



Estimation of Air Temperature and Rainfall Trends in Egypt

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/AJARR/2018/v1i413090

Editor(s):

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Complete Peer review History: <http://www.sciedomain.org/review-history/25960>

Original Research Article

Received 5th June 2018

Accepted 11th August 2018

Published 21st August 2018

ABSTRACT

This paper aims at estimating the trend of climate change and examining its effect on agriculture in Egypt. The study focused on the changes in air temperature and rainfall. The monthly time series data was obtained from the World Bank Group Climate Change Knowledge Portal on temperature and rainfall for the period of 1991-2015. Time series and regression analysis were applied for data analysis. Seasonal variations in air temperature and rainfall through the study period were examined. The study relied on the previous research and personal interviews with some experts in the field to know the effect of climate change on agriculture in Egypt.

Results showed fluctuations and an increase in the air temperature for all the twelve months of the study period. Seasonal variations and a decline in the rainfall were found particularly in the month of June. The future effect of these changes on the Egyptian agriculture was presented in this study. Also, adaptation and mitigation practices to climate change were described. The role of agricultural extension and the need for effective extension services to reduce the effects of this phenomenon on agriculture in Egypt was emphasized.

Keywords: *Adaptation and mitigation; agriculture; climate change; Egypt; rainfall; role of extension; air temperature; time series; trend.*

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1. INTRODUCTION

The phenomenon of climate change has become one of the important global issues that threaten the future of the land. The world temperature has been rising and this will seriously affect many parts of the world. According to IPCC climate change “refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity” [1]. It is a change in the average pattern of weather over a long period of time [2].

Climate change affects the agriculture in different ways: shift in climatic and agriculture zones, impact on agricultural soil, effect on soil organic matters and soil fertility, effect on biological health of soil, soil erosion, reduced soil water availability, impact on soil processes, salinization and alkalization, pest, diseases and weeds, impact on plant growth, and impact on crop production [3,6,8]. The impacts of climate change have major effects on agricultural production, with a decrease in output of certain crops and increased variability of yields to the extent that important changes may need to be made by primary producers.

There are two alternative ways to face climate change, namely: adaptation and mitigation. While adaptation manages the impact of climate change, mitigation includes all means to reduce its causes [4].

Egypt is one of the most highly vulnerable countries to climate change. It has been getting warmer since 1960 and appears to be rising in recent decades. The rise of air temperature and sea level will cause the flooding of the Nile Delta, decline in rainfall, and the decrease in water resources. Climate change will have its negative impacts on the Egyptian agriculture. Several research studies have been conducted on climate change and its effects on the Egyptian agriculture. However, more research is needed to study this phenomenon and its impacts on agricultural production to determine the appropriate adaptation and mitigation technologies to reduce its effects. Some studies have reported on the projections of these impacts on the Egyptian agriculture [3,5,6,7,8, 9,10]. It is important to make a precise estimation

of seasonal trends of climate change in Egypt to predict its future impact on the agricultural production in Egypt.

Climate change will make Egypt’s climate drier or warmer. As mentioned by Abdalla and Yunsheng [5] Egypt could face an explosive situation due to the increased warming, severe droughts and evaporation, and reduced flow in the Nile which are the main consequences. Based on previous research results [3,5,6,7,8,9,10] it is supposed that climate change will have adverse effects on Egypt’s agriculture. The most important of these effects are: inundation of 12% - 15% of most fertile low lying lands in the Delta as a result of sea level rise caused by high air temperature, decline in water flow in the Nile River as a result of high temperature and increase of evaporation, increasing land desertification and losses of fertile lands as a result of increasing land salinity and higher level of ground water, increase in irrigation water consumption particularly for summer crops, and decline in the agricultural productivity of many crops as a result of increasing the degree of air temperature and decreasing the rainfall. The expected decline in the productivity of the most important strategic crops by the year 2050 has been shown in Table 1. The decrease in the productivity of these crops ranged from 11% for rice to 28% for soybean. Cotton was the only crop for which productivity is expected to increase up to 17% by the year 2050.

Table 1. Estimated expected decline in the productivity of the shown crops by the year 2050

| Crop | Expected change in productivity (%) of the base year |
|-----------|--|
| Wheat | - 18 |
| Barley | - 18 |
| Maize | - 19 |
| Corn | - 19 |
| Rice | - 11 |
| Soybean | - 28 |
| Sunflower | - 27 |
| Tomatoes | - 14 |
| Sugarcane | - 25 |
| Cotton | + 17 |

Sources: [7,11,13]

These effects of climate change on agriculture in Egypt necessitate the adoption of an effective adaptation and mitigation strategy to face this phenomenon. As mentioned above, there are two alternative ways to face climate change,

namely, adaptation and mitigation. While adaptation manages the impact of climate change, mitigation includes all means to reduce its causes. Probable adaptation option/strategy in agriculture can be: improving cropping patterns, developing new varieties of crops which are more resistant to high temperature, soil salinity, and water scarcity, improving irrigation management, adjustment of planting dates, improving agricultural drainage, providing financial support for farmers, and increasing the level of public awareness. Among Key mitigation technologies and practices: improving crop and grazing land management to increase soil carbon storage; restoration of cultivated peaty soils and degraded lands, improving rice cultivation techniques and livestock and manure management to reduce CH₄ emissions, improving nitrogen fertilizers application techniques to reduce N₂O emissions, dedicating energy crops to replace fossil fuel use, improving energy efficiency, improvements of crop yields.

These issues of climate change and its effects need effective extension services to diffuse awareness among farmers and rural people and encourage them to adopt adaptation and mitigation methods.

1.1 Objectives

The main objectives of this study were to:

- (1) Examine the future effect of climate change on agricultural productivity of the main agricultural crops in Egypt
- (2) Estimate the trend of changes in air temperature and rainfall in Egypt through the period 1991 – 2015, and
- (3) Examine seasonal fluctuations of changes in air temperature and rainfall in Egypt through the study period.

1.2 Study Area

Egypt is located at the northeastern corner of Africa and covers the southern corner of Asia. It is bordered by the Mediterranean Sea coast to the north, Gaza strip and the Gulf of Aqaba to the east, the Republic of Sudan to the south, and the Republic of Libya to the west. The total area of Egypt is about one million square kilometer. The climate of Egypt is dry and hot with mild winter and rain over the coastal areas.

Egypt is one of the most populous countries in Africa. Its population is growing rapidly.

According to 2017 census, the total population of the country reached 94.8 million [11], and is expected to exceed 140 million by the year 2030. Most of the population lives near the banks of the Nile River and occupies only about 4% of the total area of the country.

Agriculture is a major sector in the Egyptian economy contributing up to 14.5 of the total gross domestic product. It is responsible for food supply and employs 28% of the total labor force [12].

According to the 2010 agricultural census [13], the total cultivated area of agricultural lands in Egypt was 9.7 million feddan (one feddan = 4200 m²). Most agricultural land in Egypt (70%) is in the Nile Valley and Delta and about 30% in the newly reclaimed areas. Since the same land is grown more than once a year (the cropping rate is more than 1.7), this cultivated area gives a cropping area of more than 16 million feddan. The entire crop area is irrigated, except for some rain-fed areas on the Mediterranean coast.

Agriculture in Egypt is characterized by small farms. According to 2010 agricultural census, the majority of agricultural holdings in Egypt (91.8%) were less than five feddans and 97.6% of holdings were less than ten feddans. The average holding size was 1.8 feddan [13].

The agricultural year in Egypt starts in September and is divided into three main seasons namely: winter season (from September to November), summer season (from February to May, and nili season (from July to August). A variety of field and vegetable crops, in addition to fruit trees are grown throughout the year. The most important crops grown in Egypt are: cereal crops (wheat, maize, and rice), fiber crops (cotton), sugar crops (sugar cane and sugar beet), food legumes which include a number of bean crops that are used for human consumption, such as broad beans and soybeans, forage crops (the Egyptian clover (berseem)), and fruits and vegetables [14].

2. METHODOLOGY

The main concern of this study was to estimate the trend of changes in air temperature and rainfall. The data used were obtained from the World Bank Group Climate Change Knowledge Portal and concern temperature and rainfall for the period of 1991-2015 [15]. The paper focused on the seasonal variations in air temperature and

rainfall through the study period. To estimate the trend of changes in air temperature and rainfall, different models of regression analysis were applied. But since the application of all these models leads to the same results in terms of the level of significance, the results of linear regression analysis (curve fit) were presented. Time series analysis using ARIMA model was also applied to determine the observed trend of air temperature and rainfall through the study period. Two moving averages were calculated for the application of this analysis [16]. The annual mean of air temperature and rainfall was calculated and the statistical analysis was performed on the annual mean and all months for air temperature and rainfall. All these kinds of statistical analysis were conducted using SPSS version 16.

To know the effect of changes in air temperature and rainfall on agriculture in Egypt, some personal interviews were conducted with experts in the field in addition to available information from previous research studies.

3. RESULTS OF TREND ESTIMATION

3.1 Trend Estimation of Air Temperature

The results of linear regression analysis on changes in air temperature are given in Table 2. It was found that the value of R^2 for the annual mean was 0.42. Results of t and F tests were highly significant. The value of R^2 for the twelve months ranged from 0.001 for October to 0.33 for February and

August. Results of t and F tests were significant for the following seven months: February, March, June, July, August, September, and December with some differences in the level of significance.

To know the changes in air temperature during the study period and forecast the expected air temperature in 2040, the regression equation was applied for the annual mean and each months of the year. The results of the application of regression equation on air temperature are given in Table 3. It is evident from these results that the estimated annual mean of the degree of air temperature has increased from +22.7°C in 1991 to +23.9°C in 2015 with an increase of +1.2°C degree. This estimated annual mean of the degree of air temperature is expected to increase to reach +25.2°C degree in 2040 with an increase of +1.3°C from 1991 to 2015 and a total increase of +2.5°C degree from 1991 to 2040.

The estimated degree of air temperature has increased in all months of the year but with great variations among these months. The highest increase in air temperature occurred in February. The estimated degree of air temperature has increased from +13.6°C in 1991 to +16.4°C in 2015 with an increase of +2.8°C. This estimated value is expected to become +19.3°C in the year 2040 with a total increase of +5.6°C from 1991 to 2040. The estimated increase in air temperature reached 2.1°C for March through the study period and is expected to reach 4.0°C by the year

Table 2. Linear regression analysis results of temperature through the period 1991-2015

| Month | R2 | Constant | Un-standardized coefficients | | Standardized coefficients Beta | t | Sig. | F | Sig |
|---------------|------|----------|------------------------------|------------|-----------------------------------|-------|------|--------|-------------------|
| | | | b | Std. error | | | | | |
| Annual | | | | | | | | | |
| mean | .420 | -78.829 | .051 | .012 | .648 | 4.084 | .000 | 16.677 | .000 ^a |
| January | .053 | -55.927 | .035 | .031 | .230 | 1.132 | .269 | 1.282 | .269 |
| February | .332 | -215.333 | .115 | .034 | .576 | 3.383 | .003 | 11.448 | .003 |
| March | .164 | -145.317 | .082 | .039 | .404 | 2.120 | .045 | 4.496 | .045 |
| April | .023 | -21.109 | .022 | .030 | .151 | .731 | .472 | .534 | .472 |
| May | .126 | -54.100 | .041 | .022 | .355 | 1.819 | .082 | 3.309 | .082 |
| June | .166 | -64.910 | .047 | .022 | .407 | 2.136 | .043 | 4.571 | .043 |
| July | .265 | -58.371 | .044 | .015 | .514 | 2.877 | .009 | 8.277 | .009 |
| August | .333 | -80.345 | .055 | .016 | .577 | 3.390 | .003 | 11.494 | .003 |
| September | .196 | -81.001 | .055 | .023 | .442 | 2.366 | .027 | 5.597 | .027 |
| October | .001 | 16.094 | .005 | .031 | .030 | 1.45 | .886 | .021 | .886 |
| November | .090 | -80.284 | .050 | .033 | .300 | 1.507 | .145 | 2.271 | .145 |
| December | .171 | -105.331 | .060 | .028 | .413 | 2.174 | .040 | 4.728 | .040 |

Source: Data collected

Table 3. Estimated degrees of temperature and the expected increase in temperature degree from 1991 to 2040

| Month | Linear regression equation $Y = a + bx$ | Estimated degree of temperature | | | Estimated increase in the degree of temperature | | |
|-------------|--|---------------------------------|--------|-------|---|------------|------------|
| | | 1991 | 2015 | 2040 | 1991-2015 | 2015- 2040 | 1991- 2040 |
| Annual mean | $Y = -78.829 + .05 x$ | 22.71 | 23.94 | 25.21 | 1.22 | 1.26 | 2.50 |
| January | $Y = -55.927 + .035 x$ | 13.76 | 14.60 | 15.47 | .84 | .88 | 1.72 |
| February | $Y = -215.333 + .115 x$ | 13.63 | 16.39 | 19.27 | 2.760 | 2.875 | 5.64 |
| March | $Y = -145.317 + .082 x$ | 17.95 | 19.91 | 21.96 | 1.97 | 2.05 | 4.02 |
| April | $Y = -21.109 + .022 x$ | 22.69 | 23.22 | 23.77 | .53 | .55 | 1.08 |
| May | $Y = -54.100 + .041 x$ | 27.53 | 28.52 | 29.54 | .98 | 1.03 | 2.01 |
| June | $Y = -64.910 + .047 x$ | 28.67 | 29.80 | 30.97 | 1.13 | 1.18 | 2.30 |
| July | $Y = -58.371 + .044 x$ | 29.23 | 30.29 | 31.39 | 1.06 | 1.10 | 2.16 |
| August | $Y = -80.345 + .055 x$ | 29.16 | 30.48 | 31.86 | 1.32 | 1.38 | 2.70 |
| September | $Y = -81.001 + .055 x$ | 28.50 | 29.82 | 31.20 | 1.32 | 1.38 | 2.70 |
| October | $Y = 16.094 + .005 x$ | 26.049 | 26.169 | 26.29 | .12 | .13 | 0.25 |
| November | $Y = -80.284 + .050 x$ | 19.27 | 20.47 | 21.72 | 1.20 | 1.25 | 2.45 |
| December | $Y = -105.331 + .060 x$ | 14.13 | 15.57 | 17.07 | 1.44 | 1.50 | 2.94 |

Source: Data collected

of 2040. This estimated increase in air temperature is expected to be 2.9°C for December and 2.7°C degree for August and September (Table 3).

Time series and regression analysis results on air temperature are shown in Fig. 1. As stated above, these results were found to be significant for the annual mean and seven months of the year.

3.2 Trend Estimation of Rainfall

The results of linear regression analysis on changes in rainfall through the study period are given in Table 4. It can be seen that the value of R^2 for the annual mean was 0.072. Results of t and F tests were not significant. The value of R^2 for the twelve months ranged from 0.001 - 0.44 from January to June. Results of t and F tests were not significant for all months except for June.

To know the changes in rainfall during the study period and forecast the expected rainfall in 2040, the regression equation was applied for the annual mean and all months of the year. The results of the application of regression equation on rainfall are given in Table 5. It can be observed from these results that the estimated annual mean of rainfall has declined from 2.5 in 1991 to 2.0 in 2015. This estimated annual mean of the rainfall is expected to decline to become 1.5 in 2040 with a total decrease of 1.0 from 1991 to 2040.

Changes in the estimated rainfall varied from one month to another. While there has been a decline in rainfall during January, March, April, May, July, October, November and December, an increase in the amount of rainfall during February, June, August, and September (Table 5) was seen.

Time series and regression analysis results on rainfall are shown in Fig. 2. As stated above, these results were found to be significant only for the month of June.

4. DISCUSSION

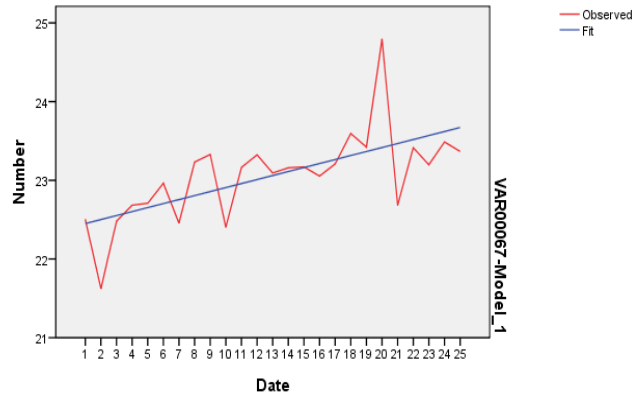
According to the results of this study, the following main outcomes of climate change can be inferred:

- (1) Noticeable fluctuations in air temperature and rainfall throughout the study period.
- (2) A noticeable increase in the annual mean of air temperature.
- (3) A noticeable increase in the air temperature in all months except for April and October with observed seasonal variations throughout the study period.
- (4) A noticeable decline in the annual mean of the rainfall with seasonal variations throughout the study period.
- (5) While a noticeable decline in the rainfall can be observed during the months of May, October, November, and December, an increase in the rainfall can be observed during February, June, August, and September.

Month

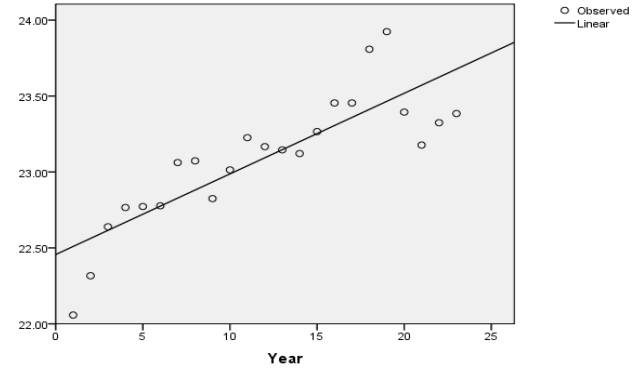
Results of Time Series Analysis

Annual mean

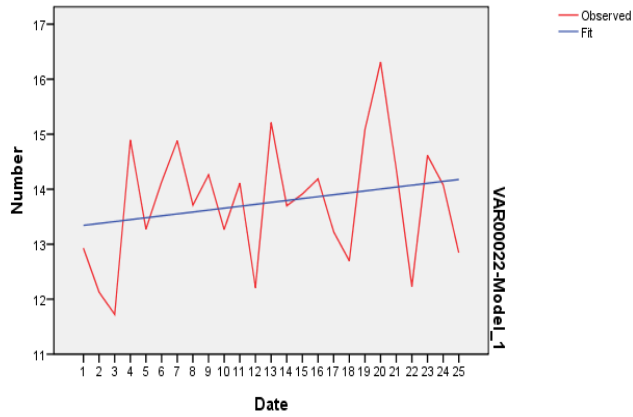


Results of Regression Analysis

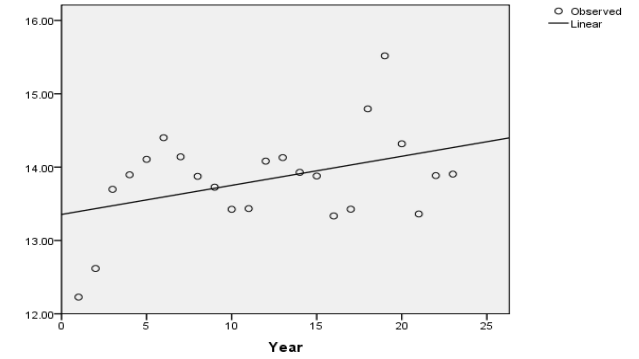
Temperature Annual Mean



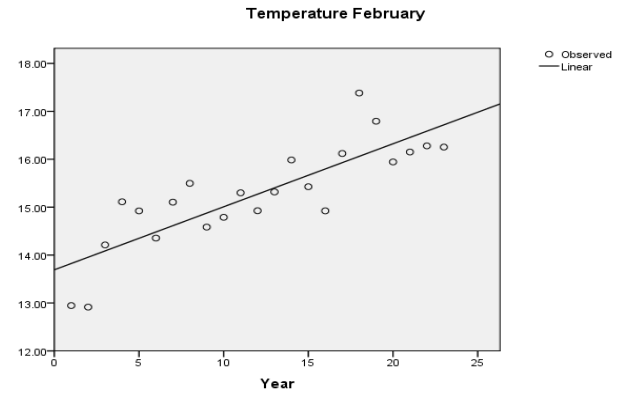
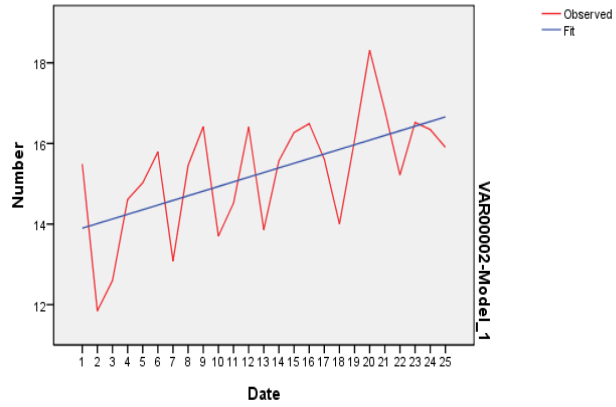
January



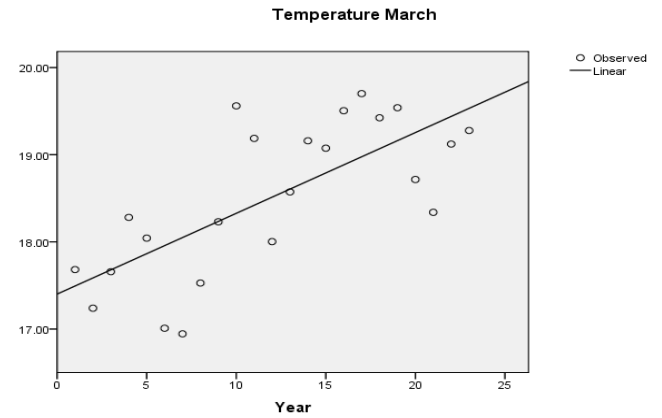
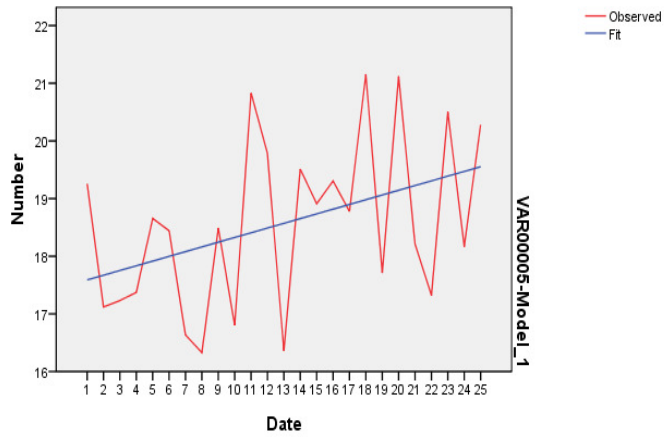
Temperature January



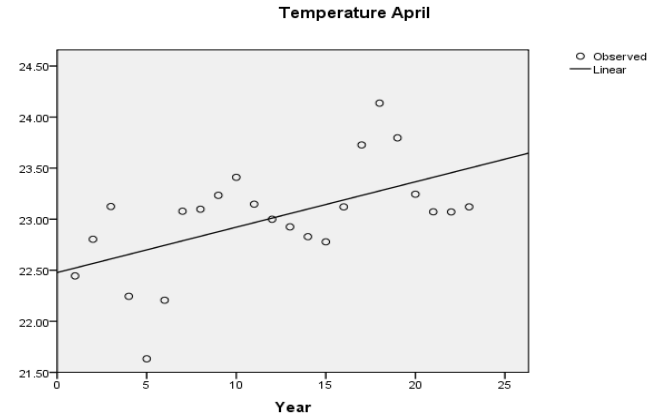
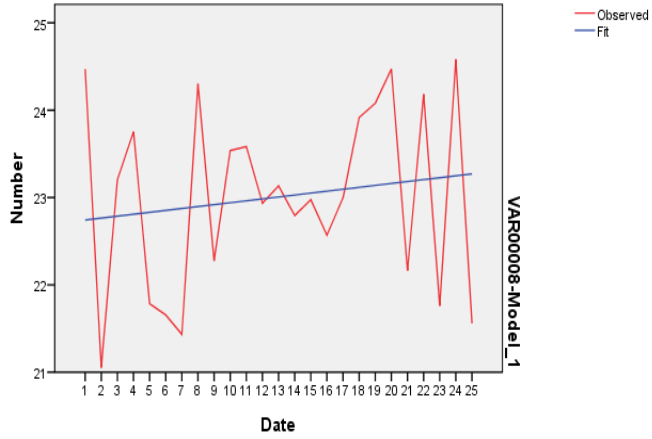
February



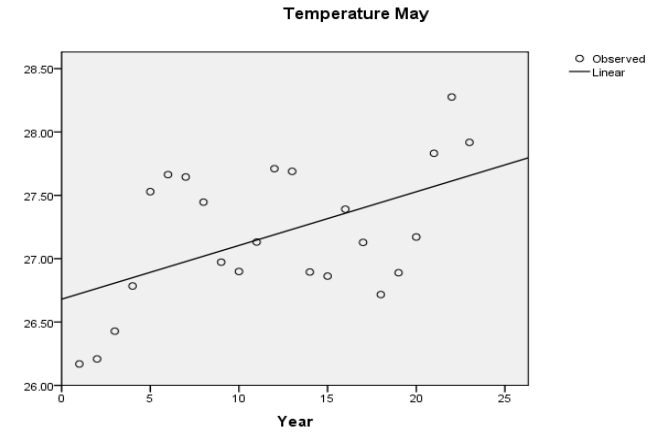
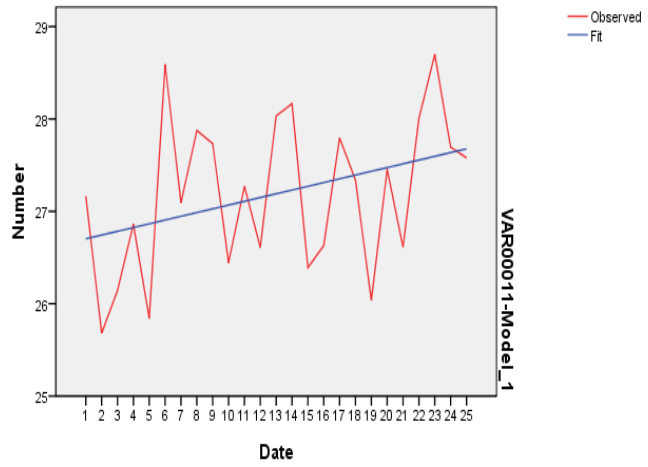
March



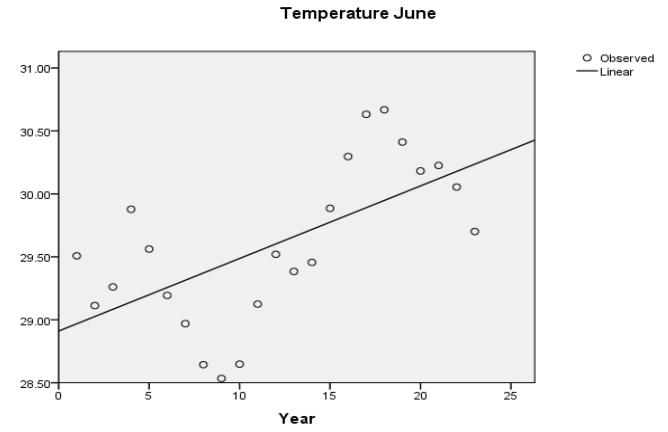
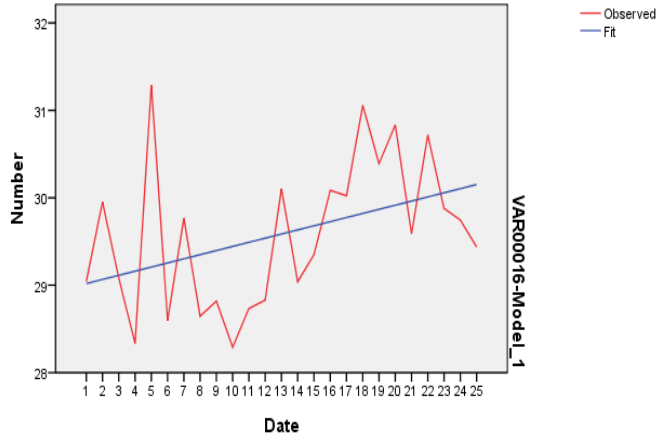
April



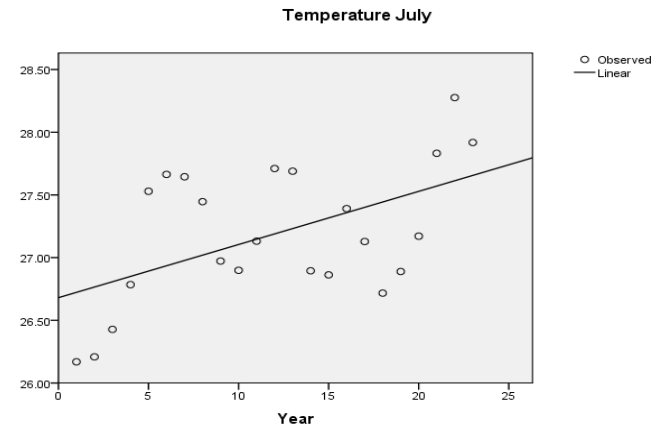
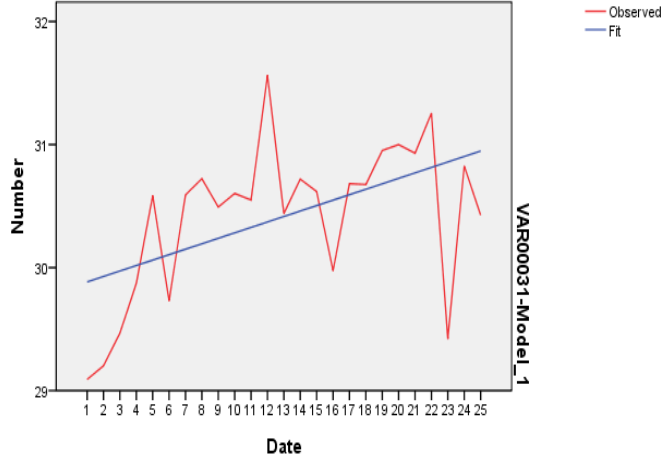
May



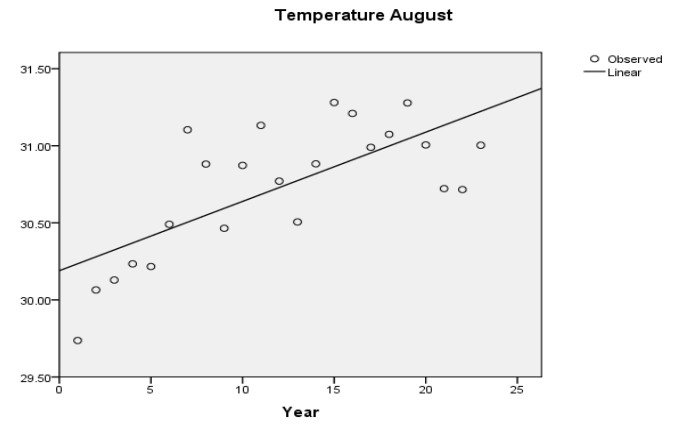
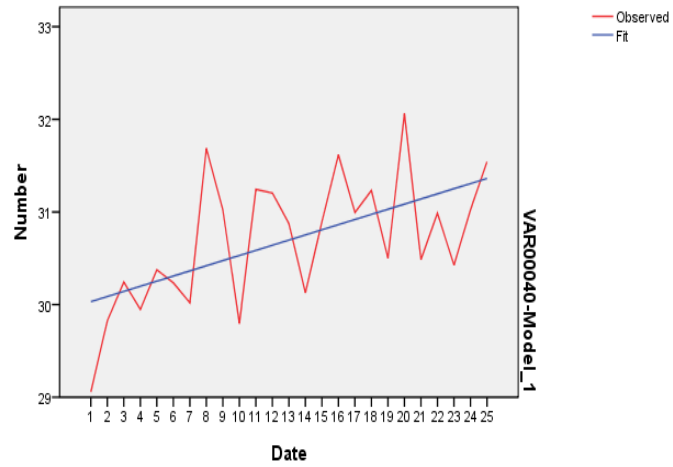
June



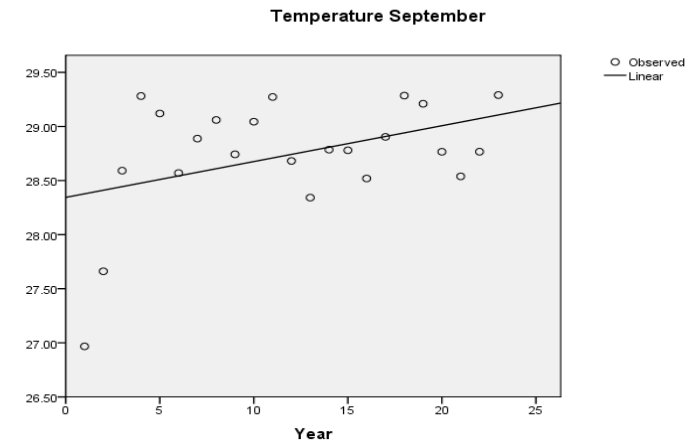
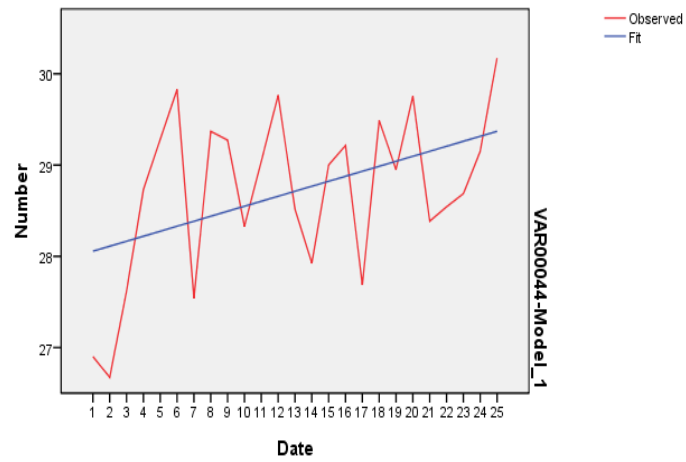
July



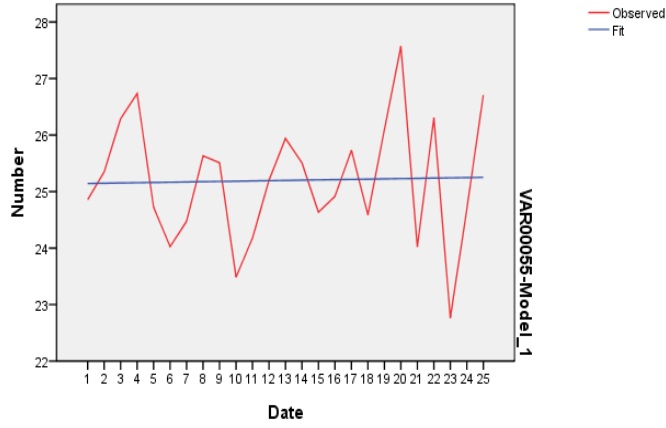
August



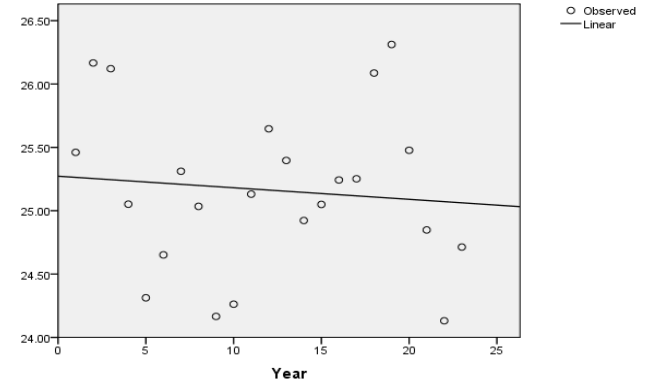
September



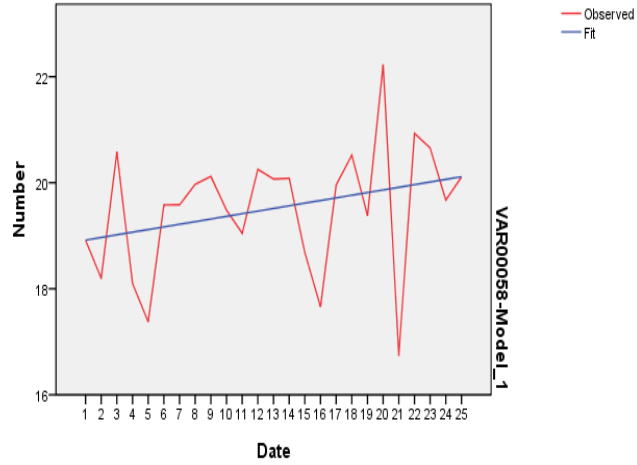
October



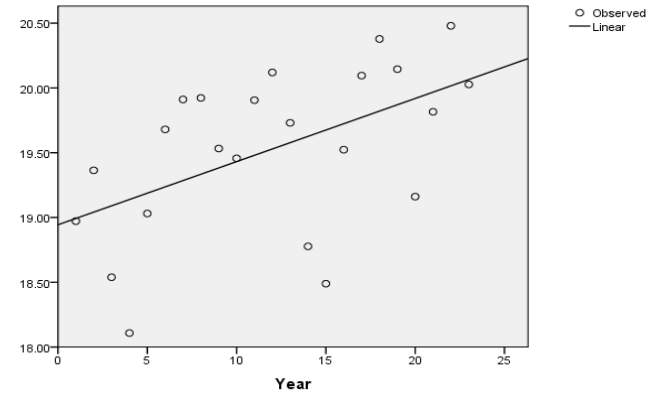
Temperature October



November



Trmperature November



December

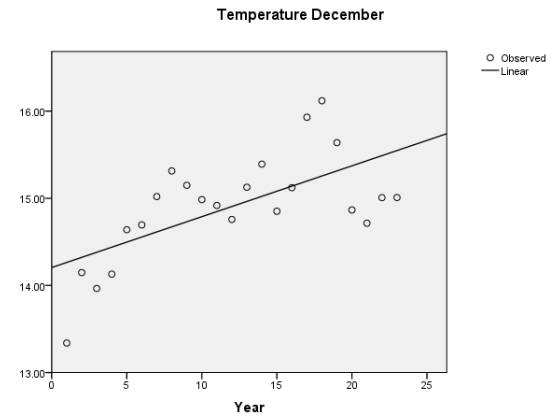
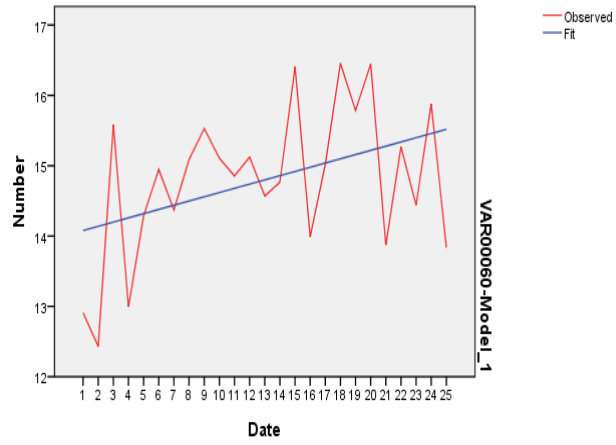
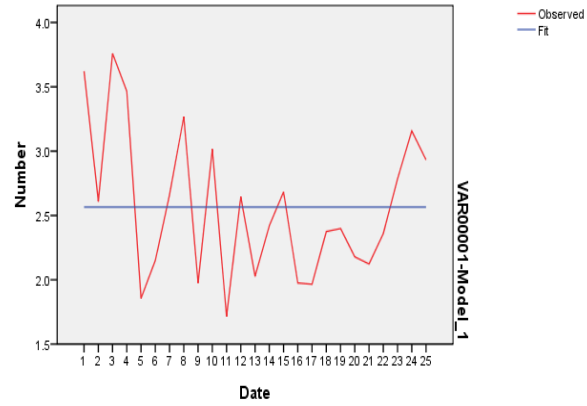


Fig. 1. Temperature trend

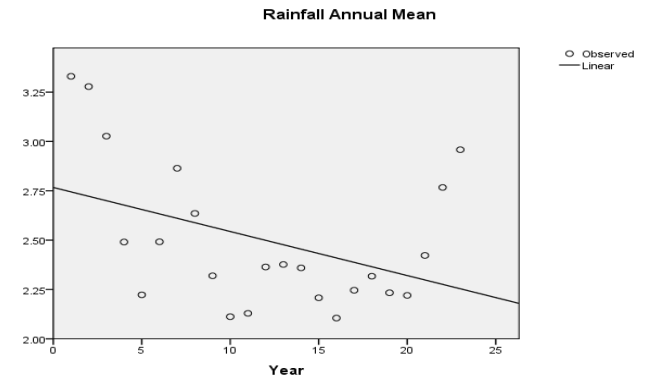
Month

Annual mean

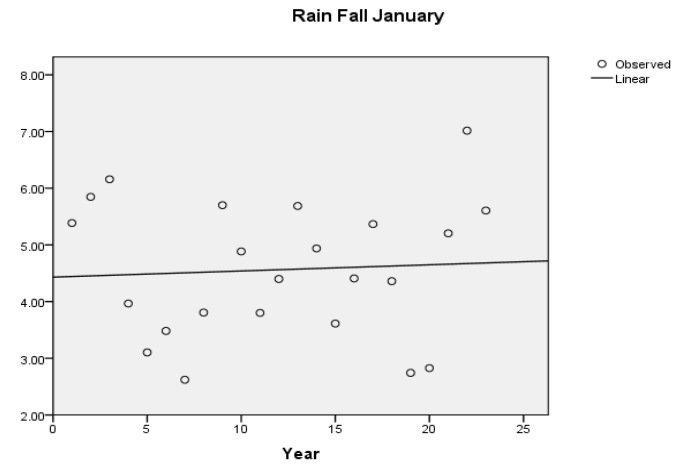
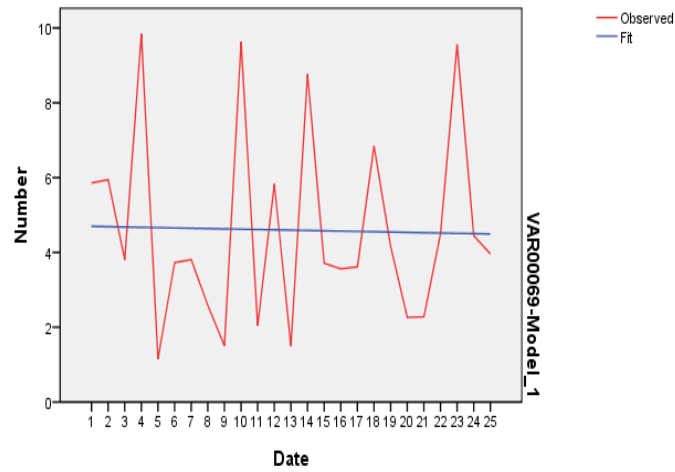
Results of Time Series Analysis



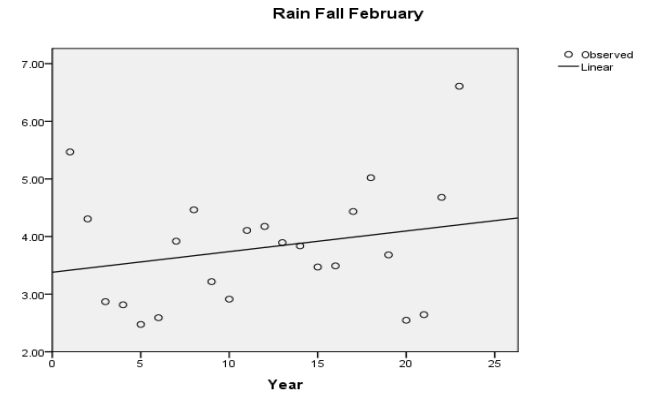
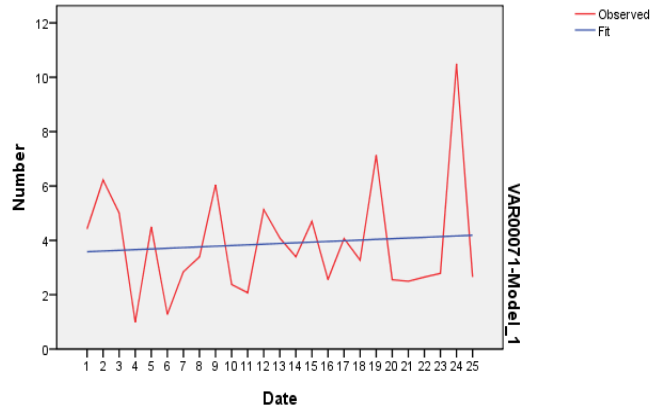
Results of Regression Analysis



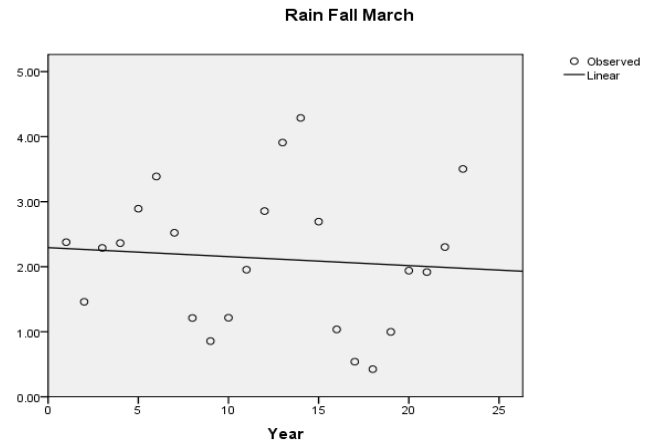
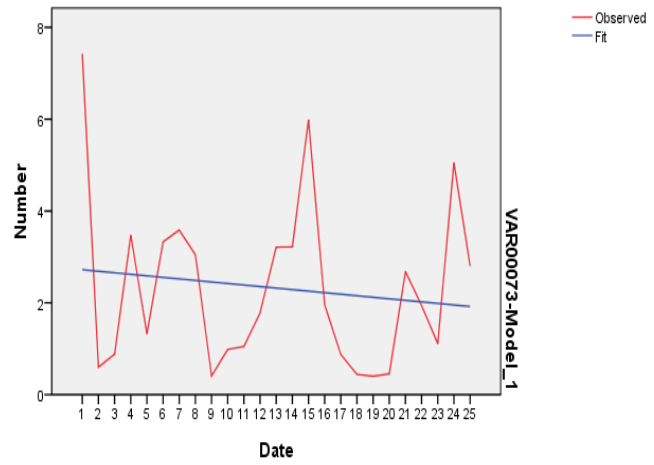
January



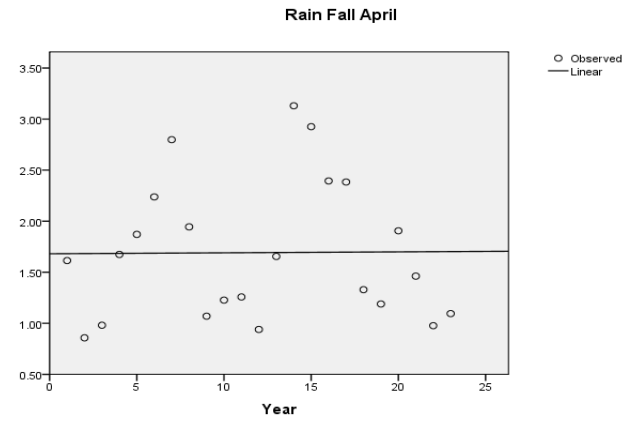
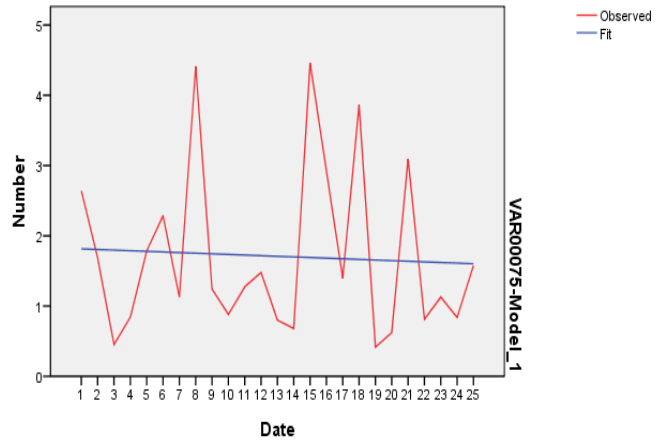
February



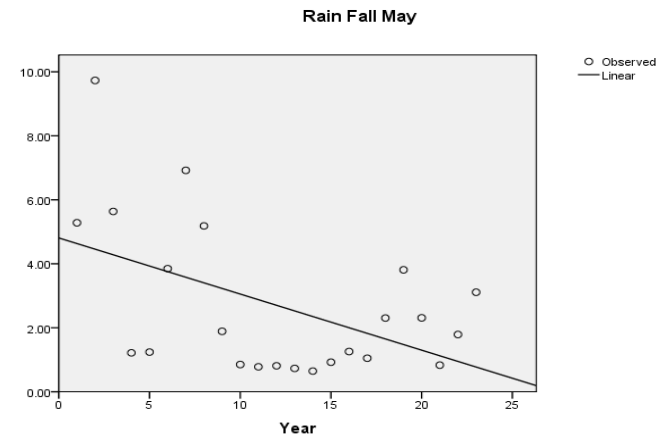
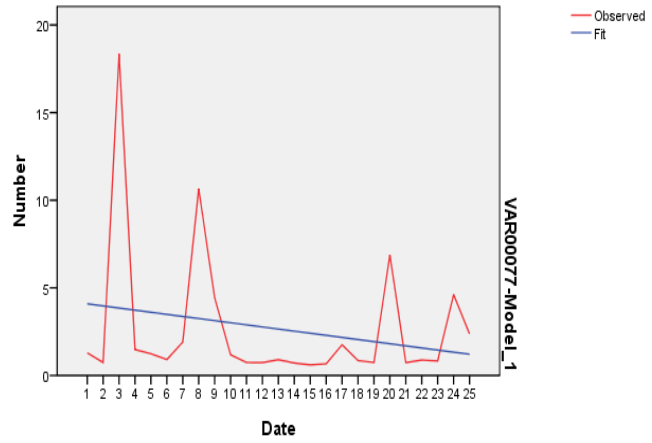
March



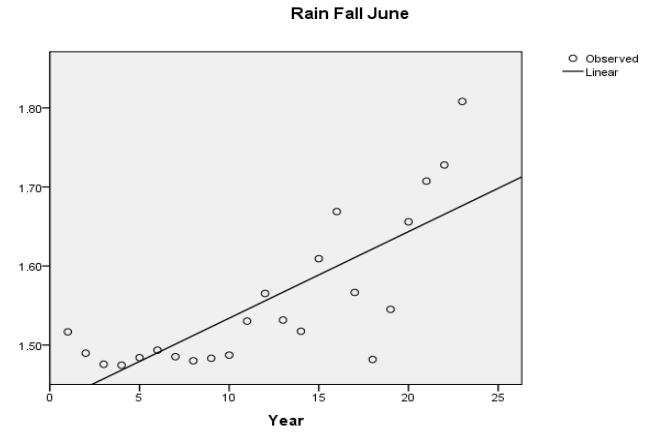
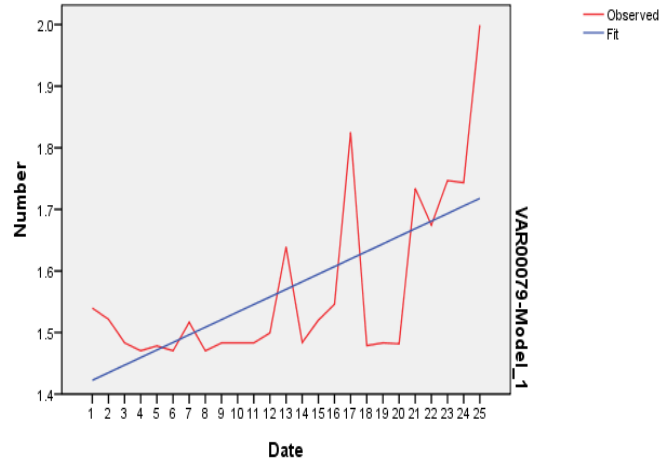
April



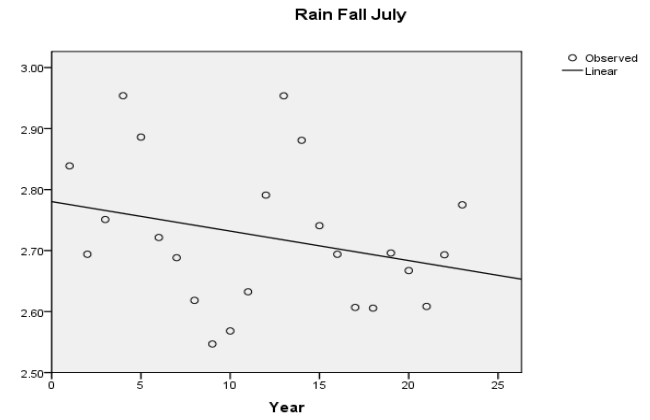
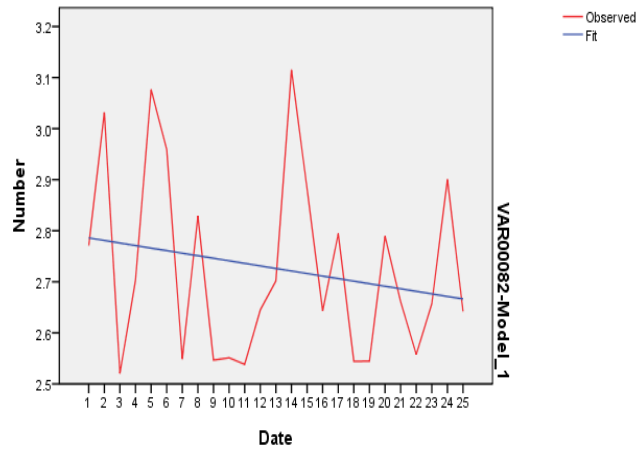
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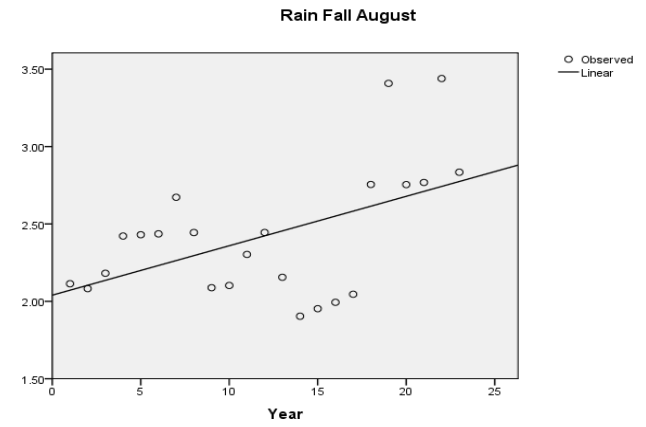
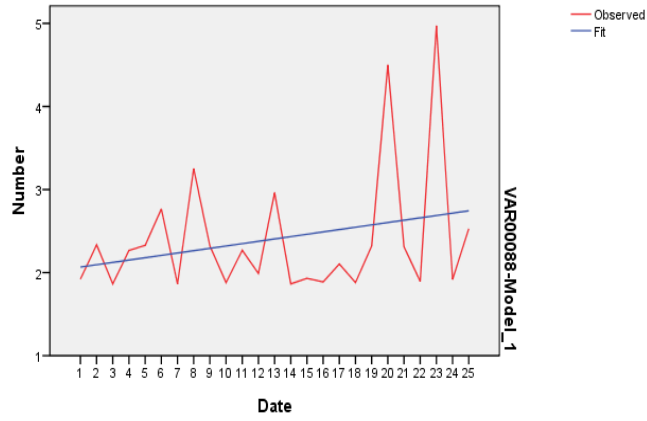
June



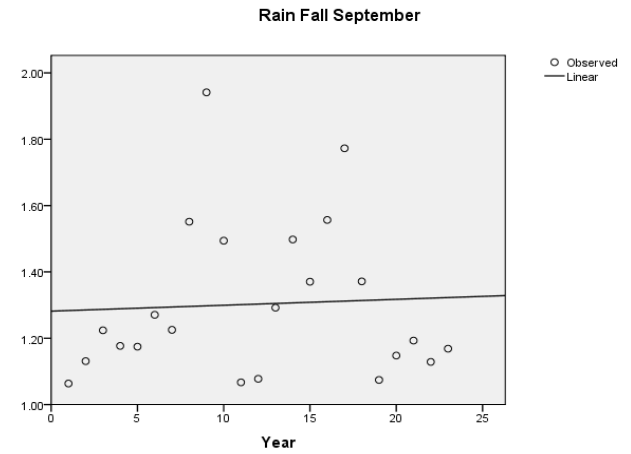
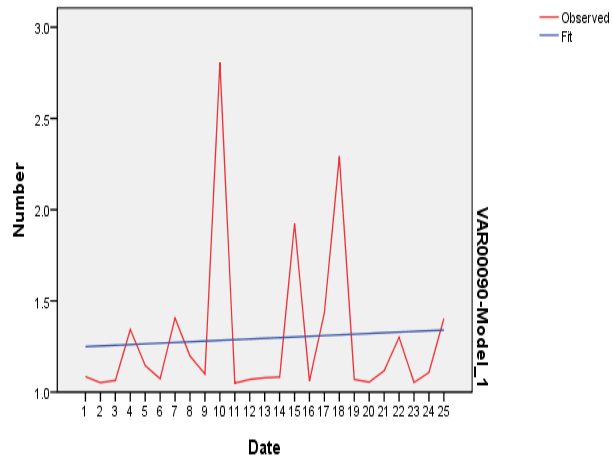
July



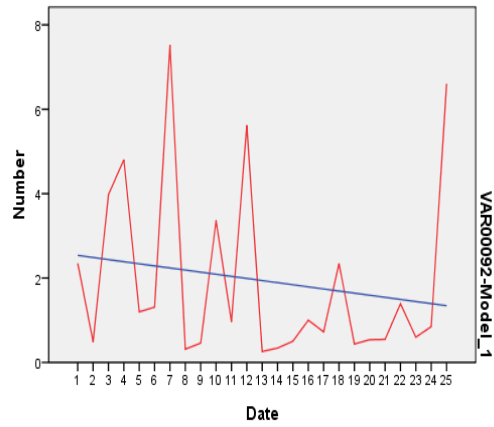
August



September

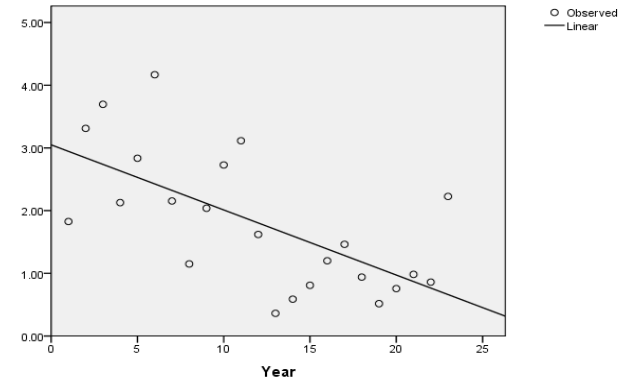


October

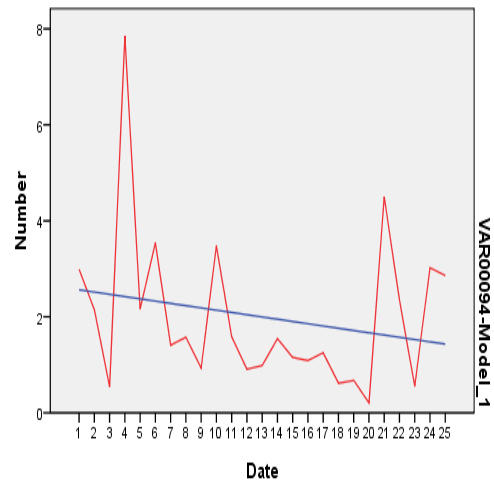


Observed
Fit

Rain Fall October

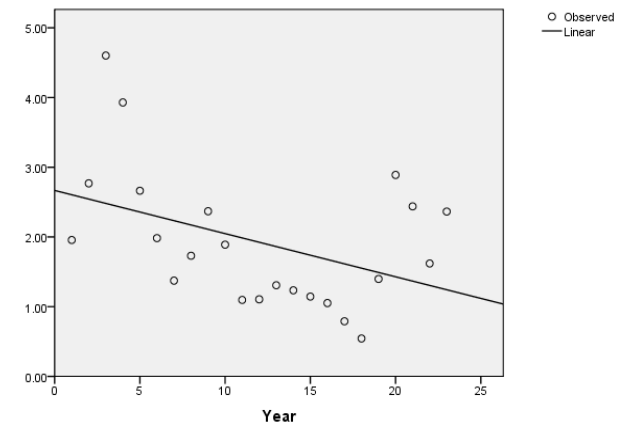


November



Observed
Fit

Rain Fall November



December

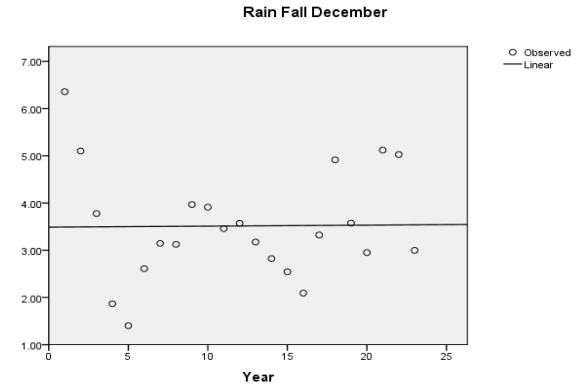
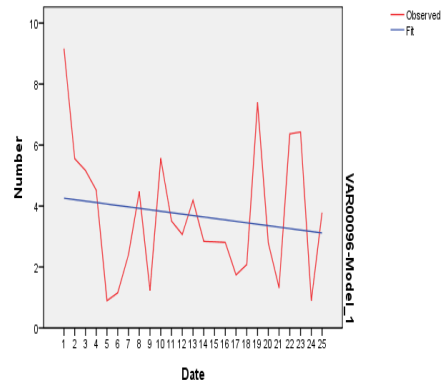


Fig. 2. Rainfall trend

Table 4. Linear regression analysis results of rainfall through the period 1991-2015

| Month | R2 | Constant | Un-standardized coefficients | | Standardized coefficients | t | Sig. | F | Sig |
|---------------|------|----------|------------------------------|-----------|---------------------------|--------|------|--------|------|
| | | | b | Std.error | Beta | | | | |
| Annual | | | | | | | | | |
| mean | .072 | 44.341 | -.021 | .016 | -.269 | -1.338 | .196 | 1.790 | .196 |
| January | .001 | 21.562 | -.008 | .074 | -.024 | -.115 | .910 | .013 | .910 |
| February | .008 | -46.551 | .025 | .058 | .090 | .435 | .668 | .189 | .668 |
| March | .018 | 69.252 | -.033 | .052 | -.134 | -.646 | .524 | .418 | .524 |
| April | .003 | 19.364 | -.009 | .034 | -.054 | -.259 | .798 | .067 | .798 |
| May | .048 | 242.669 | -.120 | .112 | -.219 | -1.075 | .294 | 1.155 | .294 |
| June | .422 | -23.084 | .012 | .003 | .650 | 4.100 | .000 | 16.810 | .000 |
| July | .041 | 12.707 | -.005 | .005 | -.201 | -.987 | .334 | .973 | .334 |
| August | .068 | -54.119 | .028 | .022 | .261 | 1.299 | .207 | 1.687 | .207 |
| September | .004 | -6.286 | .004 | .012 | .064 | .309 | .760 | .096 | .760 |
| October | .029 | 101.512 | -.050 | .060 | -.171 | -.835 | .412 | .697 | .412 |
| November | .044 | 96.395 | -.047 | .046 | -.210 | -1.030 | .314 | 1.060 | .314 |
| December | .026 | 98.663 | -.047 | .061 | -.160 | -.777 | .445 | .603 | .445 |

Source: Data collected

Table 5. Estimated rainfall and the expected change in rainfall from 1991 to 2040

| Month | Linear regression equation Y = a + bx | Estimated rainfall | | | Estimated decline in rainfall | | |
|---------------|--|--------------------|-------|-------|-------------------------------|-------------|-------------|
| | | 1991 | 2015 | 2040 | 1991 - 2015 | 2015 - 2040 | 1991 - 2040 |
| Annual | | | | | | | |
| mean | Y = 44.341 + (-.021) x | 2.530 | 2.026 | 1.501 | -.504 | -.525 | -1.029 |
| January | Y = 21.562 + (-.008) x | 5.63 | 5.44 | 5.24 | -.19 | -.20 | -.39 |
| February | Y = -46.551 + (.025) x | 3.22 | 3.82 | 4.45 | 0.60 | 0.63 | 1.23 |
| March | Y = 69.252 + (-.033) x | 3.55 | 2.76 | 1.93 | -.79 | -.83 | -1.62 |
| April | Y = 19.364 + (-.009) x | 1.44 | 1.23 | 1.00 | -.22 | -.23 | -.44 |
| May | Y = 242.669 + (-.120) x | 3.75 | 0.87 | -2.13 | -2.88 | -3.00 | -5.88 |
| June | Y = -23.084 + .012 x | 0.81 | 1.10 | 1.40 | .29 | .30 | .59 |
| July | Y = 12.707 + (-.005) x | 2.75 | 2.63 | 2.51 | -.12 | -.13 | -.25 |
| August | Y = -54.119 + .028 x | 1.63 | 2.30 | 3.00 | .67 | .70 | 1.37 |
| September | -6.286 + .004 x | 1.68 | 1.78 | 1.87 | .10 | .10 | .20 |
| October | 101.512 + (-.050) x | 1.96 | 0.77 | -0.49 | -1.20 | -1.25 | -2.45 |
| November | 96.395 + (-.047) x | 2.82 | 1.69 | 0.52 | -1.13 | -1.18 | -2.31 |
| December | 98.663 + (-.047) x | 5.07 | 3.96 | 2.78 | -1.13 | -1.18 | -2.31 |

Source: Data collected

The increase in air temperature during all months has negative effect on winter crops such as wheat and barley and on nili and summer crops such as maize, corn, and rice. This increase in air temperature has a positive effect on cotton which is grown in February. As shown in Table 3, the highest estimated increase in air temperature was occurred in February and March, which is the plantation time of cotton in Egypt.

The decline in rainfall, particularly in the beginning of the agricultural season (September and October) has a negative effect on barley

which is grown in the north coast. These changes in air temperature and rainfall interpret the decline in the productivity of the major agricultural products in Egypt reported in the previous researches.

Great efforts are needed to set up a strategy to face this phenomenon of climate change and reduce its effects on agriculture in Egypt. Great efforts are also needed by the agricultural extension system in the country to play its role effectively to face this phenomenon of climate change in Egypt.

5. CONCLUSION AND RECOMMENDATIONS

Based on the results of this research and the previous research results, it can be concluded that there is a great need to adopt an effective adaptation and mitigation strategy to face climate change in Egypt. There is also a great need for an effective agricultural extension system to implement this adaptation and mitigation strategy to face this phenomenon. The implementation of some of these adaptation and mitigation practices is in the hands of farmers. Examples of these practices are: improving cropping patterns, growing new varieties of crops which are more resistant to high temperature, soil salinity, and irrigation water scarcity, adjustment of planting dates. Other implementations are in the hands of the government through agricultural research centres and the agricultural extension system such as development of new cropping patterns, new varieties of crops, improved irrigation systems, improving agricultural drainage, providing financial support for farmers, and more public awareness, improving rice cultivation techniques, improving nitrogen fertilizers application techniques, and improvement of crop yields.

The agricultural extension system has a great role to play. It has to:

- (1) Spread knowledge and awareness among farmers and rural people on this problem, its causes and future effects.
- (2) Determine adaptation and mitigation practices to face climate change and reduce its effects.
- (3) Encourage farmers and rural people to adopt these practices to avoid the harm effect of climate change on agriculture in Egypt.

ACKNOWLEDGEMENT

The author wishes to thank the respectable reviewers of this article for their valuable comments.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. IPCC. Climate change 2007. Synthesis report. An assessment of the intergovernmental panel on climate change. Group contributions to the Fourth Assessment Report; 2007. Available:<https://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4syr.pdf>
2. Australian academy of science. The science of climate change: Questions and answers. Canberra; 2015. Available:<http://www.forestandbird.org.nz/files/The%20Science%20of%20Climate%20Change-20Questions%20Answers%20AAS2016%208%2010%2021.pdf>
3. El-Ramady HR, El-Marsafawy SM, Lewis LN. Sustainable agriculture and climate changes in Egypt, In: E. Lichtfouse (ed.). Sustainable Agriculture Reviews 12, 41; © Springer Science + Business Media Dordrecht; 2013. DOI10.1007/978-94-007-5961-9_2. Available:http://www.springer.com/cda/content/document/cda_downloadaddocument/9789400759602-c1.pdf?SGWID=0-0-45-1376404-p174727724
4. IPCC fourth assessment report: Climate change. Climate change 2007. Synthesis Report, Adaptation and Mitigation Options; 2007. Available:<file:///D:/AR4%20SYR%20Synthesis%20Report%20Summary%20for%20Policymakers%20-%204%20Adaptation%20and%20mitigation%20Options.htm>
5. Abdalla Z, Yunsheng Li. Impact of climate change on agriculture sector in Egypt and China. 4th International Conference on Agriculture & Horticulture, 13-15 July, Beijing, China; 2015.
6. Abdel-Dhafer NA. Climate changes and their effects on Egypt. Assiut Journal for Environmental Studies. 2015;41.
7. Eid Helmy M, El-Marsafawy, Samia M, Ouda Samiha A. Assessing the economic impacts of climate change on agriculture in Egypt. A Ricardian Approach; 2007.
8. El-Ramady HR, Belal A, El-Marsafawy SM. Climate change a blessing or a curse for agriculture? Contemporary Environmental Readings. First Edition. 2013;1. Available:http://www.scienzadelsuolo.org/docs/Climate_change.pdf
9. Fawaz Mahmoud M, Soliman S. The potential scenarios of the impacts of climate change on Egyptian resources and agricultural plant production. Open Journal of Applied Sciences. 2016;6:270-286.

- Available:<http://dx.doi.org/10.4236/ojapps.2016.64027>
10. League of Arab countries, Arab organization for agricultural development The Effect of Climate and Climate Changes on Arab Countries, Khartoum; 2010.
Available:<http://www.aoad.org/Studies/Climate-change-effects.pdf>
 11. Central Agency for Public Mobilization and Statistics (CAPMS), Cairo; 2017.
 12. The World Bank Group. Employment in agriculture. International labor organization. ILOSTAT Database; 2017.
 13. Ministry of agriculture. Results of Agricultural Censes, Central Administration for Agricultural Economics, Cairo; 2010.
 14. Ministry of Agriculture, Agricultural Research Centre, Agricultural Bulletins for various crops, Cairo; 2010.
 15. The World Bank Group. Climate Change Knowledge Portal for Practitioners and Policy Makers.
(Accessed on: 13/11/2017)
Available:http://sdwebx.worldbank.org/climateportal/index.cfm?page=downscaled_data_download&menu=historical
 16. Wild CJ, Seber GAF ND. Time Series, Chapter 14 of Chance Encounters;1999.
Available:<https://www.stat.auckland.ac.nz/~wild/ChanceEnc/Ch14.pdf>

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