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Estimation of Growth Rates and Analysis of its Components in the Gezira Scheme

Mohamed Elamin Abd Ellatif Mahir and Hag Hamad Abdelaziz

Department of Agricultural Economics, Faculty of Agricultural Studies, Sudan University of Science and Technology, Sudan

Abstract: The study was conducted to estimate the growth rate of area, productivity, and production and measure the contribution of different components to the growth rate of the main crops grown in the Gezira scheme. The study used secondary data covering the period before the adoption of the liberalization policy (1970/71 to 1991/92) and the period after the adoption of the liberalization policy (1992/93 to 2007/08). The crops concerned in the study were sorghum, wheat, cotton and groundnuts. The study estimated the growth rate in area, productivity, and production before and after the adoption of the liberalization policy for the four crops. Further, the study conducted a decomposition analysis to determine the contribution of different components to the growth rate. The results of the study showed that there were variations in growth rates of area and productivity for the crops during the two periods. The growth rate was positive and increasing during the two periods for sorghum, positive and decreasing for cotton and negative and decreasing for groundnuts. The decomposition analysis revealed that the main components contributing to growth rate were area, productivity and cropping pattern. Programs designed to remove the constraints facing the agricultural production in the Gezira scheme can play a substantial role in achieving high growth rate of agricultural production. Such programs and policies include rehabilitation of irrigation system, strengthening agricultural research and extension, reduction of agricultural taxes and formulation of pricing and marketing policies conducive to agricultural production.

Key words:

INTRODUCTION

Sudan's economy depends on agriculture which contributes to about 38 to 40% of the Gross Domestic Product (GDP) and provides livelihood for more than 70% of the economic active population, employs 65% of the active labor force, 80% of the country's exports (excluding petroleum) . In addition , it provides the industrial sector by 50% of the needed raw materials (Ministry of Finance and National Economy, 2007).

The total cultivable area of the Sudan is 200 million feddan, only about 41 million feddan are under crop production[1]. The large area of the country gives it a wide range of ecological zones based on the amount of annual rainfall. The north is an arid zone where annual rainfall is, on the average, 75 mm, successive zones southwards receive more rainfall. In the extreme south lies the tropical zone where rainfall is in excess of 1600 mm/annum. The rainfall, together with the surface and underground water resources, give the country a substantial amount of water resources estimated at 34 billion cubic meters per annum[6].

The country enjoys a high potentiality to produce a wide range of crops including cotton, groundnuts, sorghum, wheat, beans, dates, oilseeds, fruits and vegetables. These crops are produced under two different farming systems namely : the rainfed and irrigated systems.

The agricultural sector has performed impressively in terms of increasing productivity and intensity of cultivation since the independence of the country in 1956 and on wards. In the same period, irrigation availability has doubled and cropping intensity has increased significantly across the country, due to fast adoption of technology by farmers, and above all, the government decision to accord a high priority to agriculture by making large investments plan in infrastructure, particularly those related to agriculture (irrigation projects, agricultural research, extension, …..) beside adopting policies conducive to agricultural development. The Gezira scheme is regarded as the largest, oldest, and the most important within the agricultural sector in general and the irrigated sub-sector in particular. Gezira scheme covers 50% of the irrigated sub-sector and its total area is about 0.882 million hectare[3].

The objectives of this paper were to estimate the growth rates of area, productivity, and production and measure the contribution of different components to agricultural production of the main crops grown in the

Corresponding Author: Mohamed Elamin Abd Ellatif Mahir, Department of Agricultural Economics, Faculty of Agricultural Studies, Sudan University of Science and Technology, Sudan

Gezira scheme during the pre-prices liberalization policy (1970-1991) and post–prices liberalization policy (1992-2008).

MATERIALS AND METHODS

The study used secondary data covering the period from 1970 to 2004. The sources of data used were the Ministry of Agriculture and Forestry and Department of Statistics in the Gezira scheme.

The methods used for estimating the growth rate and decomposition of growth components are described below:

Measurement of Growth Rate: The growth rate was measured following the procedure adopted by Green (2000) and the steps followed are presented below.

Let

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

Where

Y_t = area / production / productivity of crop concerned in the year t.
A = intercept
T = year
B = 1 + r/100

Where, 'r' refers to the percentage rate of compound growth of area / production / productivity crop per annum.

By taking logarithm of both sides of the equation, we get :

$$\text{Log } Y_t = \text{Log } A + t \text{ Log } B \quad (1.2)$$

If we put Log A = a, and Log B = b, then the above equation can be written as :

$$\text{Log } Y_t = a + bt \quad (1.3)$$

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

$$\Sigma \text{ Log } Y = Na + b\Sigma t \quad (1.4)$$

$$\Sigma (t \text{ Log } Y) = a \Sigma t + b \Sigma t^2 \quad (1.5)$$

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 :

$$\Sigma \log Y = Na \quad (1.6)$$

Then

$$a = (\Sigma \log Y)/N \quad (1.7)$$

and

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

Then,

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

For deriving compound growth rate from the regression coefficients, the following procedure is adopted. When time is measured in 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.
Comparison equation (1.10) with (1.3) shows that

Log B = log (1 + r)

And

r =antilog B - 1

Percentage rate of compound growth per annum was calculated as:

r = (antilog B – 1) x 100

Which represents a rate of change from observation to observation during the period under study.

2- Decomposition of Growth Components: The decomposition of growth components of agricultural production was estimated using a decomposition model developed primarily by Minhas and Vaiyanathan[5].

Dayel R.,[2], Parikh[10] and Misra[8] employed the same model for decomposing the components of agricultural production. Narender *et. al* [9] conducted a study to estimate the contribution of various components to the growth of agricultural output by using a decomposition model developed by Minhas and Vaiyanathan and modified by Sarma P.V.,[11]. Utpal Kumar[12] analysed the contribution of different components using the same model.

The following is the converted growth rate decomposition model of Minhas seven-factor decomposition scheme.

Consider,

$$P_{io} = A_o\ C_{io}\ Y_{io} \qquad (2.1)$$

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

Where

P_{io} = production of the ith crop in the base year o
P_{it} = production of the ith crop in the current year t
A_o = gross cropped area in year o
A_t = gross cropped area in year t
Y_{io} = yield per hectare of crop i in year o
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

$$P_{it} - P_{io} = A_t\ C_{it}\ Y_{it} - A_o\ C_{io}\ Y_{io} \qquad (2.3)$$

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,

$A_t = A_o + \Delta A$
$C_{it} = C_{io} + \Delta C$
$Y_{it} = Y_{io} + \Delta Y$

Equation (4.2.3) can, therefore, be written as

$$P_{it} - P_{io} = (A_o + \Delta A) (C_{io} + \Delta C) (Y_{io} + \Delta Y) - A_o\ C_{io}\ Y_{io} = A_o\ C_{io}\ Y_{io} + A_o\ Y_{io}\ \Delta C + C_{io}\ Y_{io}\ \Delta A + A_o\ C_{io}\ \Delta Y + Y_{io}\ \Delta A\ \Delta C + A_o\ \Delta C\ \Delta Y + C_{io}\ \Delta A\ \Delta Y + \Delta A\ \Delta C\ \Delta Y - A_o\ C_{io}\ Y_{io} \qquad (2.4)$$

which can be written as :

$$P_{it} - P_{io} = C_{io}\ Y_{io}\ (A_t - A_o) + A_o\ C_{io}\ (Y_{it} - Y_{io}) + A_o\ Y_{io}\ (C_{it} - C_{io}) + Y_{io}\ (A_t - A_o)\ (C_{it} - C_{io}) + A_o\ (C_{it} - C_{io})\ (Y_{it} - Y_{io}) + C_{io}\ (A_t - A_o)(Y_{it} - Y_{io}) + (A_t - A_o)\ (C_{it} - C_{io})\ (Y_{it} - Y_{io}) \qquad (2.5)$$

In this additive scheme of decomposition, the first element on the right hand side is the area effect, i.e., an increase in output of this magnitude could have taken place in the absence of any changes in per hectare yield and cropping pattern. The second term is the effect of yield change for constant cropping pattern.

The third element 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, (1) interaction between crop pattern changes and changes in area (2) interaction between crop pattern changes and changes in yield (3) interaction between per hectare yield changed and changes in area, and (4) interaction among cropping pattern changes, per hectare yield changes and changes in area.

RESULTS AND DISCUSSION

Growth Performance:

Growth in Area: In this section, the results of analysis of the annual growth rate in area, productivity and production of principal crops in Gezira scheme during the specified periods are discussed. It may be observed from Table (1) that, area under sorghum in Gezira recorded annual growth rate of 4.7 percent during period I, but period II witnessed a negative growth rate of -5.03 percent. Area growth rate of wheat showed a positive growth rate in period I (1.88%) but it turned to be negative in period II (-29.6%). The growth rate under cotton was negative during period I (-4.28%) and it turned to be positive during period II (1.78%). Area under groundnuts showed a higher decline in period I (-11.16%) compared to period II which was (-1.65%).

Growth in Productivity: It was expected that the growth rate in productivity of principal crops during post-prices liberalization policy period increased. Sorghum was the only crop, which recorded increasing productivity growth rate in Gezira throughout the two periods under study. Annual growth rate in sorghum productivity was 1.78 percent during period I, however, it was comparatively higher during period II (2.54%).

Wheat productivity growth rate was positive during period I (1.27%) and it registered a negative growth rate during period II (-1.34%). The productivity growth rate of cotton showed a decreasing trend, i.e., (3.73%), (1.01%) during period I and period II, respectively.

Annual productivity growth rate of groundnuts was (-0.075%) during period I and (-3.9%) during period II which was comparatively lower than period I.

Growth in Production: The annual growth rate of sorghum production was 1.48 percent and 1.84 percent during period I and period II, respectively. Wheat production witnessed a positive growth rate in period I (1.28%), and recorded a negative trend in period II, (-1.46%). Growth in cotton production was positive in period I and period II, it was (3.69%) and (1.37%), respectively. There was a decline in growth rate in groundnuts production, but it was comparatively higher in period I (-11.24%) than in period II (-5.56%).

Decomposition of Growth Components: The decomposition analysis of the growth in output for sorghum crop is presented in Table (4). It is observed that the main contribution (247.12%) to the growth of output during the first period came from area. The contribution of yield was 36.54%. The contribution of cropping pattern was negative, being (-164.42%). The yield and cropping pattern interaction contribution was -3.03%. The area and cropping pattern interaction contribution was negative (-20.34%). The area yield contribution was positive being (4.52%). The last interaction was negative
(-0.38%).

During the second period (1992/93 to 2000/2004), the main contribution to change in production was due to change in yield which was (51.90%). Contribution of change in area was (48.03%), the contribution of cropping pattern was (2.64 percent). The yield – cropping patter interaction was (-0.13%), area and cropping pattern interaction was (-0.12%). Area and yield interaction contribution was (-2.28%), and the last interaction contribution was not significant.

The results of decomposition analysis of the growth in output for wheat crop are presented in Table (5). It is observed that the main contribution (72.89%) to the growth of output during the first period came from cropping pattern. The contribution of area and yield change was comparatively less, being (8.64%) and (4.16%) respectively. The yield and cropping pattern interaction contribution was 4.43%. The change in production output due to changes in cropping pattern was 9.00% and the other two interactions contributed positively, though in very small proportions, to the growth of production of wheat.

During the second period (1992/93 to 2000/2004), the main contribution to change in production was due to change in yield which was (76.31%). Contribution of change in area was (29.23%), the contribution of cropping pattern was negative (-2.49 percent). The yield – cropping patter interaction was (0.31%), area and cropping pattern interaction was positive (0.18%), and the other two interactions contributed negatively.

The results of decomposition analysis for cotton related to the two sub-periods are presented in Table (6). Area contribution to growth of production was positive in the second period and negative in the first period (-193.8%). In case of yield, its contribution was 113.6% in the first period, which increased to 173.30% during the second period. The contribution of cropping pattern was 159.43% in the first period and turned to be negative in the second period (-299.10%). The contribution of yield–cropping pattern interaction was not significant, it was -11.55% in the first period and turned to be positive in the second period (11.31%).

Area and cropping pattern interaction contribution was positive in the first period (19.71%) and decreased to 13.80% in the second period. The contribution of area and yield interaction was positive in the first period (14.03%) and turned to be negative in the second period (-7.92%). Area – yield – cropping pattern interaction contribution was negative in the two periods.

In groundnuts, contribution of area was negative (-16.4%) in the first period, it turned to be positive (5.57%) in the second period. Yield contribution was positive in the two periods and higher than that of area. Contribution of cropping pattern was the highest and it was 100.11 percent in the first period and 91.64 percent in the second period. The contributions of yield–cropping pattern interaction were negative in the two periods. The other interactions contributions were not large except area – cropping pattern in the first period, which was 12.37% (Table 7).

Conclusion: The analysis of annual growth rates in area showed a negative growth rate for sorghum, groundnut and wheat, but it was positive for cotton during post-liberalization period.

Sorghum productivity growth rate recorded an increasing trend during post-liberalization period, cotton productivity registered a positive but declining growth rate, but wheat and groundnut showed a negative growth rate during post-liberalization period.

Annual growth rate of sorghum production recorded an increasing trend. Wheat production recorded a declining trend, Cotton production growth rate was negative during post-liberalization period , production of groundnut recorded a negative growth rate during post-liberalization period.

The analysis of components of growth in sorghum production during post-liberalization period showed that the main contribution to growth was due to area and yield and during pre-liberalization period, the main contribution was due to area. The main contribution to wheat production during pre-liberalization period was

due to cropping pattern, but it was due to yield during post-liberalization period. The main contribution to cotton production growth during pre-liberalization period was due to cropping pattern. During post-liberalization period the main contribution to cotton growth production was due to area. Cropping pattern was the main contributor to groundnut growth during pre-liberalization period and during post-liberalization period.

It can be concluded that there has been a substantial increase in the production of sorghum. The increase in sorghum production was mainly due to the cultivation of high yielding varieties. The decline in cotton growth rates was due to taxes and removal of subsidies. The decline in wheat growth rates was due to the decrease in area, which was attributed to low yield, financial and irrigation problems. The decline in growth rates of groundnuts production was due to the high cost of production and low prices of output.

Table 1: Growth in area (percent)

	Period I	Period II
Sorghum	4.7	-5.03
Wheat	1.88	-29.6
Cotton	-4.28	1.78
Groundnuts	-11.16	-1.65

Table 2: Growth in productivity (percent)

Crop	Period I	Period II
Sorghum	1.78	2.54
Wheat	1.27	-1.34
Cotton	3.73	1.01
Groundnuts	-0.075	-3.9

Table 3: Growth in production (percent)

Crop	Period I	Period II
Sorghum	1.48	1.84
Wheat	1.28	-1.46
Cotton	3.69	1.37
Groundnuts	-11.24	-5.56

Table 4: Components of growth in sorghum production

Area A	Yield Y	Cropping pattern C	Y-C interaction	A-C interaction	A-Y interaction	A-Y-C interaction	All Components
			I Period				
247.12	36.54	-164.42	-3.03	-20.34	4.52	-0.38	100.00
			II Period				
48.03	51.90	2.64	-0.13	-0.12	-2.28	0.005	100.00

Table 5: Components of growth in wheat production

Area A	Yield Y	Cropping pattern C	Y-C interaction	A-C interaction	A-Y interaction	A-Y-C interaction	All Components
	Period I						
8.46	4.16	72.89	4.43	9.00	0.51	0.55	100.00
	Period II						
29.23	76.31	-2.49	0.31	0.18	-3.49	-0.01	100.00

Table 6: Components of growth in cotton production

Area A	Yield Y	Cropping pattern C	Y-C interaction	A-C interaction	A-Y interaction	A-Y-C interaction	All Components
			Period I				
-193.8	113.6	159.43	-11.55	19.71	14.03	-1.43	100.00
			Period II				
209.05	173.30	-299.10	11.31	13.80	-7.92	-0.45	100.00

Table 7: Components of growth in groundnuts production

Area A	Yield Y	Cropping pattern C	Y-C interaction	A-C interaction	A-Y interaction	A-Y-C interaction	All Components
			Period I				
-16.4	14.2	100.11	-10.7	12.37	1.76	-1.32	100.00
			Period II				
5.57	29.66	91.64	-22.34	-4.2	-1.36	1.02	100.00

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