Imperial Journal of Interdisciplinary Research (IJIR)
Vol-3, Issue-6, 2017
ISSN: 2454-1362, http://www.onlinejournal.in

Assessment of Impacts, Adaptation, and Vulnerability to Climate Change in North Sinai, Egypt

Sherine Fathy Mansour
Desert Research Center, Mataria, Cairo

Abstract: *This paper provides the assessment of climate change impacts on crop productivity using climate, water and crop yield models, so that agricultural policies in Egypt are concerned with increasing the production of food crops, especially with cereals, broad beans and sugar crops. This research tries to show how better allocation of resources will help to increase production of these crops in case of climate change in North Sinai in Egypt. The research used the linear programming technique by matlab software to determining the optimal cropping pattern to test the efficiency of agricultural resources in the production of crops in north Sinai under climate change and vulnerability. The main objective of this research is to conduct a study to reallocate the economic resources available in the agricultural sector in North Sinai under climate change and under the limited economic resources available in the agricultural sector. and The farmers adopt this idea by teaching them the best ways to adapt to climate change. The results show that while planting a farmland area of about 157318 Feddan for winter, summer and Nile season in order. Agricultural income from optimum crop composition under climate change is estimated at 535823.4 LE, net farm income of about 1038989 LE , and the use of water quantity is estimated at 1107021 m3, which is lower than the current crop structure by 457960 m3, reduce carbon dioxide emissions by about 216133 Kg , and reduce energy consumption by about 372641.15 liter. Therefore, the need for research is recommended reallocation of economic resources in plant production in North Sinai under climate change, and to encourage farmers to adopt modern agricultural methods that reduce the effects of climate change.*

Key Words: *climate change , current crop, vulnerability, net income, North Sinai, Egypt*

1. Introduction

Sinai Peninsula and Suez Canal Corridor are promising and important economic regions in Egypt due to the unique location and development opportunities. Thus, the climate change impacts should be assessed over the mentioned area. so The climate change impact, vulnerability, and adaptation of the production of some crops and irrigation water requirements in North Sinai ,Egypt were analyzed. We find North Sinai region is highly vulnerable to salinity and drought that may be attributed to climate changes. Vulnerability assessment describes a diverse set of methods used to systematically integrate and examine the interactions between humans, their physical and social surroundings [5]. North Sinai vulnerability to climate change is based on the area where Bedouin live. The Bedouin community in the rural highlands is quite vulnerable to drought risks. Both drought and salinity have significant impacts on community coherence, wellbeing, and interrelations. Therefore, it is necessary to identify the crop structure of the region of North Sinai to identify the extent of its vulnerability to these climatic changes or not. If water availability is reduced in the future, soils of high water holding capacity will be better to reduce the impact of drought while maintaining crop yield. With the temperature increasing and precipitation fluctuations, water availability and crop production are likely to decrease in the future. If the irrigated areas are expanded, the total crop production will increase.

The crop structure reflects how agricultural land use is used to produce most crops during the year. The crop structure is concerned with the identification of the agricultural crops produced and the area allocated to each. The crop structure, which recycles the available resources, is used to achieve maximum production to reach the highest possible net income [6] .

The optimum cropping structure can be accessed by studying several structures through the study of several alternative crop structures through alternative agricultural cycles and selecting whichever yields the largest possible agricultural income. The optimal crop structure is obtained by calculating net farm income for alternative courses

at the farm level or at the national level. The optimum cropping structure is given at the farm level or at the national level the largest net farm income.

2. Research problem and objectives

problem of research is the allocation of economic resources available in the agricultural sector under climate changes in the North Sinai region, As it is clear that the economic resources in Egypt in general are not used for economic efficiency, The causes of this problem must be identified and verified by research and study, and the concept of optimal crop structure is a dynamic and changeable concept, What is the optimal crop structure for the North Sinai region under the influence of climate change and vulnerability, which are exposed to many areas of Egypt, like other countries of the world. The main objective of this research is to conduct a study to reallocate the economic resources available in the agricultural sector in North Sinai under the influence of climate change and under the limited economic resources available in the agricultural sector in general, And access to the optimal combination of different production elements, which leads to the characterization and extension of a dynamic model to reallocate the economic resources available in the agricultural sector in the region of North Sinai, which works to maximize the net return of the Feddan under the climate changes and in light of global economic changes to maximize the net return of the Feddan under the changes, And a comparison between current and optimal crop composition. Therefore, the study of the economic impacts of the expected climatic changes in northern Sinai from high temperature with increased drought, high soil salinity and groundwater. The evaluation of the productive efficiency of the agricultural production units under these environmental variables and their possible treatment is the main objective of this research.

3. Search method and data sources

The research was based on the methods of descriptive and quantitative economic analysis in the study of research indicators of available agricultural production resources in North Sinai, from secondary data available from the publications of the agricultural economy, water resources and climate. The research relied on the method of linear programming as one of the scientific methods of decision making, In the best possible manner in such circumstances, the various aspects of activities. In order to maximize its target of net farm income, Using MATLAB software.

The research was based on secondary data published and unpublished by various government agencies for the average period (2011-2015).

4. Methodology

Linear programming (LP) (also called linear optimization) is a method to achieve the best outcome (such as maximum profit or lowest cost) in a mathematical model whose requirements are represented by linear relationships. Linear programming is a special case of mathematical programming (mathematical optimization).

The objective function of the model was to maximize profit subjected to the limited resources on available seasonal water and suitable soil types of each crop[4].

Algebraically the model is summarized below:

$$\text{Maximize } Z_y = \sum_{e=1}^{E}\sum_{c=1}^{C}\sum_{s=1}^{S}\sum_{i=1}^{I}\sum_{o=1}^{o}\sum_{t=1}^{T} A\,egypt\; Xegypt$$

Where:

Zy = Gross profit of the scenario during the season y

A egypt = Crop profit of crop e in crop combination g in sub-season y by sub-irrigation p for soil type t.

X egypt = Irrigated area of crop e in crop combination g in sub-season y by sub irrigation p for soil type t.

E = Crop type (e = 1, 2, 3... E)

C = crop combination (c = 1, 2, 3... C)

S = Seasonal index (s = 1, 2, 3... S)

I = Irrigation type (i = 1, 2, 3... I)

O = Soil type (o = 1, 2, 3... o)

T = Temperature Degree (t = 1, 2, 3... t)

Subject to the following constraints:

1. Land constraint. 2. Cost constraint. 3. Water constraint. 4. Capital constraint. 5. Return constraint. 6. Net profit constraint. 7. CO2 emission constraint.

8. Energy constraint. 9. Temperature Degree.

5. Search results

Current crop structure in North Sinai

The current crop structure in North Sinai is of economic importance from the range of cereal crops, vegetable crops and some other crops. Table 1 shows the current crop composition activities in North Sinai and its area to the total area of the season (2011- 2015), Where the area of winter season about 55801 Feddan , and the area of the summer season about 83412 Feddan , while the season of the Nile to about 11794 Feddan. There are many annual changes that affect the productivity of crops such as cultivated area, the quality of agricultural land, as well as the productive methods used, and the quantities of water available for irrigating crops.

Table 1. Installation current crop in northern Sinai during the period 2011- 2015

Cop	Area (Feddan)	% crop area to area each season
wheat	1946	3.49%
Barley	675	1.21%
Potato	1621	2.90%
Green Beans	15	0.03%
Green Peas	581	1.04%
Okra	134	0.24%
Cabbage	142	0.25%
Squash	2193	3.93%
Eggplant	2615	4.69%
Pepper	2250	4.03%
Cantaloupe	10761	19.28%
Cucumber	2986	5.35%
Tomato	29882	53.55%
Total winter season	55801	100.00%
Cantaloupe	14163	16.98%
Okra	513	0.62%
Potato	1356	1.63%
pepper	2095	2.51%
Squash	2315	2.78%
Eggplant	2687	3.22%
Cucumber	4778	5.73%
Tomato	55505	66.54%
Total summer season	83412	100.00%
Cabbage	37	0.31%
Tomato	7131	60.46%
Other crops	4626	39.22%
Total Nile season	11794	100.00%

Source: Agricultural economics bulletin - Egypt - different versions

The data are shown in Table 2, which refers to the economic and technical assessment of the current crop composition, Where it is clear that the total cropping area during the period 2011-2015 amounted to about 151007 Feddan , and the total capital invested in the agricultural sector during that period amounted to about 461689 LE , while the total capital invested in the winter season, summer and the Nile, respectively about 187491 , 231457, 42741 LE. The total water resources used in the current crop structure in North Sinai amounted to about 649061 m^3 , and total water resources used as reached in the winter season , summer and Nile season amounted to about 159979.84 m^3, 434178.43 m^3, 54902.72 m^3 respectively.

It is clear from Table 2 also said that the total emissions of carbon dioxide produced under the current crop composition in North Sinai amounted to about 886703 kg. and The total emissions of carbon dioxide produced in the winter, summer and Nile seasons were about 105327.33 Kg, 767568.48 Kg, 13807.2 kilograms respectively, and the total energy used in the production structure in the current crop in North Sinai reached about 2865875 liter, it stood at around 956702 ,1595673.8, 313499 liter in both winter , summer ,Nile season respectively.

It is also evident from the table 2 that the total revenue comes from the current crop structure is about 1165777 LE , and reached about 541274, 503405.9 , 121097.2 LE in both winter , summer ,Nile season respectively. while the net return income of this current crop structure in North Sinai was about 703967.8 LE , and reached about 353663, 271948.9, 78355.87 LE in the winter, summer and Nile season, respectively.

Table 2. Economic and technical assessment of installation current crop in north Sinai during the period 2011- 2015

Items	Winter season	Summer season	Nile season	Total
crop area (Feddan)	55801	83412	11794	151007
capital used in agriculture (LE)	187491	231457	42741	461689
total revenue (LE)	541274	503405.9	121097.2	1165777
Net return (LE)	353663	271948.9	78355.87	703967.8
Quantity of water consumed(cubic meter - m^3)	159979.84	434178.43	54902.72	649061
total power used (liters)	956702	1595673.8	313499	2865875
total CO_2 sent out (Kg)	105327.33	767568.48	13807.2	886703
Ratio of total revenue to costs	2.8	2.18	2.8	2.5
Net return on costs	1.8	1.18	1.8	1.5

Source: 1- Agricultural economics bulletin - Egypt - different versions

2- bulletin of irrigation and water resources statistics – different Versions

Achieving economic and productive efficiency of the agricultural sector is one of the most important agricultural development objectives.

Economic efficiency is achieved when economic resources are used in a manner that maximizes the objective of the productive unit under study. If the productive unit is a commercial farm, the goal to be maximized is profit. Productive efficiency is achieved when the productivity of resources or inputs reaches a maximum.

Limitations on optimal crop composition

The constraints assumed by the study include human resources, land resources and water resources, which aim at improving agricultural production, thereby increasing agricultural income and improving the livelihoods of farmers in the North Sinai region affected by climate change. The activities included in the model were limited to the following limitations:

- **Available agricultural area**

These included two constraints restrictions for each planting season, one of them to the maximum and the other minimum, So that the area of each restriction of what can be grown with the crops included in the model for the average period 2011 – 2015.

- **Available water resources**

Water resources matrix coefficients represent necessary for the cultivation of one Feddan of each crop in each growing season cubic meter of water requirements, So that does not exceed necessary for the cultivation of crop water needs under study in each agricultural season, the amount of water resources available for agricultural season or equal, in the same period 2011-2015

- **Available agricultural labor**

The matrix represents the agricultural labor required to grow an acre of each crop in each agricultural season, So as not to exceed the needs of agricultural labor necessary to grow crops under study.

It was estimated for agricultural labor volume through the tables distributed cost items to wages and production requirements, by dividing the total wages of workers for each crop in each agricultural season to the average wage.

- **Available capital**

Capital matrix represents the value of the capital needed to cultivate one Feddan of each crop in each growing season in pounds, So the value of the capital needed to grow crops under study in each agricultural season within the value of the capital available for the agricultural season, for the same period.

- **Total return**

Total agricultural yield matrix represents the value of the total yield from the cultivation of one Feddan of each crop in each agricultural season of each crop in each agricultural season in pounds, So the total yield from crop cultivation studied in each agricultural season is larger than the total yield of crop cultivation in previous seasons or equal, for the same period.

- **Total agricultural net income**

Matrix represents a total net value of total agricultural income net income from cultivating one Feddan of each crop in each growing season in pounds, So the total net income from crop cultivation studied in each agricultural season is greater than the total net income from crop cultivation agricultural seasons in previous or equal for the same period.

- **Emitted CO2 gas**

The total CO2 emitted represents the total amount of gas emitted from the cultivation of one acre of each crop in each agricultural season in kg, So the total carbon dioxide emitted from crop cultivation studied in each agricultural season is less than or equal to the total gas released from crop cultivation in previous agricultural seasons.

- **Energy used in agricultural production**

The power matrix used in agricultural production represents the total energy used in production to cultivate one Feddan of each crop in Litter, So the total energy used for crop production studied in each agricultural season is less than the total energy used for crop production in previous agricultural seasons or equal for the average of the mentioned period.

- **Temperature degree**

The temperature matrix represents each crop, so the total temperature in the agricultural season is more than the total temperature exhibited for crops in previous or equal seasons, for the same period.

In order to reallocate the economic resources available in the agricultural sector in North Sinai, a matrix was created for each constraint of agricultural use, where the agricultural seasons are horizontal while the crops are vertical, so that the matrix fills with the different activities of each agricultural season.

Optimal crop structure in North Sinai

Results analyses of the model were obtained by exchanging the different constraints. It was found the optimal model is the function included twenty-nine activities; each activity represents a field crop, either winter, summer or Nile season, as shown in the table 3. Which refers to the optimum harvesting

activity in North Sinai and its area to the agricultural season area.

Table 3 optimal crop in north Sinai

Cop	Area (Feddan)	% crop area to area each season
wheat	2237.9	3.90%
Barley	695.25	1.21%
Potato	1280.59	2.23%
Green Beans	15.45	0.03%
Green Peas	598.43	1.04%
Okra	138.02	0.24%
Cabbage	146.26	0.26%
Squash	2258.79	3.94%
Eggplant	2693.45	4.70%
Peper	2317.5	4.04%
Cantaloupe	11083.83	19.34%
Cucumber	3075.58	5.37%
Tomato	30778.46	53.70%
Total winter season	57319.51	100.00%
Cantaloupe	14729.52	16.84%
Okra	538.65	0.62%
Potato	1084.8	1.24%
Pepper	2136.9	2.44%
Squash	2349.725	2.69%
Eggplant	2767.61	3.16%
Cucumber	5016.9	5.74%
Tomato	58835.3	67.27%
Total summer season	87459.41	100.00%
Cabbage	38.11	0.30%
Tomato	7273.62	58.01%
Other crops	5227.38	41.69%
Total Nile season	12539.11	100.00%

Source: calculated and collected from the results of statistical analysis

The table is shown the area of winter season about 57319.51 Feddan , and the area of the summer season about 87459.41 Feddan , while the season of the Nile to about 12539.11 Feddan.

The economic evaluation of the optimal crop composition obtained from the model analysis to estimate the efficiency through input and output, according to the research problem is to determine the combination of inputs that give the maximum possible profit to the farm under climate change.

Table 4 shows the results of the analysis of the needs of optimal crop composition under climate change

Table 4. Economic and technical assessment of optimal crop in north Sinai

Items	Winter season	Summer season	Nile season	Total
crop area (Feddan)	57319.51	87459.405	12539.11	157318
capital used in agriculture (LE)	247488.12	243029.85	45305.46	535823.4
Net return (LE)	530494.5	375289.482	133204.979	1038989
Quantity of water consumed(million m3)	156780.2432	303924.901	646315.854	1107021
total power used (million liters)	861031.8	1356322.73	275879.12	2493234
total CO2 sent out (million Kg)	84261.864	575676.36	10631.544	670569.8
Net return on costs	2.1	1.5	2.9	2.1

Source: calculated and collected from the results of statistical analysis

it found the optimal crop structure requires a patch of farmland of about 57319.51, 87459.405, 12539.11 Feddan in both winter , summer ,Nile season respectively. It also requires a farm capital of about 247488.12 LE, 243029.85 LE, 45305.46 LE in winter, summer, Nile season respectively, It also requires about 1107021 m^3 of water for the three agricultural seasons, The model also showed that net farm income increased by 1038989 LE from total of three seasons (winter , summer, Nile) under climate change conditions. The results also showed that the amount of carbon dioxide emitted was reduced to about 84261.864 Kg, 575676.36 Kg, 10631.544 Kg in winter , summer and Nile season respectively.

6. Conclusion

We conclude that by reallocating economic resources in plant production in North Sinai in the context of climatic changes, in order to achieve the optimal exploitation level, which maximizes agricultural income, which by planting a farmland area of about 157318 Feddan for winter, summer and Nile season in order. Agricultural income from optimum crop composition under climate change is estimated at 535823.4 LE, net farm income of about 1038989 LE , and the use of water quantity is estimated at 1107021 m^3, which is lower than the current crop structure by 457960 m^3, reduce carbon

dioxide emissions by about 216133 Kg , and reduce energy consumption by about 372641.15 liter. Therefore, the need for research is recommended reallocation of economic resources in plant production in North Sinai under climate change, and to encourage farmers to adopt modern agricultural methods that reduce the effects of climate change.

7. Acknowledgements

The research presented in this paper has been done within the project "Mapping agricultural communities vulnerable to the impact of climate and enhancing their livelihood in selected countries of MENA and SSA", which is funded by: International Center Biosaline Agriculture (ICBA).

8. Reference

[1]Barnabás et al., 2008 B. Barnabás, K. Jäger, A. Fehér , The effect of drought and heat stress on reproductive processes in cereals , Plant Cell Environ., 31 (1) (2008), pp. 11–38

[2]Calzadilla et al., 2013 A. Calzadilla, K. Rehdanz, R. Betts, P. Falloon, A. Wiltshire, R.S. Tol, Climate change impacts on global agriculture Clim. Change, 120 (1–2) (2013), pp. 357–374

[3]Central Agency for Public Mobilization and Statistics , Water Resources Bulletin, Water Resources Bulletin, Annual Bulletin of Irrigation and Water Resources Statistics, Various Issues, Cairo.

[4]G. B. Dantzig, Linear Programming and Extensions, (1963) Princeton University Press.

[5]R. Lal. , Climate change, soil carbon dynamics, and global food security , R. Lal, B. Stewart, N. Uphoff (Eds.), et al., Climate change and global food security, CRC Press, Boca Raton (FL) (2005), pp. 113–143

[6]Saad Saad Zaki Nassar, Mahmoud El Sayed Mansour, Price Policy and Agricultural Production, Ministry of Agriculture, FAO, National Seminar on Price and Agricultural Marketing Policies, 1987

[7]S.M. Howden, G.J. O'Leary , Evaluating options to reduce greenhouse gas emissions from an Australian temperate wheat cropping system , Environ Modell Software, 12 (1997), pp. 169–176