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Total Factor Productivity and Environmental Efficiency of the Most Important Cereals Crops in Egypt

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AAER and AMR designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Authors AAER, EES and SMS collected the data. Authors AAE and SMS managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Purpose of the Study: Egyptian agriculture suffers from many problems related to the use of available economic resources, the most important of which is lack of optimal utilization of resources, wasteful use of agricultural production inputs, reduced efficiency of irrigation water use, and the fertility of agricultural lands are deteriorating, in addition to increasing rates of encroachments on agricultural lands and shifting it from agricultural use to other non-agricultural uses, which limits the agricultural sector ability to achieve high growth rates, especially with the increasing global production of biofuels from crops that individuals consume as food, including wheat and corn, which constitutes an explicit threat to Egyptian food and national security.

Objectives: The research aimed to:

1. Estimate the changes in the sources and components of the total productivity of the factors for the main cereal crops in Egypt in the presence and absence of carbon dioxide emissions,
2. Environmental impact assessment of changes in the productivity of these crops.

Methods: The study applied analytical approaches to measure changes in productivity, as parameter analysis methods are used as methods of the aggregate production function, and non-parameterized methods of estimation, in addition to (Malmquist, 1953) which is one of the most

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important indicators of measurement changes in productivity and relies on a Data Envelopment Analysis (DEA) to measure efficiency and changes in TFP productivity and identify the sources of changes in productivity through changes in technical competence and technological change, as the two most important components of the change in total productivity.

Results: Wheat Crop: Wheat crop by estimating the change in the different efficiencies of the wheat crop with co_2 emissions, it was clear that a decrease in technological change (TC) during the study period, and thus a decrease in the average change in the total factor productivity (TFP), while without co_2 emissions effect, the average change in the total factor productivity of (TFPc) indicates an increase in the actual wheat efficiency which is low due to the environmental impact of the emissions.

Rice Crop: Rice crop by estimating the change in the different efficiencies of the rice crop with co_2 emissions, it became clear that a decrease in the average technological change (TC), thus increasing the average change in the total factor productivity of the (TFP), whereas, without co_2 emissions, it was found that the average change in the total factor productivity of the (TFPc) for the study areas was higher.

Summer Maize Crop: It was clear that the average technological change (TC) for the summer maize crop with co_2 emissions, decreased during the study period, and therefore a decrease in the average change in the total factor productivity of the (TFP), but without co_2, an increase in the annual average of the change in technical efficiency (TEC), and a decrease in the average technological change (TC), i.e. in the use of technology, and an increase in the average change in the total factor productivity (TFPc).

Keywords: Total factor productivity (TFP); Malmquist index; cereal crops; CO_2 emissions; environmental impact.

1. INTRODUCTION

Despite the conditions experienced by Egyptian agriculture, it still significant, especially to its share in the gross domestic product and direct and indirect employment opportunities that it provides to other sectors and providing it with raw materials for the industry. The twelfth goal of the United Nations Sustainable Development Goals promotes ensuring sustainable production and consumption patterns that encourage efficiency in resources and energy exploitation, enhancing infrastructure sustainability, reducing future environmental and social costs, reducing poverty, and increasing net gains in welfare, by reducing the use of resources and reducing their deterioration and pollution.

According to the economic importance of the agricultural sector, agricultural productivity and growth in agriculture have become among the main areas of research over the past five decades, as researchers examined the sources of productivity growth over time and differences in productivity between different countries and regions [1], as a result of efforts Made to maintain self-sufficiency in the agricultural sector.

The trend towards measuring productivity is a significant research trend as more accurate indicators for expressing economic performance, as it reflects outputs (production or output) and inputs (supplies, labor, capital), and it should be noted that along with the average productivity and marginal productivity of the production elements, A third concept has emerged which is called multi-factor productivity, all-factor productivity combined, co-factor productivity or total factor productivity (TFP) [2].

Total Factor Productivity (TFP) is one of the most common measures of agricultural productivity, taking into account all factors of production (land, labor, capital, and material resources) used in agricultural production and comparing them to the total amount of crop and livestock production, so if the total output grows faster of the total inputs, total factor productivity (TFP) is increasing [3].

Egyptian agriculture suffers from many problems related to the use of available economic resources, the most important of which is lack of optimal utilization of resources, wasteful use of agricultural production inputs, reduced efficiency of irrigation water use, and the fertility of agricultural lands are deteriorating, in addition to increasing rates of encroachments on agricultural lands And shifting it from agricultural use to other non-agricultural uses, which limits the agrarian sector ability to achieve high growth rates, especially with the increasing global production of biofuels from crops that individuals consume as food, including wheat and corn, which constitutes an explicit threat to Egyptian food and national security. Accordingly, the study seeks to answer the following questions: Are there changes in the productivity of the most important cereal crops in Egyptian agriculture? What are the components of these changes?

The research aimed to measure the changes in the total factor productivity, and the efficiency of using agricultural production inputs for the most important cereal crops in Egypt, namely wheat, rice, and summer maize in the regions of Lower Egypt, Central Egypt, Upper Egypt, and the entire Republic, except for the rice crop in Lower Egypt and Central Egypt in addition to total Egypt during the period 1970-2017, with the introduction of carbon dioxide emissions as an environmentally harmful outlet, by achieving the following goals:

1. Estimate the changes in the sources and components of the total productivity of the factors for the study crops in the presence and absence of carbon dioxide emissions,
2. Environmental impact assessment of changes in the productivity of these crops.

2. REVIEW OF LITERATURE

Coelli and Prasada [1] present some important findings on levels and trends in global agricultural productivity over the past two decades. The results presented here examine the growth in agricultural productivity in 93 countries over the period 1980 to 2000. The results show annual growth in total factor productivity growth of 2.1 percent, with efficiency change (or catch-up) contributing 0.9 percent per year and technical change (or frontier-shift), providing the other 1.2 percent. There is little evidence of technological regression. Turning to the performance of various regions, Asia is the major performer with an annual TFP growth of 2.9 percent. Africa seems to be the weakest performer, with only 0.6 percent growth in TFP [1].

Abedullah and Mushtaq [4] used the intensive use of chemicals to work as a catalyst to shift the production frontier. Still, the most critical factor in maintaining a clean environment was totally ignored. The study attempts to estimate the environmental efficiency of rice production of Punjab in 2006. Chemical weedicides and nitrogen are treated as environmentally detrimental inputs. The mean technical efficiency index is sufficiently high (89%). Still, the environmental efficiency index of chemical weedicides alone is 14%. In comparison, the joint environmental efficiency index of chemical weedicides and nitrogen is 24%, implying that joint environmental efficiency is higher than chemical weedicide alone. It indicates that substantial reduction (86%) in chemical weedicide use is possible with a higher level of productivity. Moreover, it is likely to contribute a considerable decrease in environmental pollution, which is expected to enhance the performance of agriculture labor [4].

Ebata [5] examined TFP growth rates in the agricultural sector of 14 regions in Central America and the Caribbean, and the lowest growth rates during the first period (1976-1986) followed by faster rates of growth in the following two decades (1987-1996, 1997-2006). When CO2 emission from land-use change is considered, however, the last decade denotes lower rates of growth in most countries in comparison to the normal TFP specification methods. If the current production process keeps emitting CO_2 from land conversion and it harms TFP growth rates, policies that promote forest conversion to expand agricultural lands directly or indirectly need to be re-considered [5].

Gonzalez [6] paper develops a new measure of total factor productivity growth in agricultural production, which incorporates Bio Economic components effects. The new measure is called the Bio Economic-Oriented Total Factor Productivity (BTFP) index and incorporates components of Bio Economics as liquid biofuels. BTFP measure changes in Bio Economic efficiency and can be decomposed into bio-economy efficiency change (BEC), and Bio Economic technological change (BTC) components. An empirical analysis, involving 7 Central American countries-level during 1980-2007, is provided using DEA methods. The results have shown positive annual growth in bio-economy total factor productivity of 1.1 percent. This change is explained by 0.03 percent per year in the bio-economy efficiency change, and bio-economy technical change is providing 0.09% [6].

Saikia [7] paper discusses the determinants of TFP growth in agriculture Indian and analyzes the trends in TFP growth in Indian agriculture. The TFP growth in Indian agriculture was very low in the pre-green revolution period, and it declined during the 1970s. During the 1980s, the TFP growth rate has marginally improved, but it has again come down during the 1990s [7].

El-Kholei [8] aims are to provide up to date information on agricultural growth over the past three decades (1980-2012) for nine of the largest agricultural producers in the Arab world. Namely are Algeria, Egypt, Iraq, Jordan, Morocco, Sudan, Syria, Tunisia, and Yemen. The analysis employs a non-parametric, output-based Malmquist to estimate TFP index numbers. Results throughout the period 1980-2012 show that the average annual growth rate of agricultural productivity reached 1.2%.Efficiency changes contributed by a mere 0.2% while the rest 1% was provided by technical change. The country with the highest TFP growth is Jordan, with an impressive 3.7% average annual growth in TFP. However, for Yemen and Algeria, it reached about 3% each, Egypt (2%), Sudan (0.8%), Tunisia, and Iraq (0.4%) [8].

Dhehibi, El-Shahat, Frija and Hassan (2016) try to assess the Total Factor Productivity (TFP) of the whole agricultural sector in Egypt for the period 1961-2012 using Törnqvist index calculations. The findings showed that rural development variables were found to significantly and negatively affect agricultural productivity. It demonstrates that agricultural activity is still a marginalized activity that is linked to low levels of income and is a source of employment for low productive labor. Moreover, a significant negative effect of the infrastructure variable on the productivity gains of the agricultural sector in Egypt was found, which might indicate a form of low integration of farmers within large neighboring markets. These findings take a deeper look at their rural infrastructure strategy, knowing that it may affect the productivity of the agricultural sector [9].

Elasraag and Alarico (2017) study aimed to measure the total factor productivity of the main governorates of wheat production in Egypt during the period 1990-2012 and decompose it into technical change, efficiency change, and scale change. We used the Global Malmquist TFP index as a non-parametric approach. The results indicated that the contribution of technical change component is more important than the efficiency change component. Technical change rose, 25.7%, while efficiency change presented a little decline, 3.7%. The decomposition of efficiency change indicated that the main problem of wheat production in Egypt was scale efficiency that worsened by 5.5% [10].

Şişman [11] study the productivity and efficiency of the Turkish agricultural sector were analyzed for the years between 2006-2015 .The results of the first analysis provided the Malmquist index values for TFP change and its components (technical efficiency change, technological change, pure technical efficiency change, and scale efficiency change) in agriculture of 26 regions in Turkey for the selected time period. The result reveals that agricultural TFP of regions has decreased by 2% annually on average. The maximum TFP growth in agriculture occurred between 2007 and 2008, with a mean increase of 12% in the overall TFP of regions. On the other hand, the greatest regression in the overall TFP was observed in the 2010-2011 period by a decrease of 13% [11].

Le, Lee, Peng, and Chung (2019) study assessed the change in productivity and environmental efficiency of agriculture for nine East Asian countries for the time period from 2002 to 2010. Data were collected and then analyzed by data envelopment analysis (DEA) approaches, including Malmquist total factor productivity (TFP) index, with the consideration of undesirable outputs. The results showed that there existed relatively large differences in productivity growth and environmental performance in the agricultural sector between countries in the sample. Overall, the countries examined in the present study experienced a decline in TFP due to decreases in technical efficiency. Taiwan, Japan, and Korea were found to show growth in productivity and fully efficient environmental performances throughout the study period. At the same time, Thailand was identified as having the lowest ecological efficiency score [12].

3. MATERIALS AND METHODS

There are many methods and analytical approaches to measure changes in productivity, as parameter analysis methods are used as methods of the aggregate production function, and non-parameterized methods of estimation adopted by them (Fischer, 1922), (Tornqvist, 1936), in addition to (Mamlquist, 1953) which is one of the most important indicators of measurement Changes in productivity and relies on a data envelope analysis (DEA) to measure efficiency and changes in TFP productivity and identify the sources of changes in productivity through changes in technical competence and technological change, as the two most important components of the change in total productivity [13]. Fig. 1 shows a summary of methods for measuring total factor productivity (TFP).

The study estimates the Total Factor Productivity (TFP) based on the use of Data Envelopment Analysis (DEA) and the Malmquist Index of crops understudy in different geographical regions; (Lower Egypt, Middle Egypt, Upper Egypt) and to estimate the changes in TFP in all regions in the presence and absence of carbon dioxide emissions (CO_2eq), which reflects the environmental impact of changes in the efficiency of the productivity of these crops.

3.1 Variables in Model

Area, total cost and main price as inputs & Production as output (it's without CO_2 emissions).

Area, total cost and main price as inputs & Production and emissions as outputs (it's with CO_2 emissions).

The study depends on time series data covering the period 1970-2017 for the area, productivity, production, prices, and the costs of wheat, rice, and summer maize crops, which are issued by many government agencies such as the Ministry of Agriculture and Land Reclamation, the Central Agency for Public Mobilization and Statistics, and the United Nations Organization Food and Agriculture (FAO). Emissions data were collected from FAOSTAT [14] for each crop (included crop residue and burning), and their ratio for each region was calculated based on the area planted of crop in the region. Emissions in the model were treated as a harmful or undesirable output.

The study crops (wheat, rice, summer maize) were chosen for their nutritional importance and their impact on the food security of the community members, in addition to that they represent the main cereal crops in the crop composition in Egyptian agriculture as they represent about 38% of the total crop area [15], as well as its impact on the Egyptian agricultural trade balance. This study differs from previous studies in the time period and the geographical areas specified for the study, to measure the efficiency of agricultural production and the total productivity of factors in Egypt during the period 1970-2017.

Total factor productivity (TFP) can be defined as a ratio of total outputs relative to the total inputs used. Productivity metrics associated with only one category of input are known as Partial Productivity Measures such as labor productivity and capital productivity. Those partial metrics do not explain the effect of interdependence, overlap, and interdependence between the inputs, so the complete production measure is TFP, where it takes into account all the inputs used in the production process [16].

The study of total factor productivity growth (TFP) requires an analysis of the growth sources, there are several methods that are used for this, namely: The Growth Accounting Approach, the Index Number Approach, the Non-Frontier Econometric Approach, (4) Data Envelopment Analysis or the Distance Function Approach.

Economic Efficiency (EE) can be defined as the outcome of two main types of efficiency: Technical Efficiency TE) and Allocative Efficiency. EE represents the product of technical and distributive efficiency:

$$EE = TE * AE$$

3.2 Malmquist Index

This indicator is attributed to the Swedish economist Sten Malmquist (1917-2004), this index was presented for the first time in (1953), which is considered one of the best methods used to measure productivity as it depends on quantitative indices in calculating the changes in the level of each of the outputs and inputs of the production process between two points Two or more time periods or between two or more production facilities, and for multi-party comparisons, the Total Factor Productivity Index (TFP) indicates the ratio of change in the total of outputs to the change in the user total of inputs, and this indicator is preferred over the partial indicators of productivity through which productivity is calculated one production entry because the latter gives a misleading picture of overall performance [17].

Many researchers prefer to use the Malmquist index for several reasons, including:[20].

1. Does not require assumptions on the economic behavior of production units, such as maximizing profits or minimizing costs.
2. Does not require information about the prices of inputs and outputs, and this is an advantage because, in general, data on agricultural input prices are rarely available, and these prices can be

distorted due to government interference in most developing countries.

3. It is allowed to divide productivity into two parts, namely, technical efficiency change, and technological change, that is, it allows analysis of change in (TFP) to its components, which is represented by changes resulting from the movement towards production frontier (referred to as technological efficiency) and the transmission of the production boundary line (Which reflects technological change), and this should help gain insight into the sources of growth (TFP).
4. It allows a new definition of technology, Sequential Technology vs. contemporary technology.

We used a data envelopment analysis (DEA) to estimate Malmquist Index, the estimation of the Malmquist index depends on several methods, the most important of which is the data envelopment analysis (DEA) method (Farrell, 1957), and there are two types of DEA models:

- Constant Returns to Scale (CRS): Means that by increasing inputs by a certain percentage, and by 10%, outputs increase by the same percentage.
- Variable Returns to Scale (VRS): This means that by increasing the inputs by 10%, this allows the outputs to be increased by a greater percentage, and this is known as the increasing, increasing returns, while in the case of increasing the outputs by a smaller percentage, this is called the Decreasing Returns Estimating technical efficiency indicators and capacity efficiency for either type using either the input map or the output map [17].

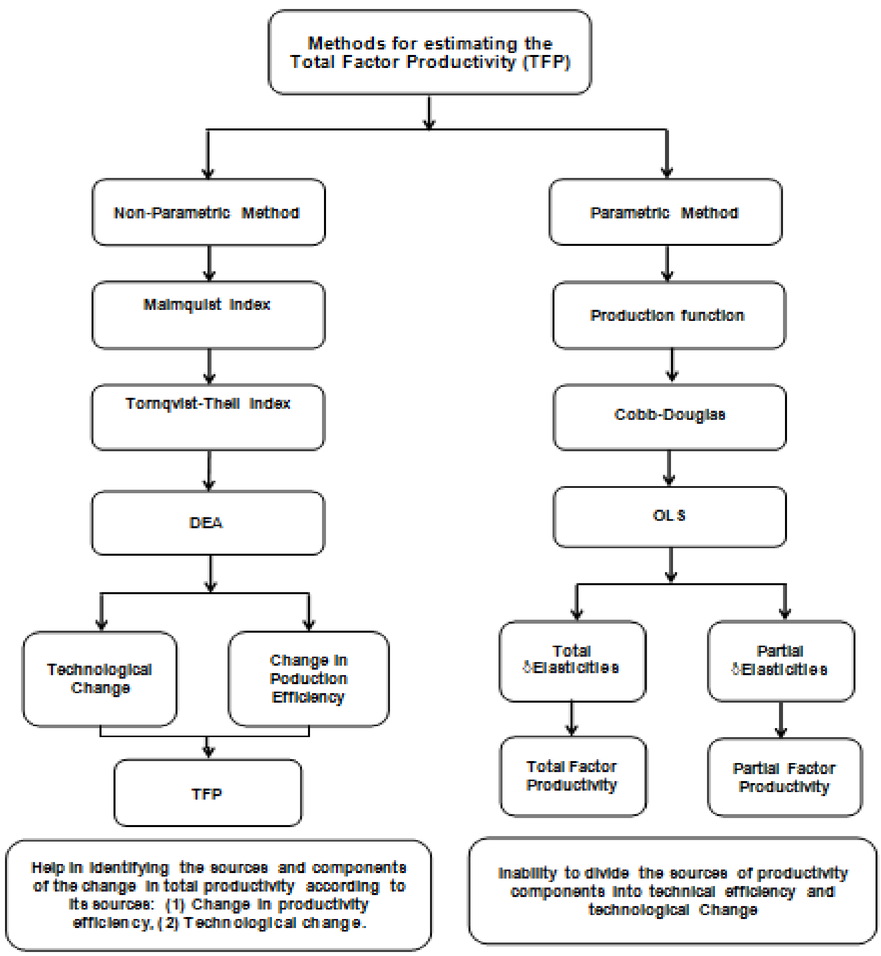

Fig. 1. The analytical methods used to estimate the total factor productivity

Source: Preparing by researchers from references: [18,19]

There are two methods of the DEA model: Input-orientated or Output-orientated. Both metrics provide the same technical efficiencies when applying a CRS model, but they are not equal when applying a variable capacitance return model (VRS). It should be noted that the capacitance yield model characteristics are very important in TFP measurement. The use of the CRS model was preferred in this study for two reasons. First: Because the study uses data collected at the level of Egypt, therefore it is not logical to think about using the VRS model. Second: In addition to the above, the use of the CRS model applies to the data at both the facility level and the aggregate level. The use of the concept of input orientation has been favored on the basis that agricultural inputs can be controlled with a greater degree of control over agricultural output.

The values of the Malmquist indicator are calculated through the efficiency model by calculating the following criteria according to the time period under the assumption of constant return to capacitance (CRS) three criteria are estimated in the period (previous, current, future) while under the variable return hypothesis (VRS) in the period Future, and it should be noted that the hypothesis of a change or stability of yields does not affect the DEM-based Malmquist model [21]. It consists of:

$$M_0^{t,t+1} = \frac{d_0^{t+1}(x^{t+1}, y^{t+1})}{d_0^{t}(x^{t}, y^{t})} \times \left[\frac{d_0^{t}(x^{t+1}, y^{t+1})}{d_0^{t+1}(x^{t+1}, y^{t+1})} \frac{d_0^{t}(x^{t}, y^{t})}{d_0^{t+1}(x^{t}, y^{t})}\right]^{\frac{1}{2}}$$

Technical Efficiency Change (TEC) Technological Change (TC)

Malmquist Index (M)
$= TEC * TC = PEC * SEC * TC$

Economists usually indicate that total factor productivity (TFP) leads to country differences [22]. Technological change is defined as shifting production limits set by technology in the corresponding periods [23], which is illustrated in Fig. (2) for production with two outputs and one input. The t_1 period and the t_2 period represent production limits at different times. The change in the productivity of overtime work for the Decision-Making Unit (DMU) may occur not only because of a change in its efficiency but also because of a change in its technology (technological change) or capacity efficiency or because of a combination of these three factors.

The Malmquist index for Total Productivity is the product of the change in technical efficiency in technological change. It represents the change between every two periods, that is, it shows the amount of increase or decrease in competencies (change of competencies), and therefore it can be greater than one, and if it is greater than one, this indicates a positive change in competencies, which indicates an improvement in productivity, but if it is less than one, this indicates a negative change in competencies, which indicates deterioration and decline in productivity over time. But if it is equal to one, this indicates that there is no change in competencies, and the technical efficiency (TE) ranges between zero, one, and if it is equal to one, this indicates the presence of technical competence, but if it is less than one, this indicates technical inefficiency, and the annual average For a change in technical efficiency, TEC is an indicator of user inputs in a way that is greater or less efficient, i.e. it represents the extent of proximity or distance from the limits of optimal production, while technological change TC refers to innovations

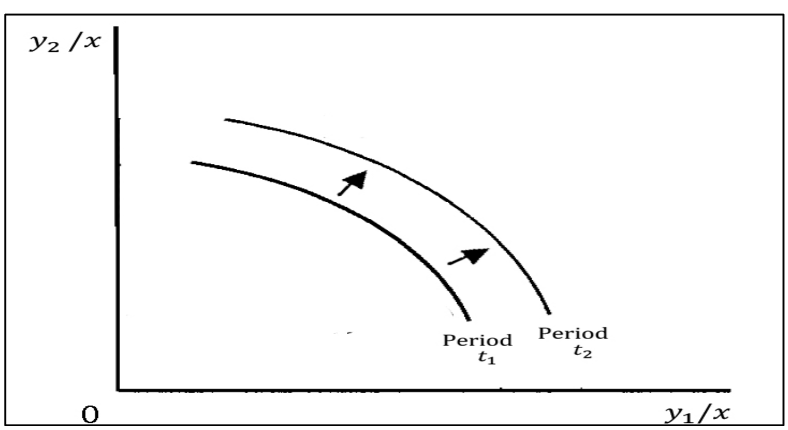

Fig. 2. Technological change (shifting of production boundaries)

or to the transition within the limits of the production function and its increase from one means progress in technology, if Less than one, this means a decline in it.

The efficiencies of the cereal crops under study were estimated in the presence and absence of carbon dioxide emissions (CO_2eq), where DEA method and the Malmquist TFP index were used to estimate the change in the overall productivity of the factors and their components in the areas and crops. The following competencies were obtained:

- Technical Efficiency Change (TEC)
- Change in Pure Technical Efficiency Change (PEC)
- Scale Efficiency Change (SEC)
- Technological Change Or Technical Change (TC)
- Total Factor Productivity Change (TFPC)

4. RESULTS AND DISCUSSION

4.1 Results of Estimating Efficiencies and TFP for the Wheat Crop

Table 1 and Fig. 3 shows the results of estimating the change in the different efficiencies of wheat crop with and without Co_2 emissions. It is clear that the annual average change of technical efficiency (TEC) during the period 1970-2017 increased by 1.1%, 0.6%, 0.1% for Lower, Middle, and Upper Egypt consequently. In addition to decreasing in TC by 3.1%, it occurred during the study period, thus a decrease in the average change of the total factor productivity (TFPc) by 2.1%, 2.5%, and 3% for the same regions, respectively.

Also, the results of estimating the changes in the wheat different efficiencies without carbon dioxide emissions showed that the annual average of technical efficiency TEC changed by 0.6%, 0.1% for Lower, Middle, and Upper Egypt, and there is no change in the efficiency of Upper Egypt. In addition to increasing in TC by 0.1% in Lower Egypt, and decreasing by 0.6%, 1.5% in Middle and Upper Egypt during the study period. And from the sum of the previous two indicators, we get the average change in the factor productivity (TFPc), which means an increase by 0.7%, 0.4% for each of Lower and Middle Egypt, and a decrease by 1.5% for Upper Egypt.

It is noted that the value of technological change (TC) is less than the value of the change in technical efficiency (TEC) during the study period 1970-2017, which means that the agricultural policy should focus more on increasing the rate of technological change TC or agricultural innovation more than the rate of technical efficiency or expansion in the use of modern technology.

Table 2 and Fig. 4 shows the environmental effect on the wheat efficiency through estimating technical efficiency using a data envelopment analysis (Malmquist DEA), whereas the carbon dioxide emissions (CO_2eq) is an environmentally bad output. It can be seen that the value of technical efficiency with CO_2 emissions is lower than without CO_2 emissions, which means that the actual effectiveness of wheat is low due to the environmental impact of emissions.

4.2 Results of Estimating Efficiencies and TFP for the Rice Crop

Table 3 and Fig. 5 shows the results of estimating the change in the different efficiencies of wheat crop with and without Co_2 emissions. It is evident that the annual average change of technical efficiency (TEC) during the period 1970-2017 decreased by 2.3% for Lower Egypt, and there was no change in efficiency for Middle Egypt. Also, an increase in the average technological change TC by 2.4% during the study period; therefore, a decrease in the average change in the total productivity of the TFPc amounted to 2.4% for Lower Egypt and increase to 0.6% for Middle Egypt. Also, the results of estimating the changes in the rice different efficiencies without carbon dioxide emissions showed that the annual average of technical efficiency TEC increased by 8.3% for Lower Egypt. There was no change in the efficiency of Middle Egypt, and an increase in the average technological change TC by 0.5%, 17.4% for the same regions, respectively during the study period, and therefore TFP increased by 8.3%, 17.4% for the same regions, respectively.

It is noted that the value of technological change (TC) is less than the value of the change in technical efficiency (TEC) during the study period 1970-2017, which means that the policy should focus more on the expansion of the use of modern technology or agricultural innovation, as well as tend towards more good agricultural practices.

Table 4 and Fig. 6 shows the environmental effect on the rice efficiency through estimating

Table 1. Results of the Malmquist index for wheat crop

Years	Regions	With CO_2 emissions					Without CO_2 emissions				
		TEC	**TC**	**PEC**	**SEC**	**TFP_C**	**TEC**	**TC**	**PEC**	**SEC**	**TFP_C**
1971- 1980	Lower Egypt	1.004	0.990	1.007	1.009	0.994	0.999	1.009	1.000	0.999	1.008
	Middle Egypt	1.009	0.990	1.000	1.009	0.999	1.004	0.997	1.000	1.004	1.001
	Upper Egypt	1.007	0.990	1.000	1.007	0.997	1.000	1.003	1.000	1.000	1.003
	Average	1.007	0.990	1.002	1.008	0.997	1.001	1.003	1.000	1.001	1.004
1981- 1990	Lower Egypt	0.994	0.932	1.013	0.987	0.926	1.010	0.992	1.000	1.010	1.002
	Middle Egypt	0.987	0.932	1.000	0.987	0.920	0.996	0.969	1.000	0.996	0.965
	Upper Egypt	1.000	0.932	1.000	1.000	0.932	1.000	0.960	1.000	1.000	0.960
	Average	0.994	0.932	1.004	0.992	0.926	1.002	0.974	1.000	1.002	0.976
1991- 2000	Lower Egypt	0.972	0.988	0.984	0.992	0.960	1.004	0.995	1.000	1.004	0.999
	Middle Egypt	0.974	0.988	0.982	0.992	0.962	1.011	0.994	0.993	1.019	1.005
	Upper Egypt	1.000	0.988	1.000	1.000	0.988	1.000	0.990	1.000	1.000	0.990
	Average	0.982	0.988	0.988	0.994	0.970	1.005	0.993	0.998	1.008	0.998
2001- 2010	Lower Egypt	1.007	0.992	1.007	1.000	0.999	0.990	1.014	1.000	0.990	1.004
	Middle Egypt	1.013	0.992	1.013	1.000	1.004	0.995	1.014	1.000	0.993	1.008
	Upper Egypt	1.000	0.992	1.000	1.000	0.992	1.000	1.002	1.000	1.000	1.002
	Average	1.007	0.992	1.007	1.000	0.998	0.995	1.010	1.000	0.994	1.005
2011- 2017	Lower Egypt	1.080	0.944	1.043	1.032	1.019	1.025	0.996	1.000	1.025	1.021
	Middle Egypt	1.047	0.944	1.014	1.032	0.988	1.030	0.996	1.014	1.015	1.026
	Upper Egypt	1.000	0.944	1.000	1.000	0.944	1.000	0.969	1.000	1.000	0.969
	Average	1.042	0.944	1.019	1.021	0.983	1.018	0.987	1.005	1.013	1.005
Summary of Firm Means	Lower Egypt	1.011	0.969	1.011	1.004	0.979	1.006	1.001	1.000	1.006	1.007
	Middle Egypt	1.006	0.969	1.002	1.004	0.975	1.007	0.994	1.001	1.006	1.001
	Upper Egypt	1.001	0.969	1.000	1.001	0.970	1.000	0.985	1.000	1.000	0.985
	Average	1.006	0.969	1.004	1.003	0.975	1.004	0.993	1.000	1.004	0.998

** All Malmquist index averages are geometric means Source: [15].*

Table 2.Technical efficiency results for wheat with and without CO_2 emissions

Years	With CO_2 emissions			Without CO_2 emissions		
	TE-CRS			TE-CRS		
	Lower Egypt	Middle Egypt	Upper Egypt	Lower Egypt	Middle Egypt	Upper Egypt
1970- 1980	0.130	0.882	0.983	0.865	0.891	1.000
1981- 1990	0.127	0.800	1.000	0.868	0.855	1.000
1991- 2000	0.110	0.665	1.000	0.983	0.904	1.000
2001- 2010	0.099	0.620	1.000	0.957	0.912	1.000
2011- 2017	0.116	0.716	1.000	0.903	0.880	1.000
Average	0.116	0.737	0.997	0.915	0.888	1.000

Source: [15]

Table 3. Results of the Malmquist index for rice crop

Years	Regions	With CO_2 emissions					Without CO_2 emissions				
		TEC	TC	PEC	SEC	TFP_C	TEC	TC	PEC	SEC	TFP_C
1971- 1980	Lower Egypt	0.978	1.016	0.978	1.000	0.993	0.985	1.045	1.000	0.985	1.030
	Middle Egypt	1.000	1.045	1.000	1.000	1.045	1.000	1.057	1.000	1.000	1.057
	Average	0.989	1.030	0.989	1.000	1.019	0.993	1.051	1.000	0.993	1.043
1981- 1990	Lower Egypt	0.984	1.000	0.984	1.000	0.984	0.997	1.007	1.000	0.997	1.003
	Middle Egypt	1.000	1.000	1.000	1.000	1.000	1.000	1.001	1.000	1.000	1.001
	Average	0.992	1.000	0.992	1.000	0.992	0.998	1.004	1.000	0.998	1.002
1991- 2000	Lower Egypt	1.050	0.936	1.050	1.000	0.983	1.015	0.981	1.000	1.015	0.996
	Middle Egypt	1.000	0.936	1.000	1.000	0.936	1.000	0.948	1.000	1.000	0.948
	Average	1.025	0.936	1.025	1.000	0.960	1.008	0.965	1.000	1.008	0.972
2001- 2010	Lower Egypt	0.863	1.133	0.863	1.000	0.978	1.000	1.002	1.000	1.000	1.002
	Middle Egypt	1.000	1.133	1.000	1.000	1.133	1.000	1.872	1.000	1.000	1.872
	Average	0.932	1.133	0.932	1.000	1.055	1.000	1.437	1.000	1.000	1.437
2011- 2017	Lower Egypt	1.011	1.037	1.000	1.011	1.048	1.416	0.992	1.516	1.000	1.405
	Middle Egypt	1.000	0.916	1.000	1.000	0.916	1.000	0.992	1.000	1.000	0.992
	Average	1.006	0.977	1.000	1.006	0.982	1.208	0.992	1.258	1.000	1.198
Summary of Firm Means	Lower Egypt	0.977	1.024	0.975	1.002	0.997	1.083	1.005	1.103	0.999	1.087
	Middle Egypt	1.000	1.006	1.000	1.000	1.006	1.000	1.174	1.000	1.000	1.174
	Average	0.989	1.015	0.987	1.001	1.002	1.041	1.090	1.052	1.000	1.131

** All Malmquist index averages are geometric means. Source: [15]*

technical efficiency using a data envelopment analysis (Malmquist DEA), whereas the carbon dioxide emissions (CO_2 emissions from agriculture) is an environmentally bad output. It can be seen that the value of technical efficiency with CO_2 emissions is lower than without CO_2 emissions, which means that the actual efficiency of rice is low due to the environmental impact of emissions.

4.3 Results of Estimating Efficiencies and TFP for the Summer Maize Crop

Table 5 and Fig. 7 shows the results of evaluating the change in the different capabilities of wheat crop with and without Co_2 emissions, it is clear that the annual average variation of technical efficiency (TEC) during the period 1970-2017 increased by 2.4%, 1.9% in Lower Egypt and Central Egypt, no change in the ability in Upper Egypt, Also, a decrease in the average technological change TC by 3.3% during the study period. Therefore a reduction in the average change in the total productivity of the TFPc amounted to 1%, 1.5% and 3.3% in the same regions, respectively. Also, the results of estimating the changes in the summer maize different efficiencies without carbon dioxide emissions showed that the annual average of technical efficiency TEC increased by 2.4%, 1.2% in Lower Egypt, and Middle Egypt. There was no change in the efficiency of Upper Egypt. A decrease in the average technological change TC by 0.8%, 2.2% for the same regions respectively, during the study period, and thus TFP increased by 1.5%, 0.3% in Lower Egypt and Middle Egypt, respectively, TFP decreased by 2.2% in Upper Egypt.

Table 4. Technical efficiency results for rice with and without CO_2 emissions

Years	With CO_2 emissions		Without CO_2 emissions	
	TE-CRS		TE-CRS	
	Lower Egypt	Middle Egypt	Lower Egypt	Middle Egypt
1970- 1980	0.008	1.000	0.919	1.000
1981- 1990	0.006	1.000	0.819	1.000
1991- 2000	0.009	1.000	0.864	1.000
2001- 2010	0.006	1.000	0.920	1.000
2011- 2017	0.001	1.000	0.914	1.000
Average	0.006	1.000	0.887	1.000

Source: [15].

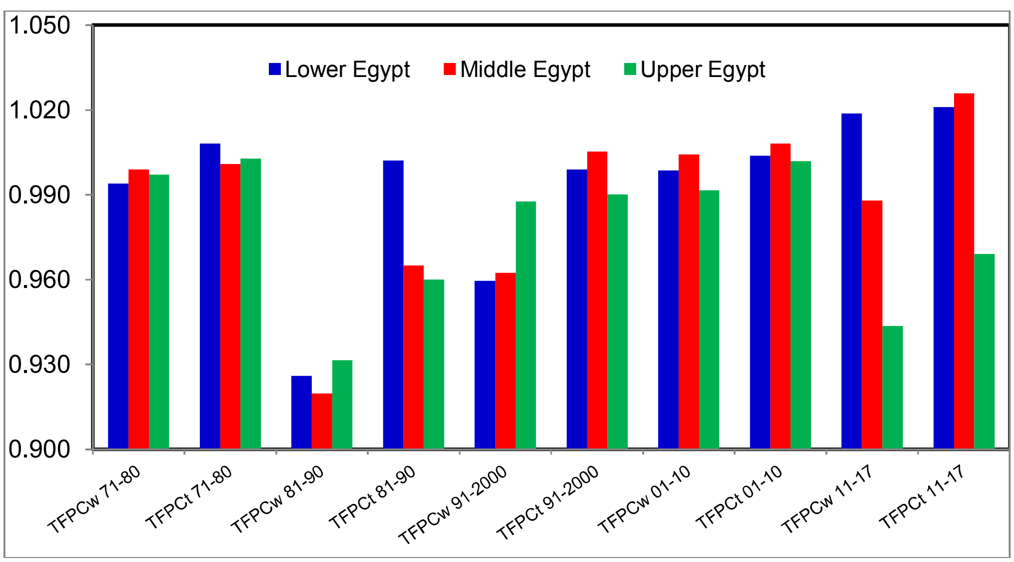

Fig. 3. Annual change in the total factor productivity of wheat crop with CO_2 emissions ($TFPC_w$) and without CO_2 emissions ($TFPC_t$)

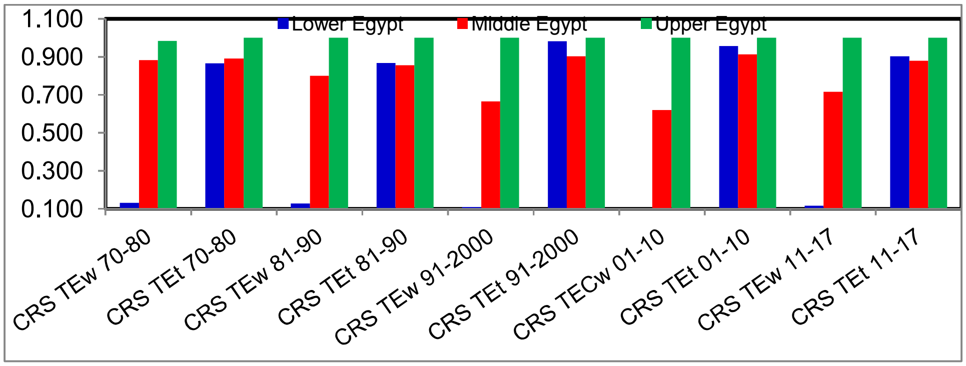

Fig. 4. The change in technical efficiency of wheat crop with CO_2 emissions (CRS TE_w) and without CO_2 emissions (CRS TE_t)

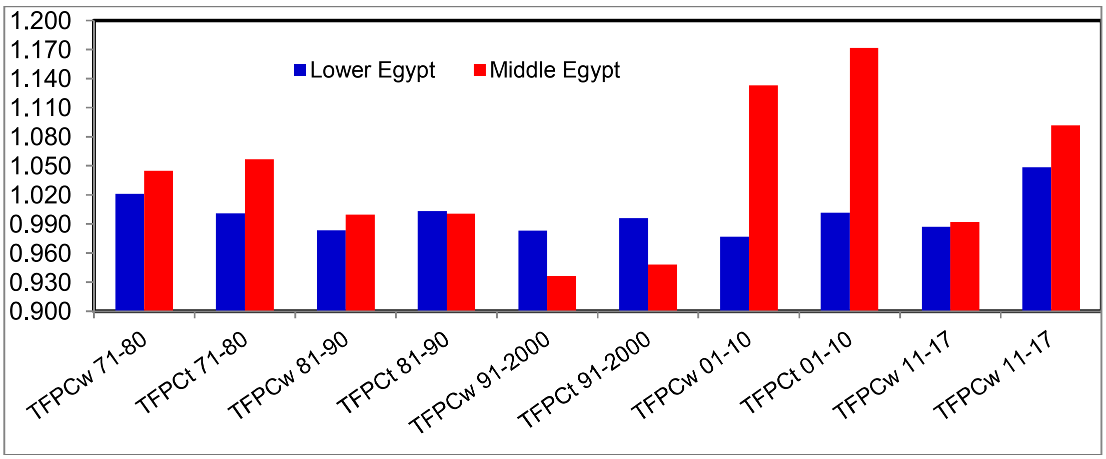

Fig. 5. Annual change in the total factor productivity of rice crop with CO_2 emissions ($TFPC_w$) and without CO_2 emissions ($TFPC_t$)

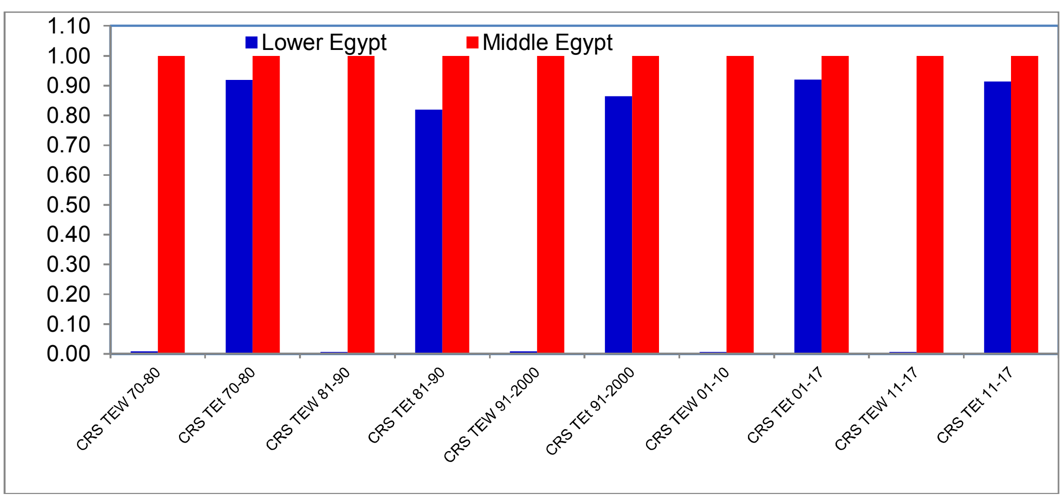

Fig. 6. The change in technical efficiency of rice crop with CO_2 emissions (CRS TE_w) and without CO_2 emissions (CRS TE_t)

Table 5. Results of the Malmquist index for summer maize crop

Years	Regions	With CO_2 emissions					Without CO_2 emissions				
		TEC	TC	PEC	SEC	TFP_C	TEC	TC	PEC	SEC	TFP_C
1971- 1980	Lower Egypt	1.005	0.988	1.005	1.000	0.992	1.133	0.982	1.000	1.133	1.112
	Middle Egypt	1.002	0.988	1.002	1.000	0.990	1.056	0.980	0.999	1.050	1.035
	Upper Egypt	1.000	0.988	1.000	1.000	0.988	1.000	0.979	1.000	1.000	0.979
	Average	1.002	0.988	1.002	1.000	0.990	1.063	0.980	1.000	1.061	1.042
1981- 1990	Lower Egypt	1.062	0.923	1.062	1.000	0.980	1.001	0.993	1.000	1.001	0.994
	Middle Egypt	1.071	0.923	1.071	1.000	0.989	1.007	0.993	1.005	1.001	1.000
	Upper Egypt	1.000	0.923	1.000	1.000	0.923	1.000	0.955	1.000	1.000	0.955
	Average	1.044	0.923	1.044	1.000	0.964	1.003	0.980	1.002	1.001	0.983
1991- 2000	Lower Egypt	1.004	0.976	1.004	1.000	0.979	0.992	0.996	1.000	0.992	0.988
	Middle Egypt	0.982	0.976	0.982	1.000	0.958	1.000	0.997	1.000	0.999	0.996
	Upper Egypt	1.000	0.976	1.000	1.000	0.976	1.000	0.987	1.000	1.000	0.987
	Average	0.995	0.976	0.995	1.000	0.971	0.997	0.993	1.000	0.997	0.990
2001- 2010	Lower Egypt	1.001	1.001	1.001	1.000	1.002	0.981	1.022	1.000	0.981	1.002
	Middle Egypt	1.007	1.001	1.007	1.000	1.009	0.988	1.022	1.000	0.988	1.010
	Upper Egypt	1.000	1.001	1.000	1.000	1.001	1.000	1.011	1.000	1.000	1.011
	Average	1.003	1.001	1.003	1.000	1.004	0.990	1.018	1.000	0.989	1.008
2011- 2017	Lower Egypt	1.047	0.949	1.047	1.000	0.994	1.013	0.967	1.000	1.013	0.979
	Middle Egypt	1.034	0.949	1.034	1.000	0.981	1.007	0.967	0.999	1.008	0.973
	Upper Egypt	1.000	0.949	1.000	1.000	0.949	1.000	0.957	1.000	1.000	0.957
	Average	1.027	0.949	1.027	1.000	0.975	1.007	0.963	1.000	1.007	0.970
Summary of Firm Means	Lower Egypt	1.024	0.967	1.024	1.000	0.990	1.024	0.992	1.000	1.024	1.015
	Middle Egypt	1.019	0.967	1.019	1.000	0.985	1.012	0.992	1.001	1.009	1.003
	Upper Egypt	1.000	0.967	1.000	1.000	0.967	1.000	0.978	1.000	1.000	0.978
	Average	1.014	0.967	1.014	1.000	0.981	1.012	0.987	1.000	1.011	0.999

** All Malmquist index averages are geometric means Source: [15]*

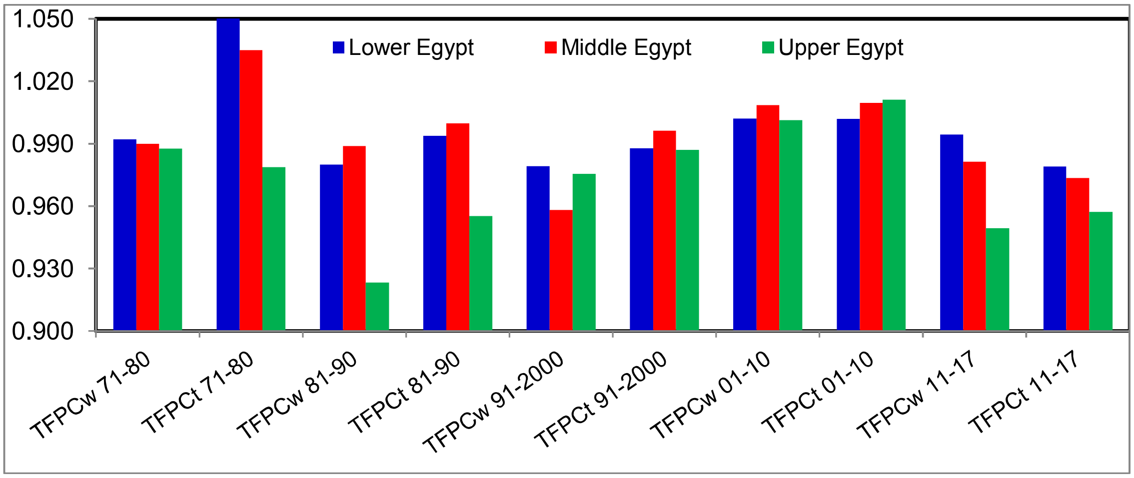

Fig. 7. Annual change in the total factor productivity of summer maize crop with CO_2 emissions ($TFPC_w$) and without CO_2 emissions ($TFPC_t$)

Table 6. Technical efficiency results for summer maize with and without CO_2 emissions

Years	With CO_2 emissions			Without CO_2 emissions		
	TE-CRS			TE-CRS		
	Lower Egypt	Middle Egypt	UpperEgypt	Lower Egypt	Middle Egypt	UpperEgypt
1970- 1980	0.047	0.289	1.000	0.614	0.842	1.000
1981- 1990	0.060	0.333	1.000	0.966	0.959	1.000
1991- 2000	0.079	0.366	1.000	0.956	0.979	1.000
2001- 2010	0.093	0.382	1.000	0.892	0.960	1.000
2011- 2017	0.100	0.419	1.000	0.807	0.933	1.000
Average	0.076	0.358	1.000	0.847	0.935	1.000

Source: [15

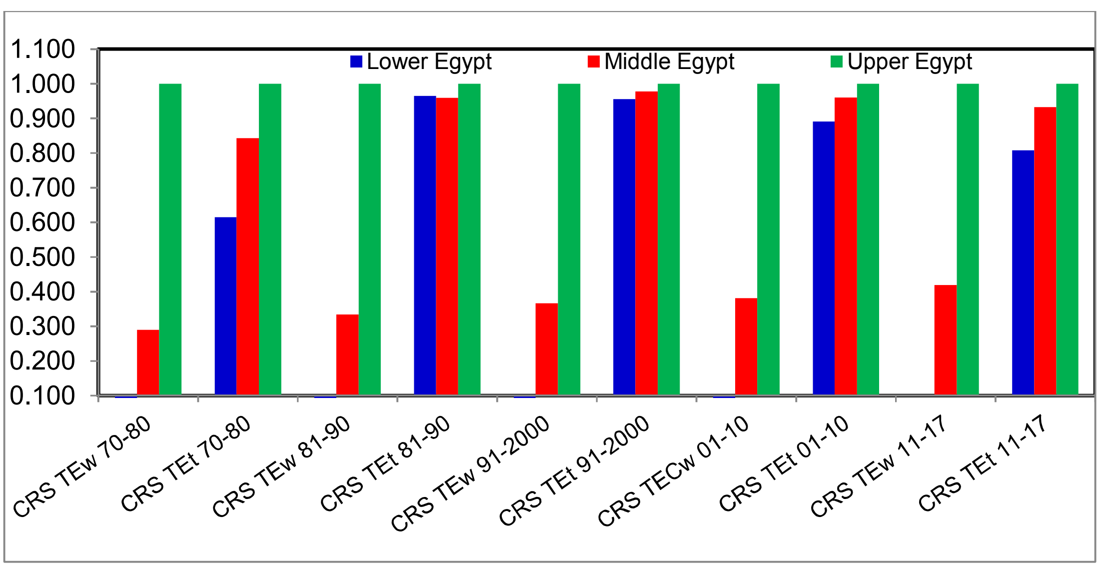

Fig. 8. The change in Technical Efficiency of Summer Maize crop with CO_2 emissions (CRS TE_w) and without CO_2 emissions (CRS TE_t)

It is noted that the value of technological change (TC) is less than the amount of the change in technical efficiency (TEC) during the study period 1970-2017, which means that the policy should focus more on the expansion of the use of modern technology or agricultural innovation, as well as tend towards more good farming practices.

Table 6 and Fig. 8 shows the environmental effect on the summer maize efficiency through estimating technical efficiency using a data envelopment analysis (Malmquist DEA), whereas the carbon dioxide emissions (CO_2 emissions from agriculture) is an environmentally lousy output. It can be seen that the value of technical efficiency with CO_2 emissions is lower than without CO_2 emissions, which means that the actual effectiveness of summer maize is low due to the environmental impact of emissions.

The research findings are consistent with the results of a number of previous studies that indicated the harmful effect of emissions on the efficiency of agricultural crop production, such as [4,12].

6. CONCLUSION

The present empirical study is based on a secondary data for the period 1970 to 2017 for wheat, rice and summer maize crops, at the level of Lower Egypt, Middle Egypt, Upper Egypt, and the total Egypt. The research focused on measuring changes in the Total Factor productivity (TFP) for crops under study using the Malmquist index in the presence and absence of carbon dioxide emissions (CO_2eq), by applying a constant return to scale (CRS) model. Environmental impact on efficiencies was estimated by assuming a single detrimental variable (Co_2eq).

Data envelopment analysis (DEA) used to estimate Malmquist Index, and the environmental impact on the efficiencies for the crops under study estimated, whereas the carbon dioxide emission (CO_2eq) is an environmentally bad output. The value of technical efficiency with CO_2 emissions is lower than without CO_2 emissions, which means that the actual efficiency of wheat is low due to the environmental impact of emissions, which means that the Egyptian agricultural policy should focus more on increasing the rate of technological change or agricultural innovation.

5. RECOMMENDATIONS

Based on the study findings, the following can be suggested:

- It is more accurate to consider the environmental dimension with the first priority, by reducing the excessive use of chemical fertilizers, which increases carbon dioxide emissions, and the use of everything environmentally friendly.
- Investing in agricultural research is the primary tool for increasing productivity, but there is a long-time difference between investments in agricultural research and the productivity response. It indicates that spending on agricultural research must be accompanied by agrarian extension programs that contribute not only to the expansion of the use of new technology but also to agrarian capital formation.
- The government must take some steps to focus on improving crop productivity and providing intensive extension services to farmers on time to make crop cultivation more efficient. It is also necessary to work on developing and updating the essential items of the production costs of the crops under study, which are the electric service and seeds.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Coelli Tim J, Prasada RD. Total factor productivity growth in agriculture: A malmquist index analysis of 93 countries, 1980-2000", Centre for efficiency and productivity analysis, school of economics, University of Queensland, Australia; 2003.
2. National Planning Institute "Productivity, wages and prices: The current status of theoretical and applied knowledge with special reference to previous studies in Egypt", Planning and Development Issues in Egypt, Cairo. 1990;49.
3. USDA. International Agricultural Productivity; 2019. Available:https://www.ers.usda.gov/data-products/international-agricultural-productivity/ (Accessed 27/12/2019)

4. Abedullah SK, Mushtaq K. Environmental efficiency analysis of basmati rice production in Punjab, Pakistan: Implications for sustainable agricultural development. The Pakistan Development Review. 2010;49(1).
Available:www.researchgate.net/publication/227346602
5. Ebata, Ayako. Agricultural productivity growth in Central America and the Caribbean, M.Sc. Thesis, University of Nebraska, Lincoln, USA; 2011.
6. González, Carlos Alberto Zúniga, "Total Factor Productivity and the Bio Economy Effects. Journal of Agricultural Studies. 2013;1(1).
Available:https://doi.org/10.5296/jas.v1i1.2383
7. Saikia, Dilip. Total factor productivity in agriculture: A review of measurement issues in the Indian Context. Romanian Journal of Regional Science, Romanian Regional Science Association. 2014;8(2).
Available:http://www.rrsa.ro/rjrs/V823.Saikia.pdf
(Accessed 2/7/2018).
8. El-Kholei, Ahmed. Estimating agricultural Malmquist total factor productivity for some Arab Countries' employing data envelope analysis A non-parametric approach. Alexandria Journal of Agricultural Research. 2015;20(1).
9. Dhehibi B, Ali AI, El-Shahat, Aymen F, Aden-Aw H. Growth in total factor productivity in the Egyptian Agriculture Sector: Growth accounting and econometric assessments of sources of growth. Sustainable Agriculture Research, Published by Canadian Center of Science and Education. 2016;5(1).
10. Elasraag, Yahia H, Alarcon S. Global Malmquist Indices of productivity change in Egyptian wheat production. Spanish Journal of Agricultural Research. 2017; 15(2):e0111.
Available:www.researchgate.net/publication/317225315
(Accessed1/4/2019)
11. Şişman, Zeynep. Using data envelopment analysis and Malmquist total factor productivity index for agriculture of Turkish Regions. Grand School of Natural and Applied Sciences, Istanbul Şehir University; 2017.
Available:http://hdl.handle.net/11498/56112
12. Le TL, Lee PP, Peng K. Ch, Chung RH. Evaluation of total factor productivity and environmental efficiency of agriculture in nine East Asian Countries. CAAC Agricultural Journals, Agricultural Economics – Czech. 2019;65(6).
Available:https://doi.org/10.17221/50/2018-AGRICECON
(Accessed 29/9/2019)
13. Dhehibi B, Haithema B, Mohamed A. Input and output technical efficiency and total factor productivity of wheat production in Tunisia. African Journal of Agricultural and Resource Economics, African Association of Agricultural Economists. 2012:7(1).
Available:www.researchgate.net/publication/270480770
(Accessed 1/6/2018)
14. FAOSTAT. "FAOSTAT Database", FAO, Rome, Italy; 2019.
Available:http://www.fao.org/faostat/en/
(accessed 19/10/ 2019).
15. Ministry of Agriculture and Land Reclamation Economic Affairs Sector, "Agricultural Statistics Bulletin", Cairo; 2017.
16. Chaudhary SB. Health and productivity: An analysis of contemporary Indian Agriculture. Delhi School of Economics, University of Delhhi, India; 2013. Available:https://shodhganga.inflibnet.ac.in/bitstream/10603/27660/8/08_chapter%202.pdf
17. Shafei, Mahmoud A, et al. The new in production economics and analysis of competencies between theory and Practice. Al-Marqab University Publications, Libya Arab Jamahiriya. (In Arabic); 2009.
18. Al-Shaya, Ali bin Saleh (1428-1429 AH). Measuring the relative efficiency of Saudi Universities using data envelopment Analysis, PhD Thesis, Department of Educational Administration and Planning, College of Education, Umm Al-Qura University, Saudi Arabia. (In Arabic); 2017.
19. González MM, Trujillo L. Efficiency measurement in the Port Industry: A survey of the empirical evidence. Journal of Transport Economics and Policy. 2009; 43Part (2).
Available:https://www.researchgate.net/publication
(Accessed 9/1/2017)
20. Kaur, Reshampal, Aggarwal M. Mathematical modelling of malmquist TFP index as applicable in banks: A study of its

origin and development. IOSR Journal of Business and Management, Special Issue - AETM' 16; 2014.
21. Shayad, Faisal. Measuring productivity changes using the malmquist index: A case study of islamic banks during the period 2003-2009. Journal of Islamic Economic Studies. 2012;18(2). (In Arabic).
22. Easterly W, Levine R. What have we learned from a decade of empirical research on growth? world bank Economic Review, No. 2; 2011.
23. Coelli Tim J, Prasada RD, O'Donnell CJ, Battese GE. An Introduction to efficiency and productivity analysis. springer science & business media; 2005.

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