | -22.0 | -106.6 | -21.9 |
| Wheat | 70.0 | 230.1 | 328.9 | -19.9 | -28.5 |

Sorghum is always the crop from which a bigger portion of land substitutes away because it has the biggest share of land followed by cotton, groundnuts and lastly wheat.

## 4.2 Supply Responses

Table (2) shows the impact of this land reallocation across crops in the two scenarios of Table (1) on the production of each. The reallocations of land to wheat according the food security scenario seem to improve the contribution of the Gezira scheme to the total country's food supply. Increasing wheat area to 300 thousand feddans would increase the supply of wheat by 120.1 thousands metric tons. However, that would reduce the production of other crops by 28%, 39%, and 20% for cotton, groundnuts, and sorghum, respectively. This increase in the supply of wheat comes more apparently at the cost of sorghum with a loss of about 89 thousand tons of sorghum due to this scenario. These changes might not be fully compensated by wheat as there are some pure sorghum consumers, for whom wheat might not be a perfect substitute of sorghum.

**Table 2: Changes (000 tons) and (%) in crops' production due to the two policies**

| Crops | Baseline supply | Food security | | Foreign exchange | |
|---|---|---|---|---|---|
| | | 000 tons | % | 000 tons | % |
| Cotton | 123.2 | -35.1 | -28.5 | 85.8 | 69.7 |
| Groundnuts | 82.1 | -32.0 | -39.0 | -32.0 | -39.0 |
| Sorghum | 443.0 | -88.6 | -20.0 | -88.6 | -20.0 |
| Wheat | 50.1 | 120.1 | 239.7 | -12.3 | -24.6 |

On the other hand, increasing supply of cotton by 85.8 thousand would come at the cost of reduced supplies of groundnut, sorghum, and wheat by 39%, 20%, and 24.6%, respectively (Table 2). It is also noted that the increase in cotton production would also affect sorghum most because it has the biggest share of land in the baseline. This might be another driver to perpetuate negative food security implications.

## 4.3 Foreign Exchange Earnings

The effects of two simulations on the foreign exchange earnings are materialized in Table (3). For the food security scenario, the deterioration of the production of crops other than wheat would decline the country's foreign exchange earnings. This is due to that, the savings from the reduced wheat imports, which is US$ million 24, do not compensate the total loss of US$ million 66, of which 53%, 25%, and 22% are from cotton, groundnuts, and sorghum, respectively.

**Table 3: Changes (US$ million) and (%) in foreign exchange earnings from crops due to the two policies**

| Crops | Baseline earnings | Food security | | Foreign exchange | |
|---|---|---|---|---|---|
| | | US$ million | % | US$ million | % |
| Cotton | 116.5 | -35.3 | -30.3 | 86.7 | 74.4 |
| Groundnuts | 5.0 | -16.3 | -3.25.5 | -16.3 | -325.5 |
| Sorghum | 0.3 | -14.5 | -4411.8 | -14.5 | -4411.8 |
| Wheat | -44.9 | 24.5 | 54.6 | -2.5 | 5.6 |
| Aggregate | 77.0 | -41.6 | | 58.6 | |

For the foreign exchange scenario on the other hand, despite the deterioration of the foreign exchange earnings from groundnut, sorghum, and wheat, the overall foreign exchange earnings from the four crops would be US$ million 58.6, driven by the earnings from cotton of US$ million 86.8 (Table 3). The percentage changes in the foreign exchange earnings from groundnuts and sorghum are always high due to their small value in the baseline.

## 4.4 Welfare implications

Table (4) reports the welfare implications of the two simulation scenarios. The welfare impact is captured through three major components, namely: a) producer surplus, b) consumer surplus, and c) government budget and the three variables are quantified in US$ millions.

The food security scenario would reduce the surplus of cotton, groundnuts, and sorghum producers by a total of US$ millions 59 in order to produce US$ millions 16.2 for wheat producers (Table 4). This would cause a net welfare loss of about US$ millions 43. The majority of the loss would be in the government budget as would decline by 86%, while the aggregate producers loss account to 14%. With respect to crops, the loss is distributed among cotton, groundnuts, and sorghum according to 52%, 27%, and 22%, respectively. The government revenue from wheat would decline despite the increasing production. This is due a drop in the tariff revenue caused by the reduced imports of wheat (Table 4).

**Table 4: Welfare implications (US$ million) of the two policies**

| | Food security | | | Foreign exchange | | |
|---|---|---|---|---|---|---|
| | Producer surplus | Government budget | Welfare | Producer surplus | Government budget | Welfare |
| Cotton | -9.9 | -20.5 | -30.4 | 24.3 | 50.3 | 74.6 |
| Groundnut | -3.7 | -12 | -15.7 | -1.6 | -5.2 | -6.8 |
| Sorghum | -8.9 | -3.7 | -12.7 | -8.9 | -3.7 | -12.6 |
| Wheat | 16.5 | -0.3 | 16.2 | -4.5 | 0.1 | -4.5 |
| Total | -6.0 | -36.5 | -42.6 | 9.3 | 41.5 | 50.7 |

The welfare implications of the foreign exchange scenario as shown in Table (4) confirm that the surplus of cotton producers would increase by US$ million 24 at the cost of US$ million 15 distributed among other crops. The government balance and overall welfare would follow the same pattern of that of the producer surplus, with the aggregate government balance to increase by US$ 41.5 million and overall welfare gains to be US$ 50.8 million. Comparing the government gains to producers, this time 82% of the surplus goes to the government, against 18% to the producers.

Food self-sufficiency is the ultimate goal to be achieved by a food security oriented policy such as the policy simulated in the first scenario in this study. Calculating the self-sufficiency index for wheat and sorghum after the two scenarios show that self-sufficiency in wheat would increase by 40% and decline by 4% due to the two scenarios, respectively. However, for sorghum both the food security and foreign exchange scenarios would have negative impact. The self-sufficiency in sorghum would decline by 4% in both cases due to the large area covered by sorghum in the baseline. Sorghum has appeared to be the major provider of land to both wheat and cotton according to the two scenarios.

## 5 Conclusions

A future impact analysis was undertaken in this study using Multimarket methods of analysis to simulate two policy measures. These measures are based on the assumption that the government would introduce two promotion policies one is toward a food crop and the second targets a cash crop. The idea is motivated by the possibility of achieving food self-sufficiency from wheat as a major food crop, or improving the foreign exchange earnings from cotton as a major cash crop through expanding their share in the cultivated land.

The two scenarios are simulated to be applied only to the Gezira scheme as the biggest irrigated scheme in the country. Secondary data were collected from different institutional sources representing both national and international institutions and used in the study.

The overall implications of the two scenarios could be summarized in a way that none of the two policies would benefit the food security and foreign earning at the same time. Each one of them might be suitable to be applied as a part of a policy package that consists of several components. That is due to fact that the two scenarios assume fixed supply of land in the model. Therefore, any allocation of land to one of the two crops would result in cuts in the land allocated to other crops. In this regard, the two policies would be successful in all sides if the expansion in the cultivated land is based on reclamation given the abundant arable land in a country like Sudan.

The food security scenario is harmful at the welfare side including both producers surplus and government budget. This is because of its negative impact on the earnings from exports (cotton exports reduction) and the revenue from tariffs as wheat imports would also decline. Therefore, increasing the area cultivated by wheat at the cost of other crops in the Gezira scheme would neither improve producers' surplus nor the government budget. However, it would be able to generate additional food supply as the increase in wheat supply would be higher that the reduction in the supply of sorghum.

The foreign currency earning scenario in the contrary has shown positive impact at the foreign earnings and welfare for both producers and the government. Although not analyzed within this study, the surpluses and gains from foreign currency due to the policy could be used for additional food importation without causing welfare damages. The latter is assumes that producers would not be affected by the additional imports of food as this a partial equilibrium model.

The exercise followed in this study would be very helpful to the policy making process at the Gezira scheme at the moment. However, additional improvements would make the results more adequate and convincing. Within these improvements the data comes at the top together with analytical tools that show the implications on the entire economy. More specifically, detailed and recent dataset would be very helpful in generating adequate recommendations.

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