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Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2018 15(2): 1087-1094. **OPEN ACCESS**

Use of remote sensing to identify the economic aspects of wheat cultivation in farafra oasis, Egypt

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Egyptian agriculture faces several limitations, as how to improve productivity, provide food security, using technology, and increase the proportion of food produced domestically. Egypt face the possibility of resource depletion and so the current research problem despite the use of modern means and high production varieties in wheat crop cultivation but the gap between production and consumption is still large. The main objective of this study is to increase wheat productivity by predicting produced quantities, selecting the suitable land for cultivation, which is commensurate with the wheat crop needs, cultivation of high-yield varieties in the area and using remote sensing and statistical data to analyze the economic aspect of wheat cultivation in Farafra Oasis. To fulfill this objective landsa-8 image of the year 2017 was used to calculate the normalized difference vegetation index (NDVI). Then the correlation between NDVI and wheat yield was determined by using statistical analysis. The results indicate that the yield of wheat cultivation in Farafra Oasis varies from 1300 to 2400 kg/acre. This variation is mainly related to the changes of soil salinity, water table and drainage condition. Also the study indicate that the most important results are the rate of change in production was decreased during (2006-2015) period from 15.27% in 2006 to 3.4% in 2015, except year 2008 (23.88%) because of climate crisis, and year 2011 (25.30%) because of Egyptian revolution. Also the rate of change in consumption is decreased from 36.09% in year 2006 to 5.7% in year 2015. General time trend analysis of the wheat crop economic variables during (2006-2015) indicates that all variables are increased except self-sufficiency rate. All variables are significant at 5%, but only area and consumption are more variables affected by the time, where R^2 is 65 and 94 %, respectively. By cultivating of 120,000 acres with Mesr 1, Sods 13 and Gemiza 9 varieties, which yielding 2.9 tons/acre, the quantity produced about 348 thousand tons. This represents about 3.63% of the average of imports quantity of wheat in Egypt. Due to the soil quality the cost needed is 875 Egyptian pounds (LE)/acre. Therefore, the study recommends planting 120 thousand acres proposed with high-yielding varieties, such as Mesr1, Sods 13 and Gemiza 9 and adherence to recommended fertilizer quantities to increase production efficienc

Keywords: Remote sensing, Wheat, NDVI Farafra Oasis, Wheat consumption, Self-sufficiency.

INTRODUCTION

In Egypt, despite the use of modern means and high production varieties in wheat crop cultivation, the gap between production and consumption is still large, and the quantities imported of it is increased. Food shortage is one of the major problems which face Egypt due to the limited cultivable land area, the increased population and depletion of land resources (Afaf and Ahlam, 2017). Reducing the burden on the environment needs to adopt new concepts, and technologies, rather than just relying on traditional inputs, as fertilizers, and expectations in farming (Osamu and Noriko, 2009). This could be achieved by using remote sensing technique which considered as survey from a distance

(Mather and Koch, 2010). The wavelengths used in most agricultural remote sensing applications cover only a small region of the electromagnetic spectrum (De Paul and Lal, 2013). Satellite sensors record the information as a single numeric value corresponding to the intensity of the energy they detect for a given area. In the case of Land sat, the sensor measures the amount of reflected energy for each “30 m * 30 m” area (Short, 2011). Each band of data provides a record of the amount of energy reflected in a specific portion of the electromagnetic spectrum. Thus, the bands are usually chosen to improve the contrast between the object under investigation and its borders (Liu and Mason, 2009). Vegetation differs from other land surfaces because it tends to absorb strongly the red wavelengths of sunlight and reflect in the near-infrared wavelengths. Chlorophyll absorbs light in the red channel (0.58-0.68 microns) and foliage reflects light in the near infrared channel (0.72-1.10 microns). Therefore, higher photosynthetic activity will result in lower reflectance in the red channel and higher reflectance in the near infrared channel. Compressed vegetation shows up very strongly in the imagery, and areas with no vegetation are also clearly identified. The normalized difference vegetation index (NDVI) is one of the most common indicators of crop growth characteristics and, indirectly, of specific site qualities (Sumfleth and Duttmann, 2008).

The main objective of current study is to increase wheat productivity through predicting produced quantities, selecting the suitable land for cultivation, cultivation of high-yield varieties and use of remote sensing and statistical data to analyze the economic aspect of wheat cultivation in Farafra Oasis.

MATERIALS AND METHODS

The study was based mainly on the preliminary data of a sample of farmers in Farafra Oasis through the questionnaire (2017). The data obtained through the remote sensing, as well as secondary data published in statistical publications of the Central Agency for Public Mobilization and Statistics and FAO. Also a simple descriptive analysis method to describe the problem is used to calculate the percentages and analyze the general time trend to measure the direction of evolution of the economic variables of the wheat crop. The depression of Farafra Oasis is located in the central part of the Western Desert about 650 km to the southwest of Cairo; it almost covers an area over 10000 km^2 (Figure 1). Around the Oasis wide areas have been recently reclaimed, leveled and irrigated, but artificial drainage network have not yet been constructed, as it is usually thought that the natural drainage of deep sandy soils is capable to control rising water tables and salt accumulation in these areas (El Bastawesy and Ali, 2013). Normalized difference vegetation index (NDVI) shows patterns of vegetative growth by indicating the quantity of actively photosynthesizing biomass on a landscape (Burgan et al., 1996). Landsat-8 image (path 178, row 041) acquired in 22 April, 2017 was used in this study to estimate the NDVI, Table (1) shows the specifications of Landsat-8 bands. The image was converted to reflectance by using ENVI 5.3 software. Consequently Arc-GIS 10.3 was used to calculate NDVI following the next equation:

NDVI = (NIR - RED) /(NIR+RED)

Where: NIR is the near infrared band (band 5) and RED is the red band (band 4). The equation produces values ranging from –1 to 1. Negative values are indicate non vegetated areas or non-reflective surfaces, while positive values denote vegetated or reflective surfaces (Burgan and Hartford, 1993).

Figure 1: Location of the studied area

Table 1: Specifications of Landsat 8 bands.

Bands	Spatial resolution (m)	Wavelength (μm)
Band 1 – Coastal aerosol	30 m	0.43 - 0.45
Band 2 – Blue	30 m	0.45 - 0.51
Band 3 – Green	30 m	0.53 - 0.59
Band 4 – Red	30 m	0.64 - 0.67
Band 5 – Near Infrared (NIR)(	30 m	0.85 - 0.88
Band 6 – SWIR 1	30 m	1.57 - 1.65
Band 7 – SWIR 2	30 m	2.11 - 2.29
Band 8 – Panchromatic	15 m	0.50 - 0.68
Band 9 – Cirrus	30 m	1.36 - 1.38
Band 10 – Thermal Infrared (TIRS) 1	100 m	10.6 - 11.2
Band 11 – Thermal Infrared (TIRS) 2	100 m	11.5 - 12.5

Field work over the study area has been worked out to collect information on wheat crop areas and yield. The coordinates of the visited sites were noted to use it as ground truth point when mapping the wheat cultivation in the Oasis by using ENVI 5.3. Also these data were used to determine the correlation between NDVI and wheat yield using SPSS software.

RESULTS

Wheat cropped areas in Farafra Oasis was mapped using the field data and Landsat-8 satellite imagery as presented in Figure (2). The total area of wheat cultivation is about 93 km^2 (22320 acres) including the old cultivation (inside the Oasis), newly reclaimed areas, and unplanned cultivations around the depression

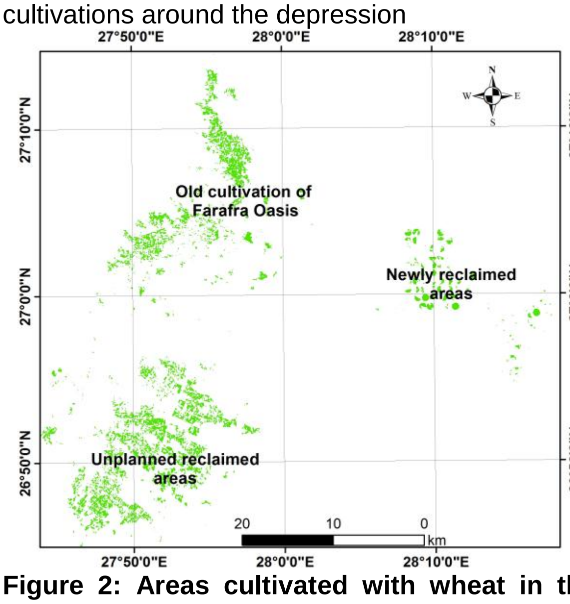

Figure 2: Areas cultivated with wheat in the studied area

Normalized difference vegetation index (NDVI) and wheat yield

The NDVI of wheat crops was estimated, the data show that the NDVI values change from 0.207 to 0.757, where most of wheat field have a NDVI of 0.207 to 0.4 indicating low productivity in these areas. Small areas have a good NDVI (0.601–0.757) concentrated in the middle and south parts of the Oasis. The NDVI for wheat fields in Farafra Oasis is presented in Figure 3. The correlation between wheat yield (data collected during field work) and NDVI values was obtained and outlined as: Wheat yield = 1902 (NDVI) + 917.23 (see Figure 4) this correlation was employed to estimate the wheat yield as presented in Figure 5. The data indicated that the yield changes from 1300 to 2400 kg/acres.

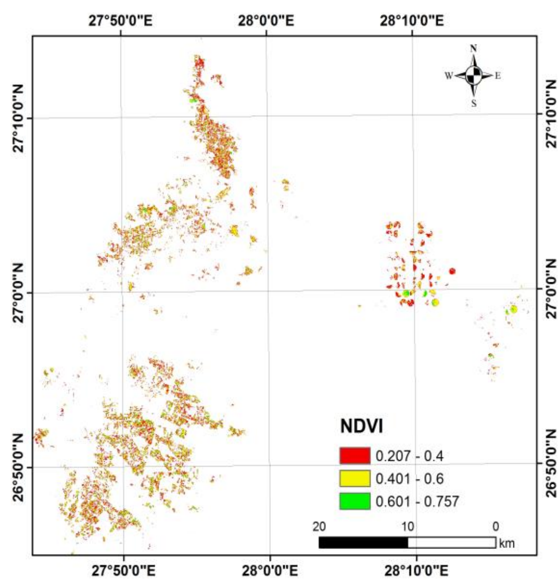

Figure 3: NDVI for wheat fields in Farafra Oasis

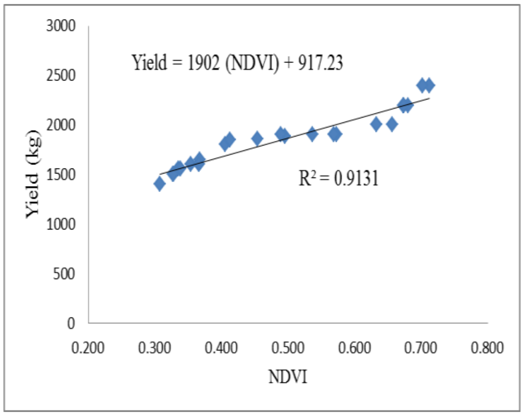

Figure 4: Correlation between NDVI and wheat yield in the Oasis

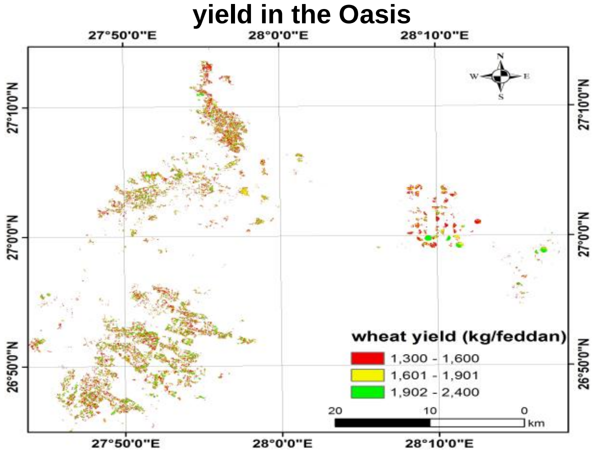

Figure 5: Estimated wheat yield in Farafra Oasis

The Evolution of economic variables of wheat crop (2006-2016)

Table (2) includes statistics on area, production, consumption, food gap, self-sufficiency, value of wheat imports and quantity of wheat imports. The data shown that the average during (2006-2016) period is reached about 4132.54, 8453.27,1673016730, -8276.72, 53.55, 2723.79 and 9594.7 respectively.

The rate of change in production is decreased during the period (2006-2016) from 15.27% in 2006 to 3.4% in 2015, except year 2008 is reached about 23.88% because of climate crisis, and year 2011 to about 25.30% because of the Egyptian revolution, Also the rate of change in consumption is decreased from 36.09% in year 2006 to 5.7% in year 2015. Table (3) showed equations of general time trend of the wheat crop economic variables during this period, and indicates that all economic are variables are increase except self-sufficiency rate. Also all variables are significant at 5%, but only the area and consumption are more variables affected by the time, where R^2 Value varied between 65% and 94% respectively. During this period population increment was 71.35 million people in 2006 to 92.11 million people in 2016.

The economic effects of the redistribution of wheat cultivation:

The state plan for the development of Egypt included the reclamation of 1.5 acres, which includes the area of Farafra (96 thousand acres in the old Farafra, 120 thousand acres in the new Farafra). The proposed area is a part of the Egyptian Government project “1.5 million acres” as it located in the new Farafra and exhibit an area of 120 thousand acres. Geographically it located outside the old Oasis planning area, and characterized by a good soil quality in terms of availability of soluble nutrients, organic matter, soil aeration and fertility, as indicated by the data shown in Table (4). The current wheat cultivation in this area is 11.760 thousand acre, gives the production of about 28.224 thousand tons of the Sods 12 Varity (with mean productivity of 2.4 tons per acre). The replacement of Mesr 1 Varity (with mean productivity of 2.9 tons per acre) instead of Sods 12, the production will increase to 34.104 thousand tons, by replacing the varity only. With planting the total proposed area (120 thousand acres) with high-yield varieties such as Mesr 1, Sods 13 and Gemiza 9 (2.9 tons / acre) the projected productivity will be increased to 348 thousand tons. This represents about 3.63% of the average of imports quantity of wheat (9594.7 thousand tons during the 2006 - 2016) almost, and then the redistribution of these recommended varieties is essential to achieve high Productivity Efficiency of land resources. Considering the data collected during field work (questionnaire data) in this area the recommended quantity of seed for the total are cultivated with wheat in Farafra Oasis (22.320 thousand acres) is 1.56 thousand tons, while the added quantity was about 1.006 thousand tons in (2015). This represents a shortage in seed rate by 64.4% that led to a decline in total production. Regarding to soil fertility, the addition of chemical fertilizer at the rates used in the study sample of the nitrogen fertilizer is 300 kg containing 100.5 units of Azote where ammonium nitrate contains 33.5% effective unit. The superphosphate fertilizer is used at 150 kg/acre equivalent to 23.25 units effective 15.5%. Potassium fertilizer, which is potassium sulfate equivalent to 5 kg / acre, these rates lead to a decrease in production by about 210 kg per acre. This decrease leads to a loss of about 600 LE of wheat return

Table (2). The Evolution of economic variables of wheat crop during (2006-2016)

Year	Area/ thousand acres	Quantity of production /thousand tons	Rateof change in production %	Productivity)ton(	Totalconsumption (thousand tons)	Rateof change in consumption%	Food gap thousand tons	Average/ capita / kg / capita	Self-sufficiency	Value ofwheat imports in million pounds	Quantity of wheat imports/ thousand tons
2006	3985	8141	15.27	2.04	13230	36.09	-5089	152.6	61.5	5538.77	8004.151
2007	4064	8274	13.88	2.04	13260	35.94	-4986	160.1	61.2	8819.34	8241.874
2008	3716	7379	23.20	1.99	14200	31.40	-6821	177.7	56.4	1150.91	8327.793
2009	3920	7977	16.98	2.03	14120	31.79	-6143	191.1	53.5	867.59	9120.779
2010	4179	8523	11.29	2.04	17340	16.23	-8817	177	54.8	1225.32	10593.51
2011	4066	7177	25.30	1.77	16860	18.55	-9683	182.7	62.5	1907.94	9800.061
2012	4059	8371	12.87	2.06	17550	15.22	-9179	140.9	40.5	2152.19	11428.3
2013	4182	8795	8.46	2.1	18240	11.88	-9445	160.1	48.8	1831.06	10288.43
2014	4401	9461	1.53	2.15	18920	8.60	-9459	152.1	50.7	2282.29	9362.4
2015	4414	9280	3.41	2.1	19610	5.27	-10330	122.5	50.1	1940.46	10169.7
2016	4472	9608	0.00	2.15	20700	0	-11092	126.5	49.1	2245.84	10204.7
Average	4132.54	8453.27	13.22	2.042	16730	21.10	-8276.72	158.48	53.55	2723.79	9594.7

Source: Central Agency for Public Mobilization and Statistics data Egypt from (2006-2016).

Table (3). Equations of the general trend of the wheat crop economic variables during the period (2006-2016).

Variable	Equation	F	R2
Area	**Equation**	19.528	0.65
Production	$y=3789.23+ 57.2x_1(4.419)^*$	9.97	0.47
Consumption	$y= 7412+ 173.53x_2(3.16)^*$	172.42	0.94
Food gap	$y=12074.+ 776x_3(13.13)^*$	5.34	0.30
Self-sufficiency	$y=183.34 - 4.14x_4(-2.31)^*$	7.17	0.38
Quantity of imports of wheat	$y= 61.58 - 1.33x_5(-2.67)^*$	8.3	0.42

Source: calculated from Table 2 (*) significant at 5%.

Table (4). The current and proposed situation of wheat cultivation in Farafra Oasis.

Total area (22320 acres)	Acre area (thousand)	Productivity (kg/acre)	The production (ton)	The variety	Fertility		
					ESP	OM%	CEC cmol /kg
Old land	8160	1300	10608	Skha 69	12.5	0.3	52.4
Reclaimed land	2400	1600	3840	Sods 12	6.8	0.1	6.2
Unplanned land	11760	2400	28224	Sods 12	8.9	0.2	7.6
Total current production of the studied area (Current varieties)	22.320	-	42672	Skha 69 Sods 12	-	-	-
The production in the studied area, which is located outside of planning by (120 thousand acres proposed) with the current cultivar (sods 12)	120	1600	288000	Sods 12	8.9	0.2	7.6
The production of variety Mesr 1 in the same area of (120 thousand acres proposed)	120	2900	348000	Mesr 1 Gemiza 9	8.9	0.2	7.6

Source: The studied area data by using GIS .

Table (5). Current fertilizer rates for wheat acre in the studied area.

Wheat	Nitrogen fertilizer (Kg/acre)			Potassium fertilizer (kg/acre)			Phosphate fertilizer (kg/acre)		
	Wheat fertilizer recommended	Quantity used	Deviation kg/acre	Wheat fertilizer recommended	Quantity used	Deviation kg/acre	Wheat fertilizer recommended	Quantity used	Deviation kg/acre
Quantity (kg)	100	300	200	30	150	120	48	50	2
Unit price/pound (50 kg package)	245	245	-	85	85	-	300	300	-
Value/pounds	490	1470	-	85	255	-	300	300	-
Total current fertilizer costs	=1470+255+300= 2025 LE								

Source: Questionnaire data with wheat farmers in the studied area (2017).

The superphosphate fertilizer is used at 150 kg / acre equivalent to 23.25 units effective 15.5%. Potassium fertilizer, which is potassium sulfate equivalent to 5 kg / acre, these rates lead to a decrease in production by about 210 kg per acre. This decrease leads to a loss of about 600 LE of wheat return. In addition the excess quantities of fertilizers led to soil and water pollution, and increase the costs. The total loss due to the increase of use the chemical fertilizers quantities is equal to (980+170+600)=1750 LE/acre. The recommended area for wheat cultivation (120 thousand acres) is characterized by fertility of soil, and also contain a large proportion of nutrients, it do not need these rates of recommended fertilizer. Even by adding these rates, the cost does not exceed 875 pounds per acre, and the current used quantities costs are reached about 2025 pounds per acre as shown in Table (5).

Recommendations:

Selecting the crop that matches its needs with soil characteristics to minimize production costs.

Commitment to quantities of fertilizers and seed recommended from the Ministry of Agriculture.

Cultivation of high-yielding varieties such as Mesr 1, Gemiza 9, which produce 2.9 tons/acre, to increase production efficiency which means optimal use of inputs to obtain the best outputs, including the scientific methods of management, such as planning, organization, direction and control

CONCLUSION

The main goal of the present study is to increase wheat productivity through predicting produced quantities, selecting the suitable land for cultivation, cultivation of high-yield varieties and use of remote sensing and statistical data to analyze the economic aspect of wheat cultivation in Farafra Oasis.

CONFLICT OF INTEREST

The present study was performed in absence of any conflict of interest.

ACKNOWLEGEMENT

Thank you for Prof. Dr. Rafat Ramadan Ali, Soils and Water Use Dept. National Research Centre, Egypt. For his contribution and assistance in the research, and soil analysis in the study area, by using remote sensing device.

AUTHOR CONTRIBUTIONS

All authors contributed equally in all parts of this study.

REFERENCES

Afaf Othman and Ahlam Hassan (2017). Comparative Economic Study of Some Agricultural Methods to Increase Wheat Production in Egypt. Bulletin of the National Research Centre journal, (12):187-199.

Burgan R.E.; Hartford R.A. (1993). Monitoring vegetation greenness with satellite data. Gen. Tech. Rep. INT-297. Ogden, UT:US Department of Agriculture, Forest Service, Intermountain Research Station. 13 p.

Burgan R.E.; Hartford R.A.; Eidenshink J.C. (1996). Using NDVI to assess departure from average greenness and its relation to fire business. Gen. Tech. Rep. INT-GTR-333. Ogden, UT:US Department of Agriculture, Forest Service, Intermountain Research Station. 8 p.

Central Agency for Public Mobilization and Statistics data-Egypt from (2006-2016).

De Paul O. and Lal, R. (2013). Assessing land cover and soil quality by remote sensing and geographical information systems (GIS). Catena, 104:77-92.

El Bastawesy M. and Ali R. (2013). The use of GIS and remote sensing for the assessment of water logging in the dry land irrigated catchments of Farafra Oasis, Egypt. Hydrological Processes, 27:206–216.

Liu J.G. and Mason P.J. (2009). Essential Image Processing for GIS and Remote Sensing. Wiley-Blackwell publisher, New York, USA.

Mather P.M. and Koch, M. (2010). Remote Sensing: Basic Principles. Computer Processing of Remotely-Sensed Images. 4th ed. John Wiley and Sons, Chichester, United Kingdom.

Ministry of Agriculture and Land Reclamation-Bulletin of Agricultural Economics and

Statistics-Central Administration of Agricultural Economics and Statistics (2016-2017).

Osamu Nishiguchi and Noriko Yamagata (2009). Agricultural Information Management System Using GIS Technology,The Hitachi Software Engineering Co., Hitachi Review Vol.58 (2009), No. 6.

Questionnaire data with wheat farmers in the studied area (2017).

Short N.M. (2011). The LANDSAT Tutorial Workbook: Basics of Satellite Remote Sensing. NASA Reference Publication 1078. NASA, USA.

Sumfleth K. and Duttmann R. (2008). Prediction of soil property distribution in paddy soil landscapes using terrain data and satellite information as indicators. Ecological Indicators, 8 (5):485-501.