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Original Article

Temperature as Climate Change Indicators and Reference Evapotranspiration in The Western Region Of Libya

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Abstract

Climate change is the main environmental issue all over of the world. Temperature is the main climate change indicator. The warming is the main feature of the climate change. Libya is one of the driest and the semi driest regions in the world, therefore the climate changeresearch should be the main research issue.The area of study is located in the north western region of Libya, where the most population of Libya is concentrated. The monthly basis historical temperature for long term data station in the western zone of Libya were obtained from the Libyan National Climate Centre (LNCC). Data of threestations were used to represent Jeffara plain from east to west (Misurata,Tripoli city, Tripoli A/P) in addition to Zwara, and data of two stations were used to represent Nefusa upland (Garian and Nalut). These stations are considered a good representative for the Western region, as they cover the north –west, north-east, south-west and midlands-east part of Western region. The entire climate database is divided into four periods; 1961- 1990 represents the recent historic prediction or baseline, while 2010- 2040, 2041-2070, 2070-2100 represents the short-term, middle-term and long-term future climate projections for air temperature. The mean of the temperature of the six stations were estimated to represent the mean annual temperature of the region. The results show that the annual temperature mean of the region shows an increasing trend. The regression equations shows increasing indicators for all stations and the expected temperature for the mid of years of short, mid and long term of the future which are within the expected rise in global temperatures of between 1.4 and 5.5°C by the end of the 21sh century. The decade beginning 1990 has been the warmest decade where the warmest year is 1999 (in contrast to the global year 1998) in the instrument record for the region. The regression analysis shows an increasing trend of reference evapotranspiration (ETo) with the time. Reference evapotranspiration ETo for the mid of years of short, mid and long term of the future show as the temperature will increase the reference evapotranspiration will be increased too.

Keywords: Climate,Temperature, Climate change, evapotranspiration.

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Introduction

Climate change is the main environmental issueall over the world. The warming is the main feature of the climate change. The temperature of the earth is determined by a balance between energy coming in from the sun in the form of visible radiation as the sunlight and energy constantly being emitted from the earth to space. Some of the outgoing radiation is absorbed by naturally occurring greenhouse gases, including water vapour, creating a natural greenhouse effect which keeps the surface of the earth around 33°C warmer than it would otherwise be and helps to sustain life on the earth (Pachauri and Reisinger, 2007). The third assessment report of the climate change,represents the most authoritative contribution on the topic (Houghtonet al., 2001). Among the principal conclusions of the third assessment report are the following:

● Global average temperature has increased by 0.6°C ± 0.2°C since the mid - 19thcentury and the trend seems to have accelerated in the past three decades. A further increase of 1.5-6.0 is projected for the period to 2100.

●The 20th century was the warmest century of the last millennium in the Northern Hemisphere. The 1990s was the warmest decade and 1998 was the warmest year.

Climate change indicators divide in two divisionsprimary and secondary. Primary Indicators are the instrumental observation of climate over time. Secondary indicators are systems/ organisms the vitality and responses of which change in response to environmental conditions, therefore, Secondary indicators are more problematic as they study the effect of climate change on natural flora and fauna which are complex and multifaceted and subject to a large uncertainty.Temperature is the main primary climate change indicator,where changes in temperature, can have impacts on water availability. Temperature is predicted to rise in most areas, but is generally expected to increase more in inland areas and at higher latitudes. Higher temperatures will increase loss of water through evaporation. The net impact on water supplies will depend on changes in precipitation (including changes in the total amount, form, and seasonal timing of precipitation). Generally speaking, in areas where precipitation increases sufficiently, net water supplies may not be affected or they may even increase. In other areas where precipitation remains the same or decreases, net water supplies would decrease. Where water supplies decrease, there is also likely to be an increase in demand, which could be particularly significant for agriculture (the largest consumer of water) and also for municipal, industrial and other uses (Pachauri and Reisinger, 2007).Finally as the temperature increases the crop water requirement will be increased. Reference evapotranspiration (ETo) defined as the depth of water needed to meet the water losses through evapotranspiration (ET) of a disease free crop, growing in large fields under non restricting soil conditions including soil water and fertility while achieving full production potential under the given growing environment. Evapotranspiration is important to evaluate the irrigation potentialities of various agricultural zones and helps improve the practices of water management and crop production.Due to difficulty in obtaining accurate field measurements, the prediction methods are applied to determine ET. The ET can be estimated using historical, meteorological and cropping conditions. The accuracy of ET estimates depends on the availability of equations being used to describe the physical processes governing the losses and the accuracy of the meteorological and cropping data. The choice of method primarily depends on the type of climatic data available and on the accuracy required in determining the water needs. There are four methods generally used to determine reference evapotranspiration (ETo). These are: (i) BlaneyCriddle, (ii) Radiation, (iii)Penman, and (iv) Pan Evaporation methods.

The climate is dry in Libya, and within Libya as many as five different climatic zones have been recognized, but the dominant climatic influences are Mediterranean and Saharan. The region under study is situated in the zone of Mediterranean climate type. Rainfall is often erratic, and a pronounced drought may extend over two seasons. For example, episodic floods in 1945 left Tripoli underwater for several days, but two years later an unprecedented severe drought caused the loss of thousands of head of cattle (Barich, et al 2006). The latest report of the National Climate Centre 2010 mentions that all regions of Libya passed in specific in the western zone through a pronounced drought season, with rise in temperature, and decline in rainfall in Nov and Dec 2009 compared with the previous general means. Water is the most precious natural resource in Libya and water shortages is one of the major environmental challenges to Libyan’s modernization in the past and will be in future too. Shortages threaten Libyan’s social and economic development in the 21st century. This study will identify the rise of temperature in the western region of Libya as climate change indicator and will investigate impact of rise in temperature on plant water consumptive use in the western zone of Libya.

Materialsand Methods

Area of study

The area of study is located in the north western region of Libya, where the most population of Libya was concentrated. The area of study with almost triangular in shape is a part of Tripolitania bounded by the following coordinates; Long. 12° 00° – 15° 07° E; Lat. 31° 52° – 32° 54° N. The area under study extends for 270 km from west to east, its width (distance from sea) varies between 8 and 115 km, where its estimated area is about 1 664 596 hectareas in Figure.1.

Geomorphology and Topography of area

The relief of the Tripolitania territory under study has developed in the course of geomorphologic evolution in the recent geologic period of tectonic activity. The intensification of fault tectonics gave rise to volcanic activity. Basalt lava effusion from fissures led to the formation of spacious volcanic plateau on Jebel Nefusa (Nefusa Mountains). As a result, there appeared three largest morpho- structures of the western zone, namely: the littoral plain (Jeffara lowland) and outlier plains on the Joffra lowland and in between Jebel Nefusa plateau.

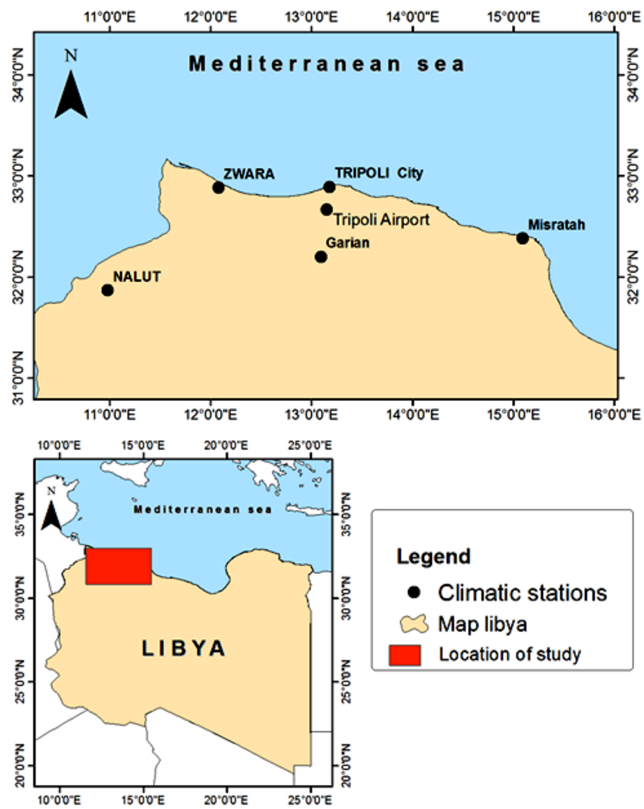

Figure 1 Western zone area under study

Jeffara Plain

The width of Jeffara Plain as a part of Jeffara lowland is about 45 km in the western part of the zone. In the direction from Tripoli to Alkhoms, the Jeffara Plain abruptly narrows and wedges out in the area of Al Ghanimah, where the Jebel Nefusa upland drops as a cliff to the Mediterranean Sea. East of Alkhoms, the Plain is 3-5 km wide gradually widening in the area of Misuarata up to 22 km. There are many wadis cross the Jeffara Plain in the western zone as (wadi al Majinin, wadiGan, wadizarit and others). Numerous wadis originating from Jebel Nefusa upland terminate as dry deltas on the Jeffara Plain. The width of the largest wadis reaches 100 m and more. The wadis cut to a depth of 5-7m, having steep and abrupt banks and flat bottom covered with coarse-texture alluvium. Sometimes, a fluffy mantle is stripped off, and the bottoms expose bedrocks or crusts.

Jebel Nefusa upland

The Jebel Nefusa upland represents a plateau, which was formed as a result of tectonic elevation of primary plain of marine accumulation. The maximum absolute height of the upland is 980.0 m. As to its morph metric features, the Upland is referred to as a low plateau of medium height. The surface of the plateau is atypical structurally-denudated plain and only in the marginal parts of the plateau, in the zone of its scarp, a deep erosion dissection adds to the relief of the features of the mountainous one. The morphology of the plateau surface is determined by the nature of erosion dissection: depth, density and pattern of erosion network. The erosion dissection of the plateau various parts depends, first of all, on the distance from denudation basis, the heightover the basis, the geological structure and the climatic conditions (Selkozprom, 1980). Accordingly, a number of types of the erosion- denudation relief representing a succession of primary plains dissections may be singled out within the limits of Jebel Nefusa.

Temperature data of the region

The monthly basis historical temperature for long term data station in the western zone of Libya was obtained from the Libyan National Climate Centre (LNCC) in the region. Three stations represent Jeffara plain From east to west (Misurata,Tripoli city, Tripoli A/P),Misurata, in the far east of the region and Zwara were add to extend the study to the far west of the region, and two stations represent Nefusa upland (Garian and Nalut) were used to show rise in temperature in the region. These stations are considered a good representative for the Western zone, as they cover the north–west, north-east, south-west and midlands-east part of Western zonedivided into four periods; 1961- 2000 represent the recent historic prediction or baseline, while 2010- 2040, 2041-2070, 2070-2100 represent the short-term, middle-term and long-term future climate projections for air temperature.

Long term monthly records (1961 -2003) of (Monthly maximum mean, minimum mean) were obtained from (LNCC) and monthly mean temperature were estimated for a number of stations, Zwara, Tripoli city, Tripoli airport, and Misuratawhich represent Jeffara plain and Garianand Nalutstations whichrepresent Nefusa upland. Simple linear regression method was used to show rise in temperature for western zone region as shown in the results.

Reference evapotranspiratin evaluation for the region

The BlaneyCriddle, was used as indicated by Abderra- oufElferchichi et al, 2017to evaluate thereference evapotranspiration, ETo, of the western region of Libya, because it depends on the temperature mainly the most available climate data for the region. The Blaney Criddlemethod can be written as.

$$ETo = p\,(0.46\ T\ mean + 8) \qquad (1)$$

ETo = annual mean daily referenceevapotranspiration (mm/day)

Tmean= annual mean daily temperature (°C).

p = annual mean daily percentage of daytime hours of Latitude 30 North the nearest line in table1 (Doorenbosand Pruitt, 1977) for west region of Libya (0.28).

Results and Discussion

Air Temperature of western region

The statistical analysis show that the mean air temperature of the region 19.5 º C and with range of (11-28) while the standard deviation and variance between locations and years are very low (Slandered deviation; 1.1 and 0.65) and (Variance; 1.2 and 0.42) consequently. All the stations in the region show the same temperature pattern trend across the whole year and there is not abig variation in temperature where Garian has the lowest trend of temperature over the whole of the year as it is located on the top of Nefusa upland. Also the variation is a bit recognized in wintertime between Jeffara plain station and Nefusa upland due to the effect of sea on sea shore station, therefore they are a bit higher than Nefusa upland stations, and the sea shore city station almost have the same trend over the whole of the year as shown in the Figure.2.

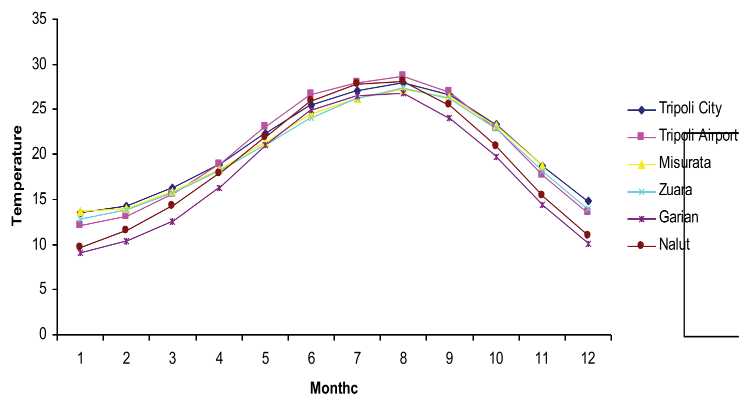

Figure 2. Mean monthly air temperature over the whole of year for five station of the region.

The mean annual temperature for all the stations in the region shows an increasing trend. The regression analysis results as shown in the table below shows the regression equation and their determination coefficient (R2) for the five stations in the western region of Libya. It shows increasing trend for all stations and the expected temperature for the mid year of short, mid and long term of the future which are within the expectedrise in global temperatures of between 1.4 and 5.5°C by the end of the 21sh century. The decade beginning 1990 has been the warmest decade in the instrument record for the region. This is comparable to the global pattern, which revealed a 0.6 °C increase.

Table.1 Recent mean Temperature, regression equation and expected temperature for the mid of years of short, mid and long term future.

Station	Mean Temperature °C	Regression equation	R^2	Expected future temperature °C Short term 2025	Mid term 2055	Long term 2085
Tripoli City	20.8	Te = 0.0371 (year) - 52.814	0.48	22.3	23.4	24.5
Tripoli Airport	20.5	Te = 0.0271 (year) - 32.866	0.43	22.0	22.8	23.6
Misurata	20.3	Te = 0.0272 (year) - 33.711	0.21	21.3	22.1	22.9
Garian	18	Te = 0.0386 (year) - 58.77	0.21	19.4	20.6	21.7
Nalut	19.1	Te = 0.0327 (year) - 46.712	0.34	19.5	20.5	21.5
Region mean	19.7	Te = 0.0327 (year) - 45.344	0.41	21.1	22.1	23.0

Over all the stations in the region the regression analysis shows an increasing trend of temperature for the different temperature parameters (minimum, maximum and mean) but it is a bit greater for max than min. The mean of the whole period shows an increasing trend with the time as shown in figure3.

Mean annual air temperature index

The mean annual air temperature index has been derived from the average of the mean annual temperatures for six station records, with the warmest year within the 1990decade where the warmest year is 1999 (in contrast to the global year 1998). The decade beginning 1990 has been the warmest decade in the instrumental records for the region. Over the whole period there has been an increasing trend this is comparable to the global pattern, which was revealed as shown in figure4.

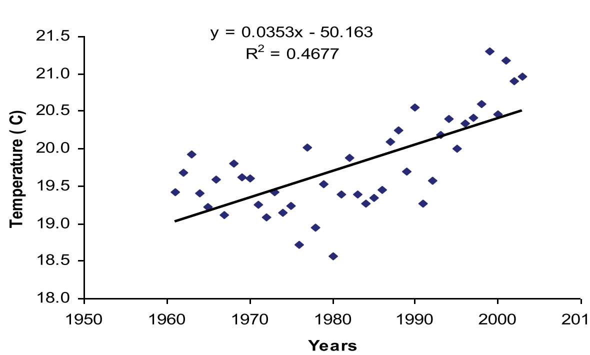

Figure 3 Relation between temperaturesandtime in the western zone of Libya.

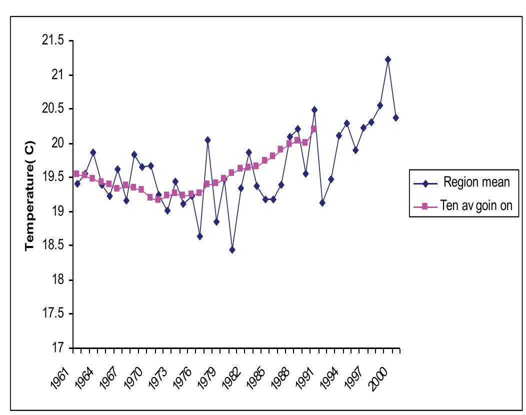

Figure 4. Mean annual air temperature index. 1961-2003 (tenyear movingaverage).

Region air temperature anomaly

Figure 5 shows an air temperature anomaly for the region based on data for these six stations. This is based on the calculation of an annual anomaly, from the based period 1961-2003, average to give a western zone region anomaly. The most of years before 1978, slightly decreasing 1978 and three years after above average in (terms of 1961-2003 mean), since 1993 warming is continuing to the end of the series. There is variation in temperature from year to year up to 1993 where rapid warming is apparent since then. 1999 was the warmest of the past century on the index with+1.65 ◦C greater than the normal, where 1998 is the warmest year global anomaly +0.58. The ten year average for first decade below average the next two decades is almost the equal to mean. The last decade is above of the mean, while ten years average going on is below the average up to 1983. In 1983 it started going up of the mean. The ten years going on average line start with decreasing trend up to the mid-1970, after that the trend started to increase even it was below the average.

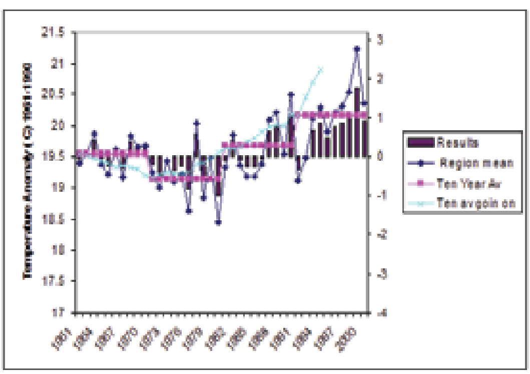

Figure 5.Regional temperature anomaly, from 1961-2003 mean (10years average, 10-year moving average).

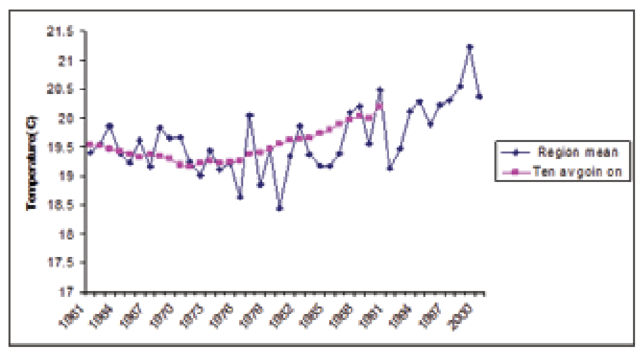

Figure 6. Annual mean air temperature index, 1961-2003(10-year moving average).

Region station air temperature index 19611990-

Figure 6.displays an Index derived from mean annual temperature for 5 stations in the region averaged for each year, and also the 10-year moving on average for these data. The index is considered representative for the western zone region, as the stations are dispersed throughout the region.The decade beginning 1990 has been the warmest decade in the instrument record for the region. This is comparable to the global pattern, which revealed a 0.6 °C increase.

Reference Evapotranspiration results

(ETo) for the whole period (1961-2000) were calculated. The regression analysis shows an increasing trend of reference evapotranspiration(ETo) with the time as shown in the Figure.7.

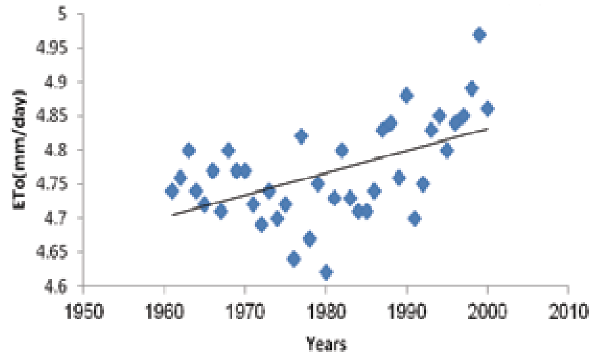

Figure 7. Linear regression showing the reference evapotranspiration ETo trend line for the whole region.

Table2.showsmeanannualtemperatureandmeanannualreferenceevapotranspirationETo for the five stations in the western region of Libya and the mean of them for the whole region and the expected temperature and crop water requirement ETo for the mid of years of short, midandlongtermofthefutureasthetemperatureincreasethereferenceevapotranspirationETo will be increased too.

Table 2 Recent mean Temperature and reference evapotranspirationand expected temperature and reference evapotranspiration for the mid of years of short, mid and long term future.

Station	Recent		Short term 2025		Medium term 2055		Long term 2085	
	T ◦C	ETo	T ◦C	ETo	T ◦C	ETo	T ◦C	ETo
Tripoli city	20.8	4.9	22.3	5.11	22.3	5.11	24.5	5.40
Tripoli Airport	20.5	4.92	22.0	5.07	22.0	5.07	23.6	5.28
Misurata	20.3	4.85	21.3	4.98	22.1	5.09	22.9	5.19
Garian	18	4.56	19.4	4.74	20.6	4.89	21.7	5.03
Nalut	19.1	4.7	19.5	4.75	20.5	4.88	21.5	5.01
Region mean	19.7	4.78	21.1	4.96	22.1	5.09	23.0	5.20

Conclusion

Libya is located in driest and the semi driest regions in the world, therefore the climate change research should be the main research issue. The area of study is located in the north westernregion of Libya. The results show that the annual mean temperature for all the stations in the region show an increasing trend. The regression equation shows increasing trends for the mean of the region and the expected temperature for the mid of years of short, mid and long term of the future which are within the expected rise in global temperatures of between 1.4 and 5.5°C by the end of the 21sh century. The decade beginning 1990 has been the warmest decade where the warmest year is 1999 (in contrast to the global year 1998) in the instrument record for the region.The regression analysis shows an increasing trend of reference evapotranspiration with time.

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المجلة الليبية للعلوم الزراعية
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ورقة أصيلة

الحرارة كمؤشر للتغير المناخي والبخرنتح المرجعي في المنطقة الغربية من ليبيا

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المستخلص

التغير المناخي من أهم المواضيع البحثية على مستوى العالم كله،والتدفئةأهم مظهر للتغير المناخي؛ لذا فإن الحرارة من أهم مؤشرات التغير المناخي. وليبيا تقع ضمن نطاق الدول الجافة وشبه الجافة في العالم، وعلى ذلك يجب أن يكون التغير المناخي من أهم مواضيع البحث العلمي . تقع منطقة الدراسة في الشمال الغربي من ليبيا؛ حيث يتركز معظم السكان،وتم الحصول على بيانات درجة الحرارة لفترات طويلة من محطات الرصد الجوي في المنطقة الغربية من المركز الوطني الليبي للأرصاد الجوية . ولتمثيل منطقة الساحل وسهل الجفارة من الشرق إلى الغرب تم الحصول على بيانات درجة الحرارة من محطات: (مصراته – طرابلس – مطار طرابلس)، بالإضافة الى زوارة،ولتمثيل منطقة جبل نفوسة تم الحصول على بيانات درجة الحرارة من محطتي: (غريان – ونالوت)، هذه المحطات ستعطي تمثيلاجيدا للمنطقة ككل؛ حيث تتوزع على المنطقة بشكل كامل والبيانات المتحصل عليها من المركز 1960 – 2003.تعد البيانات التاريخية للمنطقة وتمثيل قاعدة البيانات الأساسية للدراسة وللتنبؤ بدرجة الحرارة في المستقبل القريب 2010 – 2040 والمستقبل المتوسط 2040 – 2070 والمستقبل البعيد 2070 – 2100،أظهرتحليل الانحدار لمتوسط درجة الحرارة للمنطقة للفترةمن 1960 – 2003 اتجاه تزايدي،كما أظهر اتجاه تزايدي لدرجة الحرارة في متوسط كل محطات المنطقة، وكان ضمن التزايد المتوقع على مستوى العالم من 1.4 °م و5.5 °م بنهاية القرن الحادي والعشرين. وأن عقد التسعينات، كان أدفئ عقد، وأن أدفئ سنة كانت 1999، في حين كانت أدفئ سنة 1998 على مستوى العالم. أظهرت نتائج تحليل الانحدارللبخرنتح المرجعي للنباتات اتجاهاً تزايدياً مع الزمن..

الكلمات الدالة: التغير المناخي، الحرارة،مؤشرات التغيرالمناخي. البخرنتح المرجعي.

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