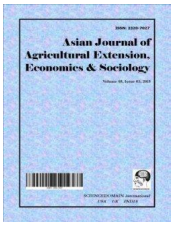

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An Analysis of Agricultural Crops Outputs in New Halfa Agricultural Scheme, Sudan: A Policy Implications

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Authors' contributions

This work was carried out in collaboration between the both authors. Authors MEAE and MMME designed the study, wrote the protocol and manage literature search. Author MEAE managed data collection and analysis. Author MMME wrote the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: This study aimed at examining and comparing the impact of the governmental policies; pre-liberalization (1970 - 1992) and post-liberalization (1992 - 2012), on the growth of the main crops grown in the New Halfa Agricultural Scheme (NHAS) Sudan: sorghum, wheat, cotton and groundnuts.
Place and Duration of Study: New Halfa Agricultural Scheme, 1970 - 2012.
Methodology: The study depended mainly on secondary data which were collected from the Ministry of Agriculture, Central Bureau of Statistics and New Halfa Agricultural Scheme. The compound growth rate and the seven steps decomposition model were used to achieve the stated objectives.
Results: Results revealed that the growth rate of sorghum area (5.73) and productivity (9.44) pre-liberalization policy were far better than the post-liberalization period (0.91) and (0.34), respectively.

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Likewise, the growth rate for the wheat area (-4.1), productivity (2.87) and production (2.77) pre-liberalization were substantially more than post liberalization (area=-11.44. productivity=2.33 and production=1.28). In the same vein the growth rate of cotton area (3.57), productivity (5.85) and production (5.98) pre-liberalization were better than post-liberalization period (area=-2.66, productivity=-1.49 and production=-9.16). For groundnuts, the growth rate pre-liberalization of productivity (0.3) and production (1.59) was greater than pre-liberalization (productivity=-3.88 and production=-3.84), even though, the growth rate of an area before the liberalization (-1.89) was lesser than the post-liberalization (-0.72).

Conclusion: The adopted agricultural liberalization policy was failed to achieve its goals of improving the growth rate of the main crops grown in NHAS. The study recommends that the government should intervene in the scheme management and farmers support.

Keywords: Liberalization policy; growth rate; crop productivity; decomposition of growth; New Halfa Scheme.

1. INTRODUCTION

New Halfa Agricultural Scheme (NHAS) was established in 1964 with the aims of resettlement of the affected people by the construction of High Dam [1], in addition to, improving the country export earning, self-satisfaction of sorghum and wheat, and utilizing the country's share of Nile water. The scheme is considered as one of the largest irrigated projects in Sudan with a total area of 184 thousand hectares [1,2] and tenant's number of 23000. The scheme, which is irrigated by waters from Khashm Al Girbah Dam on Atbara River [1], is situated in the arid climatic zone at the western bank of Atbra River between latitudes 15^0 - 17^0 N. It is characterized by annual rainfall 250 - 500 mm. Khashm Al Girbah Dam is currently suffered from the problem of accumulated silt, which in turn has reduced its storage capacity to less than 50% [3]. The project which was run under the authority of New Halfa Corporation was designed to plant cotton, wheat, sorghum, groundnut and other crops [4]. Each tenant was given a total area of 6.3 hectares to cultivate two cash crops (cotton and groundnuts) and other two (sorghum and wheat) for household consumption [4].

In 1992 the country adopted liberalization policy. Since then the scheme witnessed dramatic changes towards privatization. Consequently, NHAS tenants are facing a lot of difficulties such as poor irrigation infrastructure, meager basic agricultural services and lack of alternative source of credit, in addition to, the large cuts in governmental expenditures. In fact, the average cultivated area of the project for the studied periods pre-liberalization was 92.55 thousand hectare, out of which there was an average of about 23%, 28%, 28% and 13% thousand hectares are grown by sorghum, wheat, cotton and groundnuts, respectively. But after liberalization the cultivated area dropped to 82.55 thousand hectares, with sorghum, wheat, cotton and groundnuts constituting about 29%, 24%, 25% and 23% on average, respectively.

Before 1992, particularly during the 1970s and 80s, the Sudanese economy was characterized by negative growth rates and internal and external imbalances. In 1992 the government of Sudan has launched a liberalization program to reverse the decline in economic growth and revitalize the private sector. Despite the positive impact of liberalization policy on livestock subsector growth on it is early days, yet, it achieved a negative impact on the irrigated sub-sector [2,5,6].

In fact, there were many studies that were conducted to analyze and compare the impact of the governmental policy on the growth rate of the agricultural sector. Minhas and Vaiyanathan in 1965 was first to develop a model called "compound growth rate model" (CGRM). They decomposed the growth into four constituents "area, yield, cropping pattern and a residual component showing an interaction between cropping pattern and yields" to identify the main source of growth [7]. Later on, Minhas decomposed the growth into seven constituents: area, yields, production, interaction between yield and area, interaction between yield and production, interaction between area and production and interaction between area, yield and production. From that on CGRM was widely used in the literature. [8] followed the same steps of Minhas in "decomposing the change in the value of crops agricultural output at prevalent prices into three gross components: area, productivity and price and their interactions". Similarly [9] used the decomposition model that

was developed by Minhas and Vaidyanthan and modified by Sarma (1975) to study the contribution of numerous constituents to the growth of agricultural output in Andhra Pradesh area. Another author [10], investigated the root factors behind the changes in cropping pattern in West Bengal, he followed Minhas seven elements decomposition model to identify the main reasons behind the growth of agricultural output (crop output only) in the state. He also analyzed the changes in agricultural output (in value terms) due to the substitution of crop areas. In the same vein [11] studied the "growth decomposition of foodgrains output in West Bengal: A district-level study". He improved the existing Minhas decomposition model by valuing food grain out at a constant price. The factors identified for output decomposition are area, yield and cropping pattern. Likewise, [5 and 6] applied the model (CGRM) in Sudan agriculture to determine and compare the growth rates before and after the adoption of Liberalization policy in two different irrigated scheme of the country Rahad Agricultural Corporation and Gezira Scheme. Similarly [12] used CGRM to investigate and compare the trends in the area, production and yield of four major crops (wheat, rice, sugarcane and cotton), pre and post-structural Adjustment program. They also decomposed the growth into seven constituents to the primary source of changes. [13] analyzed the determinants of growth performance through decomposing them with reference to area, price, cropping pattern and yield. Price elements introduced to capture for inflation.

This study aimed to examine and compare the impact of the governmental policies; pre-liberalization (1970-1992) and post-liberalization (1992 – 2012) on the growth of the main crops (sorghum, wheat, cotton and groundnuts) grown in the New Halfa Scheme, Sudan.

Fig. 1. The Location of the New Halfa Scheme in the Central-Eastern Sudan
New Halfa Scheme
Source: [2]

2. MATERIALS AND METHODS

This study depended mainly on secondary data. Data on yields (tons/ha), cultivated area (ha), production (1000 tons) of the major crops grown on NHAS (sorghum, wheat, cotton and groundnut) was collected from different institutional sources such as Federal Ministry of Agriculture and Forestry, New Halfa Corporation, Central Bank of Sudan, Central Bureau of Statistics and Ministry of Finance. Sorghum, wheat, cotton and groundnut crops were chosen because they constitute 28%, 24.8%, 24% and 22% of the total cultivated area in the scheme. The study covered the period from 1970 to 2012. Analytical techniques used to achieve the goals of the study are described hereafter:

The compound growth rate was used in the estimation of area, production and productivity of the major crops grown in NHAS. Here, the general growth performance of the major crops grown in NHAS was analyzed through fitting exponential growth function with time normalization on the area, production and productivity [14]. The following steps were used in the measurement of growth rate of different crops grown in the New Halfa Scheme [15]:

$$Y_t = AB^t \quad (1.1)$$

Where:

Y_t = area /production/productivity of crop concerned in the year t.

A = intercept

T = year

B = 1 + r/100; r= the percentage rate of the compound growth of area, production and productivity of each crop/annum.

The linear form of the equation is written as:

$$Y_t = \log_A = \log_B \quad (1.2)$$

The same equation (1.2) can be rewritten as follows:

$$\log Y_t = a + b_t \quad (1.3)$$

Where: Log A = a, and Log B = b,

By using ordinary least square techniques, we have normal equation of the type

$$\sum \log Y = Na + b\sum t \quad (1.4)$$

$$\sum (t \log Y) = a\sum t + b\sum t^2 \quad (1.5)$$

Where, N is the number of observations (years).

By solving equation (1.4) and (1.5) the value of (a) and (b) were computed. When derivations are taken from middle year, i.e., $\Sigma t = 0$, the above equation takes the following form:

$$\sum \log y = Na \quad (1.6)$$

Then

$$a = \left(\sum \log Y \Big/ N\right) \quad (1.7)$$

and

$$\Sigma(\log Y = b\Sigma t^2) \quad (1.8)$$

Then,

$$b = \sum \frac{t \log Y}{\sum t^2}$$

For deriving compound growth rate from the regression coefficients, the following procedure was adopted. When time is measured at discrete intervals, such as quarter or years, a constant growth series would be expressed as

$$Y_t = Y_0(1 + r)^t \quad (1.9)$$

Where,

Y_0 = base year (value of year (0) base year)
Y_t = value of Y in year t.
r = compound growth rate

Taking logarithms of (1.9) to base 10 gives

$$\log Y_t = \log Y_0 + (\log (1 + r))^t \quad (1.10)$$

This is the equation estimated with actual data.

Thus

Intercept = estimate of log Y_0
Slope = estimate of log (1+r)

And so an estimate of (r) can be obtained.

In comparing equation (1.10) with (1.3) we found that:

$$\log B = \log (1 + r)$$

And

$$r = \text{antilog } B - 1$$

According to [15] the percentage rate of compound growth per annum was calculated as:

$$r = (\text{antilog} B - 1) \times 100$$

r= represents the rate of change from observation to another during the period under consideration.

The second used model was the decomposition model developed primarily by Minhas and Vaiyanathan in 1965 [16]. They decomposed the agricultural outputs growth into different components: growth in area, yields and cropping patterns and the interaction between these three components. The same model was employed by [17] for decomposing the components of agricultural production. The following is the converted growth rate decomposition model of Minhas seven-factor decomposition scheme.

Consider,

$$P_{i0} = A_0 C_{i0} Y_{i0} \quad (2.1)$$

$$P_{it} = A_{it} C_{it} Y_{it} \quad (2.2)$$

Where

P_{io} = production of the i^{th} crop in the base year 0

P_{it} = production of the i^{th} crop in the current year t

A_o = gross cropped area in year 0

A_t = gross cropped area in year t

Y_{io} = yield per hectare of crop i in year 0

Y_{it} = yield per hectare of crop i in year t

C_{io} = proportion of area under crop i to the total cropped area in year 0

C_{it} = proportion of area under crop i to the total cropped area in year t

Differencing over time

$$P_{it} - P_{i0} = A_t C_{it} Y_{it} - A_0 C_{i0} Y_{i0} \quad (2.3)$$

Each variable in the current period can be expressed as its counterpart in the base year plus the change in the variable between the current and the base year. For example,

$$A_t = A_0 + \Delta A$$

$$C_{it} = C_{i0} + \Delta C$$

$$Y_{it} = Y_{i0} + \Delta Y$$

Equation (2.3) can, therefore, be written as

$$P_{it} - P_{i0} = (A_0 + \Delta A)(C_{i0} + \Delta C)(Y_{i0} + \Delta Y) - A_0 C_{i0} Y_{i0}$$

$$= A_0 C_{i0} Y_{i0} + A_0 Y_{i0} \Delta C + C_{i0} Y_{i0} \Delta A + A_0 C_{i0} \Delta Y + Y_{i0} \Delta A \Delta C + A_0 \Delta C \Delta C + C_{i0} \Delta A \Delta Y + \Delta A \Delta C \Delta Y - A_0 C_{i0} Y_{i0} \quad (2.4)$$

The equation then can be written as:

$$P_{it} - P_{i0} = C_{i0} Y_{i0} (A_t - A_0) + A_0 C_{i0} (Y_{it} - Y_{i0}) + A_0 Y_{i0} (C_{it} - C_{i0}) + Y_{i0} (A_t - A_0)(C_{it} - C_{i0}) + A_0 (C_{it} - C_{i0})(Y_{it} - Y_{i0}) + C_{i0} (A_t - A_0)(Y_{it} - Y_{i0}) + (A_t - A_0)(C_{it} - C_{i0})(Y_{it} - Y_{i0}) \quad (2.5)$$

In this additive scheme of decomposition, the first element on the right-hand side is the area effect. That is any change in the area could have taken place in the absence of any changes in per hectare yields and cropping pattern. The second word is the effect of yield change for constant cropping pattern. The third term is the effect of changes in cropping pattern in the absence of any changes in per hectare yields. The remaining four terms measure the effect on output which could be attributed to, (a) interaction between crop pattern changes and changes in area (b) interaction between crop pattern changes and changes in yield (c) interaction between per hectare yield changes and changes in area, and (d) interaction among cropping pattern changes, per hectare yield changes and changes in area.

3. RESULTS AND DISCUSSION

It is very important here to shed light on the average yield for the major crops grown in New Halfa Agricultural Scheme. The average yield for sorghum, wheat, cotton and groundnuts before liberalization period were 1.09, 1.13, 1.35 and 1.71 tons/hectare, but after liberalization period, they changed to 1.46, 1.25, 1.26 and 2.16 tons/hectare, respectively.

Results of the growth rate in the area, productivity and production for the studied crops are presented hereafter.

It is noticed that sorghum area, productivity and production are positive under both pre and post-liberalization periods, although, the incremental increase, for both area and productivity, before the liberalization is more than after liberalization (Fig. 2). It is worth mentioning here that, the expansion of sorghum cultivation might be due to the fact that sorghum is the summer crop that can depend on the rainfall for its irrigation. But both wheat and cotton depend entirely on the irrigation which is seriously affected by sedimentations of Khashm AlGirbah Dam as mentioned earlier.

On the other hand, the area cultivated with wheat showed declining trends during the two periods; pre and post-liberalization period (Fig. 3). The level of declining is worse during the post-liberalization period than the pre one. This could be true if known that most farmers have given up cultivating wheat in favour of sorghum. Three reasons could be responsible for that; first is the worse reduction of the scheme agricultural area during post-liberalization era due to governmental negligence. These negligence has resulted in the huge reduction of the scheme area suited for agricultural cultivation due to the water shortages and the widespread of Prosopis spiny weed trees (mesquites) [18] quoted Mageed et al. 2001. Second, privatizing the scheme without passing a transitional stage to pave the way for active private sector involvement, that is, farmers have been given free choice in selecting the crop/s to cultivate. Third, taking in mind the governmental support of wheat consumption that has resulted in low market price of the crop, many farmers stopped cultivating wheat for commercial purposes but rather for household consumption only, as wheat is considered as the main staple crop for most of the people in the location. It is also noticed that wheat production witnessed substantial increases in terms of both productivity and production, during the two eras (Fig. 3). The amazing thing is that the vertical expansion pre liberalization period was better than the after liberalization. This could be attributed to the fact that, in the pre-labialization era NHAS was fully controlled and managed by the government. It is worth mentioning here that, during the first agricultural season of the post-liberalization policy (1991/1992) wheat area, production and productivity reached its highest ever level due to the adoption of strong incentive programs and commitment by the Government. Two main policies were responsible for that success, namely (a) price support; declaring an attractive price before planting time and (b) inputs supported; provision of subsidized wheat inputs.

Area, production, the productivity of cotton during the pre-liberalization period showed increasing trend over time (Fig. 4). No wonder, because at that time the cotton company, a governmental company monopolizing the marketing of cotton, used to support and exert power on New Halfa Scheme to manage and monitor the crop. But after liberalization, farmers given a full choice for crops cultivation, hence, all growth rate indicators showed a declining pattern. Many farmers abandoned cotton cultivation because it needs a lot amount of irrigation and intensive capital and labour which farmers could not afford. This result contradicts the findings of [19] in their analysis of the growth rate in Gazira Scheme, Sudan, in which they found a positive cotton growth after the liberalization.

On the other hands, although the area allotted for groundnuts is decreasing, before the

liberalization policy, still the crop maintains increasing growth in production (Fig. 5). The main reason behind that increase is the improvement in productivity. But after liberalization, it seemed that farmers' has given up the area allotted for cash crop production (cotton and groundnuts) into sorghum production. The main reasons behind that might be the annual reduction of the water in the dams due to the sedimentations of mud in the dams, spread of mesquites, and negligence of government for cleaning both agricultural lands and canals hence the overall area allotted for agriculture crop declined with time. Although groundnut is a cash crop and can be grown under rainfall conditions, it needs a labour intensive work which much of the farmers could not afford. This result comes in line with the finding of [20]. They found that competitiveness and profitability of groundnut crop grown under the rain-fed condition during the post-liberalization period were seriously affected by the huge taxes imposed on both sides of its input and output.

The decomposition analysis of the growth in output for all crops is presented hereafter. Results revealed that the liberalization policy has succeeded in achieving the vertical expansion of all crops grown in the scheme but failed in upgrading farmers' agricultural skills and knowledge. Cropping pattern was the main obstacle hindering the full benefits of the liberalization.

Results revealed that the liberalization policy has succeeded in achieving the vertical expansion of sorghum (Fig. 6). The main player for sorghum production increase is the increase in area. Yield improvement was also witnessed during both era, although, in the post-liberalization period was greater. Accordingly, it seemed that the liberalization policy has succeeded in achieving what it has been set for; improved productivity.

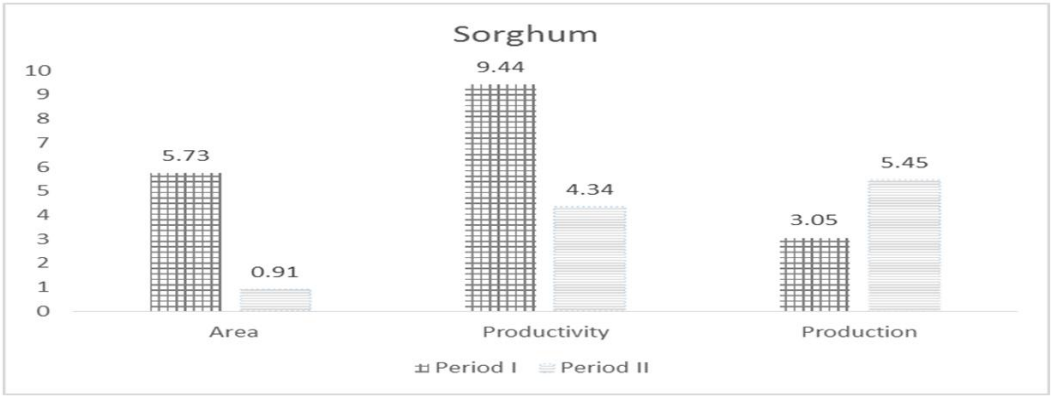

Fig. 2. Growth rate of sorghum (area (000 Ha), productivity (tons/Ha) and production (000 tons)) grown in New Halfa Scheme pre and post-liberalization periods (%)

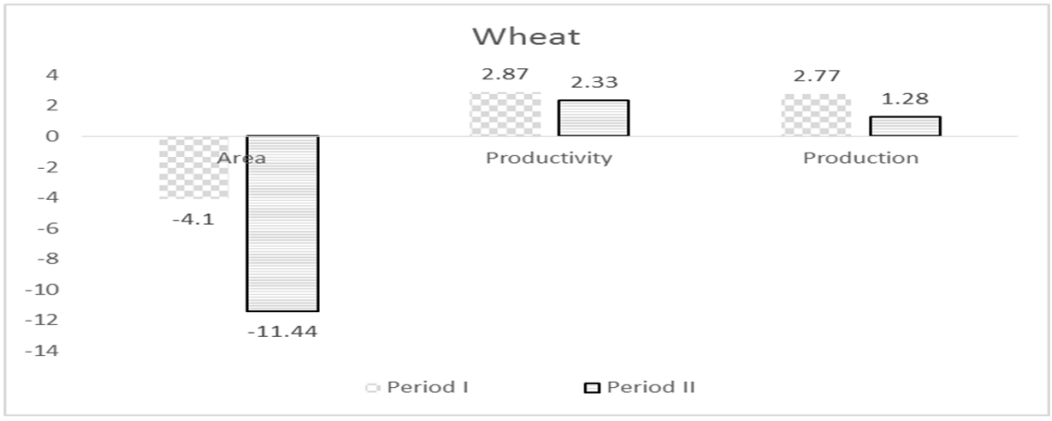

Fig. 3. Growth rate of wheat (area (000 Ha), productivity (tons/Ha) and production (000 tons)) grown in New Halfa Scheme pre and post-liberalization periods (%)

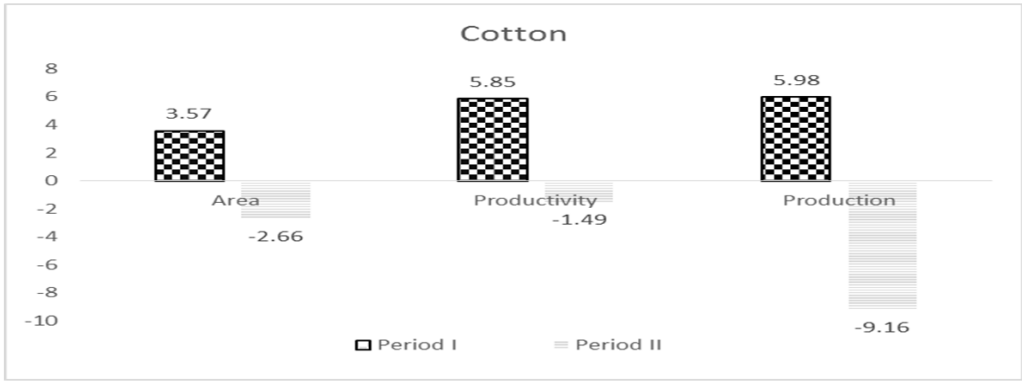

Fig. 4. Growth rate of cotton (area (000 Ha), productivity (tons/Ha) and production (000 tons)) grown in New Halfa Scheme pre and post-liberalization periods (%)

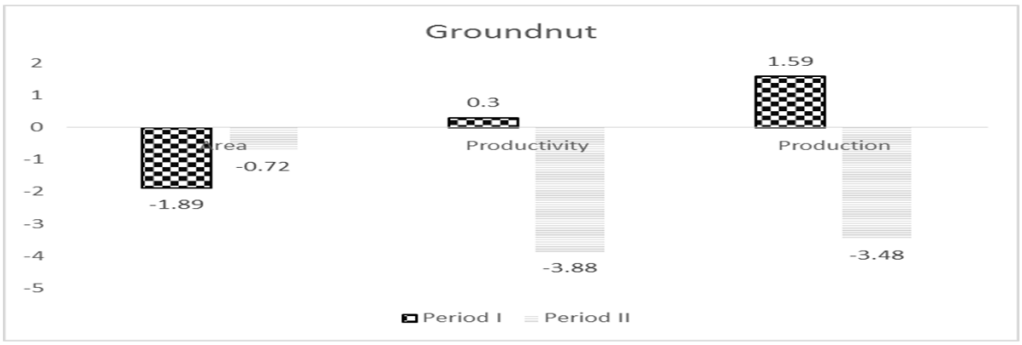

Fig. 5. Growth rate of groundnut (area (000 Ha), productivity (tons/Ha) and production (000 tons)) grown in New Halfa Scheme pre and post-liberalization periods (%)

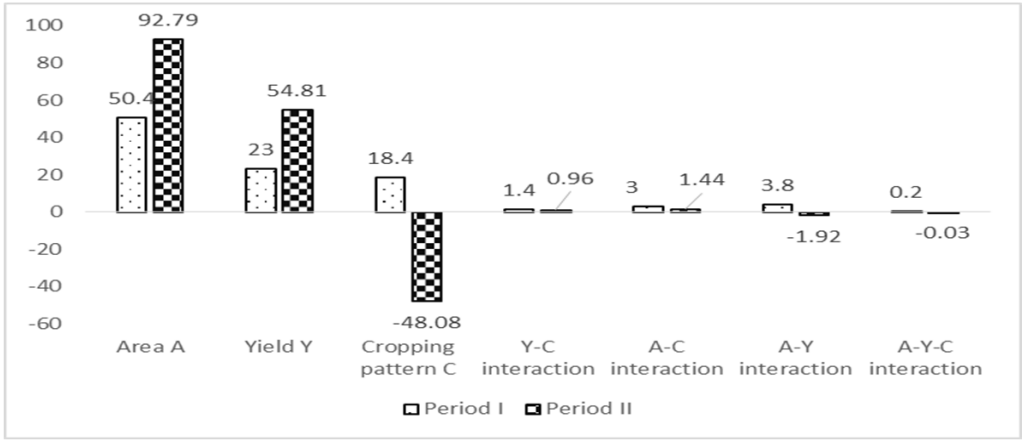

Fig. 6. Decomposition of growth in sorghum crops grown in New Halfa Scheme to their components: pre and post liberalization policy.

Where: Y-C=Yield-Cropping Pattern interaction, A-C interaction=Area-Cropping Pattern interaction, A-Y interaction=Area-Yield interaction, A-Y-C interaction=Area-Yield-Cropping pattern interaction.

The decomposition analysis of growth in output for wheat crop before the liberalization period is attributed mainly to the cropping pattern and area (Fig. 7). At that time New Halfa Corporation was functioning with strict crop rotation and adoption of recommended packages for crop's

cultivations, even though, it was witnessing a huge pressure of irrigation water shortages. But after liberalization the growth in output is attributed to both vertical (yield) and horizontal expansion of the commodity (area). This is particularly true if known that the government supports the production of wheat, particularly at early stages of liberalization. It is also noticed here that, the free cropping pattern used after the liberalization policy constitute the major obstacles to output growth.

The substantial increase in cotton output before the liberalization period is mainly attributed to the horizontal expansion of the crop (Fig. 8). Yes, at that time the government supports the crop in all agricultural practices. It also sells the product in the international markets on behalf of the farmers, through the Cotton Company. Yield is the second factor that played a good role in the production of cotton. But after liberalization, the massive decrease of cotton output is attributed to the reluctant of farmers to cultivate the crop due to the somehow huge capital it needs, hence both cotton cultivated area and productivity declined (Fig. 8). Poor productivity might be due to farmers' poor cropping pattern resulting from unavailability and/or poor extension service. This result contradicts the findings of [21] in their study of the technical efficiency and productivity of cotton farmers in Gezira scheme, Sudan. They found a very high technical efficiency of cotton farmers after liberalization period.

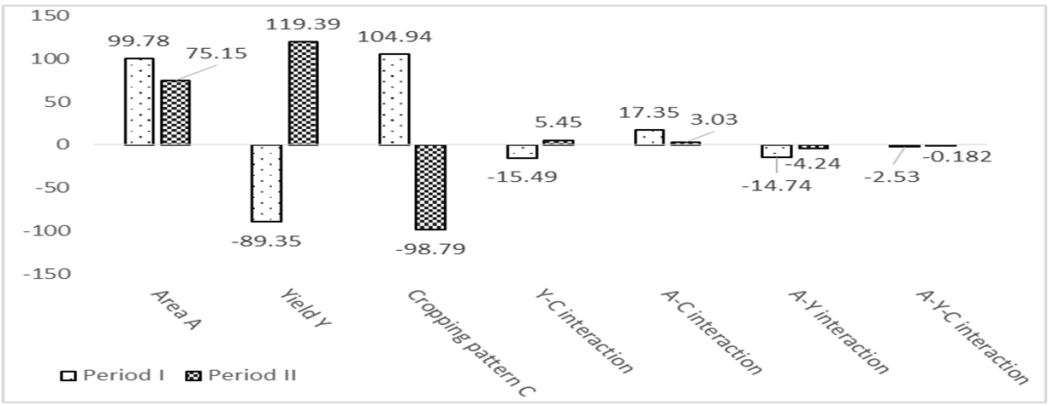

Fig. 7. Decomposition of growth in wheat crops grown in New Halfa Scheme to their components: pre and post liberalization policy.

Where: Y-C=Yield-Cropping Pattern interaction, A-C interaction=Area-Cropping Pattern interaction, A-Y interaction=Area-Yield interaction, A-Y-C interaction=Area-Yield-Cropping pattern interaction

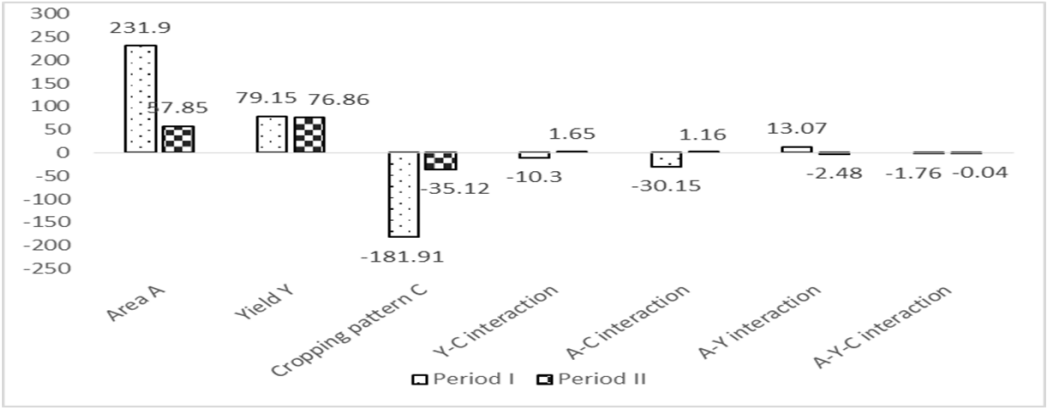

Fig. 8. Decomposition of growth in cotton crops grown in New Halfa Scheme to their components: pre and post liberalization policy

Where: Y-C=Yield-Cropping Pattern interaction, A-C interaction=Area-Cropping Pattern interaction, A-Y interaction=Area-Yield interaction, A-Y-C interaction=Area-Yield-Cropping pattern interaction

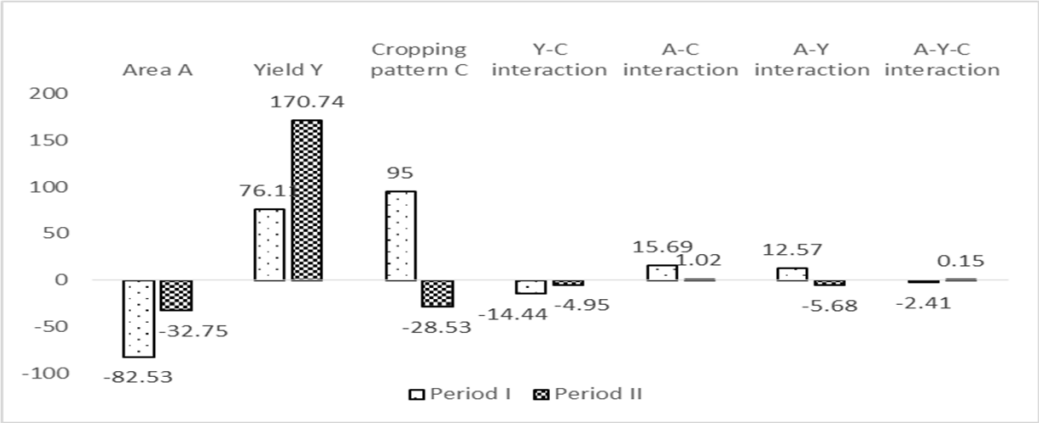

Fig. 9. Decomposition of growth in groundnut crops grown in New Halfa Scheme to their components: pre and post liberalization policy

Where: Y-C=Yield-Cropping Pattern interaction, A-C interaction=Area-Cropping Pattern interaction, A-Y interaction=Area-Yield interaction, A-Y-C interaction=Area-Yield-Cropping pattern interaction

The decomposition analysis of groundnuts has related the slight increase of groundnuts output before the liberalization to cropping pattern and yield, respectively (Fig. 9). Both cropping pattern and yield is highly related to the adoption of the recommended technical packages and the continuous monitoring by The NHC. On the other hand, the decomposition analysis model has related the huge decline of the groundnuts growth after liberalization to the huge reduction in area and poor cropping pattern, even though, a substantial improvement in productivity is witnessed here.

It is worth mentioning here that, central management could be a good solution to NHAS, at this time because most of the farmers have not reached the level of using commons property. They have little education and faced with a lot of financial and economic problems.

4. CONCLUSION

The liberalization policy adopted by the Sudanese government in 1992 failed to achieve the positive growth in the agricultural sector, particularly in the primary crop grown in New Halfa Scheme. It leads the farmers to change their agricultural production towards sorghum mono-cropping. Accordingly, to achieve the full benefits of liberalization policy the government should keep its role in the cleaning of the canals and the Dam's reservoir, support farmers to encourage their production and put the scheme under a transitional period of the central management systems.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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