ÇUKUROVA UNIVERSITY
INSTITUTE OF NATURAL AND APPLIED SCIENCES

MSc THESIS

Soidri BOURHANE AHMED

TREND ANALYSIS OF CLIMATE PARAMETERS IN GRAND-COMOROS

DEPARTMENT OF AGRICULTURAL STRUCTURES AND IRRIGATION

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We certify that the thesis titled above was reviewed and approved for the award of degree of the Master of Science by the board of jury on ….../..…./2018.

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ABSTRACT

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This thesis identifies the correlations and the trends of change in precipitation, maximum temperature, average temperature and minimum temperature (monthly data) in Grand-Comoros during 1982-2013 from one station. The procedure utilizes the Spearman's rho correlation non-parametric test to detect statistically correlations, the Mann-Kendall non-parametric test to determine statistically significant ($p<0.05$) trends and Sen's slope estimator to detect the magnitude of the change to measure the correlation of climate parameters. The application of correlation detection model has yielded the identification of precipitation: 72 positive and 60 negative correlations, of maximum temperature: 100 positive and 32 negative correlations, of average temperature: 128 positive and 4 negative correlations and of minimum temperature: 124 positive and 8 negative correlations. The application of the trend detection technique to precipitation has not yielded any significant increasing and decreasing trends; to maximum temperature has offered significant increasing trends of the months with the average magnitude of 2.08, 1.99, 2.04 and 2.12 °C; to average temperature has showed significant increasing trends of the months with the average magnitude of 1.54 and 1.57 °C and to minimum temperature has yielded significant increasing trends of the months with the average magnitude of 2.99, 1.50, 2.97, 1.99 and 1.79 °C during a period of 32 years. The trend rate obtained shows 83.3% for increasing trends and 16.7% for decreasing trends.

Keywords: Grand-Comoros, Climate-parameter, Monthly, Statistical, Analysis

ÖZ

YÜKSEK LİSANS TEZİ

GRAN-KOMORDAKİ İKLİM PARAMETRELERİNİN TREND ANALİZİ

Soidri BOURHANE AHMED

ÇUKUROVA ÜNİVERSİTESİ
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Bu tez, 1982-2013 yılları arasında, yağış, maksimum sıcaklık, ortalama sıcaklık ve minimum sıcaklık dahil olmak üzere bir istasyondan aylık verileri kullanarak, Grand-Komorlar'daki iklim parametrelerindeki değişimin korelasyonlarını ve eğilimlerini tanımlamaktadir. Istatistiksel olarak pozitif ve/veya negatif korelasyonları saptamak için Spearman'ın rho korelasyon parametrik olmayan testi, istatistiksel olarak anlamlı ($p <0.05$) eğilimleri belirlemek için Mann-Kendall parametrik olmayan test ve Sen'in eğim tahmincisi değişimin büyüklüğünü tespit etmek için ve Pearson'un katsayısı iklim indislerin korelasyonu ölçmek için prosedürler kullanılır. Korelasyon tespit modelinin uygulanması, yağışların tanımlanmasını sağlamıştır: 72 pozitif korelasyon ve 60 negatif korelasyon, maksimum sıcaklık 100 pozitif korelasyon ve 32 negatif korelasyon, ortalama sıcaklık 128 pozitif korelasyon ve 4 negatif korelasyon ve minimum sıcaklık 124 pozitif korelasyon ve 8 negatif korelasyon. Eğilim algılama tekniğinin yağışa uygulanması, tüm aylar için önemli ölçüde artan ve azalan eğilimlerin belirlenmesini sağlamamıştır; maksimum sıcaklığa, ortalama 2.08, 1.99, 2.04 ve 2.12 °C büyüklüğündeki önemli artış trendlerinin belirlenmesi önerilmiştir; ortalama sıcaklığa göre, ayların önemli ölçüde artan eğilimlerinin ortalama büyüklüğü ile 1.54 ve 1.57 °C ve minimum sıcaklık, 32 yıllık bir süre boyunca ortalama 2.99, 1.50, 2.97, 1.99 ve 1.79 °C ortalama büyüklükteki ayların önemli artış eğilimlerinin tanımlanmasını sağlamıştır. Böylece, elde edilen trend, artan trendleri için %83,3 ve trendlerin azalması için %16,7'dir.

Anahtar Kelimeler: Büyük-Komor, İklim-Parametre, Aylık, İstatistiksel, Analiz

EXTENDED ABSTRACT

Climate is an important and important factor in maintaining a better environment, good agriculture and other sectors. Variations in rainfall and temperature significantly affect and have direct impacts on water level and water regime, quality and quantity of agricultural production but also on evapotranspiration and other factors. Fu et al. (2004) reported that land use/land cover change, including agricultural activities, deforestation/forestation, urbanization and road building with effects that may outweigh any climatic trends are one of the major factors resulting in the observed runoff reduction.

Reported by IPCC (2007) also that a positive trend around south-eastern Namibia and the coast of Mozambique was registered. For surface temperature, positive trends occur over almost the entire study area, with relatively strong signals over the western part of the continent from Namibia to Angola. In the eastern coastal area of Madagascar, after the early 1990s, rainfall amounts decreased from 15ºS to 25ºS, with the southern area experiencing a particularly large reduction of rainfall bands. These results suggest that the recent trends of decreasing rainfall in areas north of 20ºS reflected an abrupt change around the early 1990s rather than a gradual trend.Different studies world over on trend of climate and hydro-meteorological sciences point towards fluctuations in various parameters like precipitation, temperature leading to alternate cycles of flood and drought conditions (Kharmeshu, 2012). For the statistical study, there are two methods including the parametric method and the non-parametric method for the detection of trends. The use of the three statistical analyzes will make it possible to diversify the climatic parameter trends and to enrich our interesting work. Moving averages have used for missing data.

According to various studies on trend analysis, non-parametric methods are the many usually used, Mann-Kendall test (Mann, 1945 and Kendall, 1975) is one of the best methods amongst them, which is preferred by various scientifical studies (Douglas et al, 2000; Yue et al., 2003; Jain and Kumar, 2012). Mann-Kendall test is used for analysis and ascertains statistical significance by hypothesis test of hydrological variables (Yue et al, 2003). The advantages of the Mann-Kendall test are that it does not require that datasets follow normal distribution and show homogeneity in variance; transformations are not basically required if data already follows normal distribution, in skewed distribution greater power is achieved (Duhan and Pandey, 2013). Mann-Kendall test also discusses about function of slope in the trend, coefficient of variation, and type of probability distribution (Yue et al, 2002a). Mann-Kendall test is used for trend analysis as it eliminates the effect of serial dependence on auto-correlated data which modifies the variance in datasets (Hamed and Rao, 1998). To analyse the magnitude of trend in the series, Sen's slope estimation, non-parametric, (Sen, 1968) method is used. This method assumes the trend line is a linear function in the time series (Jain and Kumar, 2012). In Sen's slope model, the slope value shows the rise and fall of the variable (Jain and Kumar, 2012). Another advantage of using Sen's slope is that it is not affected when outliers and single data errors are present in the dataset (Salmi et al, 2002). Rupa Kumar et al, (1992) analyze trend for north-east India, north-west and north-east peninsular India and have found that the trend has decreased for monsoon period; they used 100 years dataset of this region.

The results of Mann-Kendall test for monthly precipitation data shown that there is a significant decrease in trend for the month of January for Dehragopipur and Kangra stations which were located at lower altitude in Kangra district while the other two stations located at high elevation had no significant trend for the month of January, even though the trend was falling across the entire district for the month of Jamuary. The first monsoon month of June shown a rise in trend across all stations with Dharamshala located at a high altitude, shown a significant increasing trend at 0.05 levels of significance. The following monsoon months of July, August and September shown fall in trend across the entire district, however, these were not significant except for Dharamshala which shown a significant decrease in trend at 0.01 levels of significance for the month of August, Sen's slope magnitude was also large corresponding to the falling trend. The month of October too shown a falling trend across all stations for the data set used, however significant falling trend was founded at 0.05 levels for Kangra station only. Though Palampur follows rainfall pattern similar to Dharamshala, no significant trend was founded at 0.05 and 0.10 level of significance for any month.

Ülker G. B. and Ahmet Tanrıkulu, (2017) studied trends analysis of evaporation data in Aegean Region of monthly evaporation data which belongs to 25 stations. According to the results of the Mann-Kendall and Sen's Slope tests, 12% decrease and 24% increase of trend in seasonal evaporation was determined during summer months. Monthly evaporation evaluation shown continuity an increasing trend had been observed in Kuşadası, Bornova, Gediz and Bolvadin stations. The trend duration varied from 3 to 7 months. Decreasing trend had been observed in Muğla, D. Manisa, Aydın, Tavşanlı and İzmir stations.

Found statistically significant decrease in one station compared to Spearman rank correlation and Mann-Kendall tests applied to 3 stations with 20-25 years installed in the Van Lake Closed Area, while the decrease in the other two was not significant (Topaloğlu et al. 1997). Applied the Spearman rank correlation test to the annual maximum instantaneous data (n=15-56 years) of 13 stations located in the Seyhan river basin and did not find any significant flow in the currents. However, a trend in the direction of decrease in the basin currents was found (8 stations) in general (Topaloğlu 1999).

Nitin Mishra et al., (2014) by using Mann-Kendall and Sen's Slope Estimator for the determination of the temperature trend analysis of air temperature time series of Upper Ganga Canal Command (1901-2002). The results founded shown that generally trend for Pre-Monsoon is increasing in Saharanpur. From the analysis of both maximum and minimum temperatures, it was found that they both follow the same trend. From the monsoon season, the trend is decreasing, while all other months shown an increasing trend. Annual trend was increasing in all conditions.

Milan Gocic and Slavisa Trajkovic (2012), by using Mann-Kendall test and Sen's slope estimator were applied to the time-series 1980–2010 for the seven meteorological variables: T_{min}, T_{max}, RH_{min}, RH_{max}, e_a, U_2 and P. Results of the applied Mann-Kendall and Sen's slope estimator statistical tests for seasonal and annual RH_{max} over the period 1980–2010 shown, the majority of the trends in the annual RH_{max} series were not significant, while the significant decreasing trend was found only at the Negotin station. However, the negative RH_{max} trends were significant at the 1% and 5% significance levels according to the statistical tests in the spring, summer, autumn and winter seasons in about 16.67%, 41.67%, 16.67% and 8.33% of the stations, respectively. On the contrary, no significant trends were detected at Loznica, Nis, Novi Sad and Vranje in all seasons.

The results obtained with the Spearman rho correlation test show between precipitation more positive correlations and negative correlations. The maximum temperature and average temperature showed more non-significant positive correlations than all the other correlations. But it is minimum temperature that has shown a lot of positive and very significant correlations. Seasonally and annually, as many positive and negative correlations, significant and non-significant were obtained between the parameters. For Mann-Kendall and Sen's Slope Estimator trend analysis results, these two non-parametric methods showed on both sides a great similarity of trends in climatic parameters. Precipitation did not give very significant increasing trends against minimum temperature, has largely shown very significant increasing trends and maximum temperature with increasing trends that are highly significant compared of average temperature. The statistical study of Grand-Comoros climate data for the peridode 1982-2013, the results of the Man-Kendall test gave of the trend rate 83.3% for increasing trends and 16.7% for decreasing trends.

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CONTENTS **PAGE**

ABSTRACT I
ÖZ II
EXTENDED ABSTRACT III
ACKNOWLODGEMENT VII
CONTENTS VIII
LIST OF TABLES X
LIST OF FIGURES XII
LIST OF ABBREVIATIONS XIV
1. INTRODUCTION 1
2. OBJECTIVES 3
3. LITERATURE REVIEW 5
4. AREA OF STUDY, DATA AND METHODS 19
4.1. Area of study 19
4.2. Data 21
4.3. Methods 25
4.3.1. Moving averages 25
4.3.2. Spearman's rho Correlation Test. 26
4.3.3. Mann-Kendall and Sen's Slope Estimator tests 27
5. RESULTS AND DISCUSSIONS 31
5.1. Results of Spearman's rho Correlation Test. 32
5.1.1. Correlation results of precipitation 32
5.1.2. Correlation results of maximum temperature 35
5.1.3. Correlation results of average temperature 39
5.1.4. Correlation results for minimum temperature 43
5.1.5. Seasonal correlation results between all parameters 47
5.1.6. Annual correlation results between all parameters 51
5.2. Results of Mann-Kendall Test and Sen's Slope Estimator Tests 51

6. CONCLUSION AND RECOMMENDATIONS 59
REFERENCES 63
BIOGRAPHY 73

LIST OF TABLES **PAGE**

Table 4.1. Monthly Precipitation data (NACAM, 2016).. 21
Table 4.2. Monthly Maximum Temperature data (NACAM, 2016)...................... 22
Table 4.3. Monthly Average Temperatures data (NACAM, 2016)........................ 23
Table 4.4. Monthly Minimum temperatures data (NACAM, 2016)....................... 24
Table 5.1. Correlation results between precipitations 33
Table 5.2. Correlation results between maximum temperatures 36
Table 5. 3. Correlation results between average temperatures 40
Table 5. 4. Correlation results between minimum temperatures 44
Table 5.5. Seasonal correlations of precipitation and maximum temperature........ 48
Table 5.6. Annual correlation results between all parameters................................ 51
Table 5.7. Results of Mann-Kendall and Sen’s Slope Estimator Tests 52

LIST OF FIGURES **PAGE**

Figure 4.1. Map of Grand-Comoros Island (NAPA, 2006) 20
Figure 5.1. Trends for Mann-Kendall and Sen’s Slope 53
Figure 5.2. Mann-Kendalla and Sen's Slope trends of precipitation 56
Figure 5.3. Mann-Kendalla and Sen's Slope trends of maximum temperature 56
Figure 5.4. Mann-Kendalla and Sen's Slope trends of average temperature 57
Figure 5.5. Mann-Kendalla and Sen's Slope trends of minimum temperatur......... 57

LIST OF ABBREVIATIONS

EM	:	Expectation Maximization
EPA QA/G	:	Environmental Protection Agency Guidance for Quality
GCM	:	General circulation model
IMD	:	India Meteorological department
IOC	:	Intergovernmental Oceanographic Commission
IPCC	:	Intergovernmental Panel on Climate Change
KZN	:	Kwa Zulu-Natal
LR model	:	Likelihood-ratio test
MK	:	Mann–Kendall
NACAM	:	National Agency of Civil Aviation and Meteorology
NAPA	:	National Action Programme of Adaptation to climate change
NOA	:	National Observatory of Athens
SVD	:	Singular Value Decomposition analysis
TSMS	:	Turkish State Meteorological Service
USA	:	United States of America
USSR	:	Union of Soviet Socialist Republics

1. INTRODUCTION

The challenge of climate change is important because the consequences are observed all over the world and these effects are not reduced at all despite the various struggles against global warming (Hughes et al. 2005). Industrialization especially and other human activities significantly cause the problem composition of the atmosphere since the climate changes from the natural state to the artificial state. These climatic variations provoked, transform themselves into one of the most thoughtful appearances of the climate (Mitchell et al., 1966; Karl, 1988; Dickinson, 1989; Balling, 1992). Given that, the Indian Ocean occupies an important place among the places most affected by the negative effects of climate change; these Islands are among the first victims of external shocks that result: increasing temperatures and sea levels, more frequent natural disasters and more intense, food safety and energy dependence, erosion, destruction of ecosystems (IOC, 2015). Faced with these dramatic consequences variables related to climate change, Grand-Comoros is also increasingly threatened.

By definition, Olaniran (1991) defines a climate trend as either a steady increase or decrease in the mean value between the moment of departure and the end of a series of events. However, as Mitchell et al. (1966), trends in climate study are for the most part distorted. Even if the trend is continue, the linear regression method is not the reassuring instrument to take position where this trend takes its starting point.

As any study of climate change in a given region, it depends on climate data. In the case of the Grand-Comoros, the study will also depend on the dataset collected monthly over the last three decades (198-2013), of which in some periods there are missing data. This leads us to apply the method of technical analysis of the moving average to complete the missing data. In this study the fundamental purpose of this study is to determine increasing or decreasing in trends during this period of 32 years by using Mann-Kendall Test and Sen's Slope Estimator and

Spearman's Correlation that is a non-parametric test to measure the strength of association between two variables, where the value r = 1 means a perfect positive correlation and the value r = -1 means a perfect negative correlation on the data of the various climatic parameters collected in the Grand-Comoros for the period from 1982 to 2013. The results that will be obtained will allow a better follow-up climate change and allow for good management of the trends that will be observed during the four seasons of the last 32 years.

2. OBJECTIVES

This work on trend analysis of climate parameters in Grand-Comoros, is a work that is of paramount importance of climate change in Comoros because it occupies an important place. With its scientific characteristics, such a model of study is very little realized. It is noted that a few ministerial reports and some competent services that are not so focused in a strictly scientific but limited way given the inadequacy of major national researchers especially. But not everything is overwhelming because in the main meteorological service of the Grand-Comoros, specialized statistical agents evaluate and analyze all the climatic data collected in their various stations for close monitoring of climate change. Thus, in this part, the objectives that mentioned in this study will lead this work so that the results that will be obtained, will in turn contribute to the awareness of each party taking in the fight against global warming.

The objectives set throughout this work are the following:

1. To analyze correlations and trends between the different climate data from 1982 to 2013 to determine increasing or decreasing and significance.
2. To provide knowledge to different public and private services for a better understanding of the climate change evolution and developing better adaptation strategies in Comoros.
3. To determine the trend rate.

3. LITERATURE REVIEW

Throughout this chapter "literature review" will enrich it while reporting as many previous scientific researches similar with our subject of studies already carried out by other researchers from all the different study areas in the world. This part will give us more learning in direct relation with our subject who all these contributions will help to better define the own study and better frame the methodology of approach to deduce effectively expected results. To make a research study in the field of climate change as broad with different statistical methods, in this case it focus specifically on precipitation and different temperatures with Spearman's rho Correlation that is a non-parametric test, the Mann-Kendall and Sen's Slope Estimator tests which are our statistical methods for climatic data of Grand-Comoros.

As a reminder, for a good statistical analysis study for the detection of climate data trends, it should be remembered that reliable measurements of climate data constitute the essential basis of quantitative climate analyzes. Unfortunately, several conditions and factors affect the quality of climate data and these factors must be understood and taken into account for both scientific and climate analyzes. Although universally accepted standards exist for the installation and observation of tools, measurement practices and instruments may differ from one station to another in a given area, region or country even though there may be have changes in a punctual station. As a result, variations in station time series are caused by these factors.

The choice to use Spearman’s rho correlation, Man-Kendall test and Sen’s Slope Estimator, they are effective and approved by so many scientists who have used it in their previous and current studies. Several and diverse studies on trend analysis leave a wide choice between parametric methods and nonparametric methods. Many have chosen the non-parametric methods of which they are mainly used, the Mann-Kendall test (Mann, 1945 and Kendall, 1975) is one of the best methods among them, which is opted by many researchers (Douglas et al., 2000; Yue et al., 2002; Jain and Kumar, 2012). For a good choice of using the Mann-Kendall test, Duhan and Pandey (2013) demonstrated that this Mann-Kendall test has advantages that do not require normal distribution and homogeneity of the variance to be shown by datasets and should not follow that as much; variations are not necessarily required if the data have a normal distribution, in the case of asymmetric distribution, more power is obtained. The Mann-Kendall Test is widely used in different trend analyzes. It also applies to the function of the slope in the trend, the coefficient of variation, and the type of possibility assignment (Yue et al., 2002). This test is used for the analysis of statistical trends since it eliminates the effect of series dependence on self-correlated data that changes the variance in datasets (Hamed and Rao, 1998).

For monotonous increasing or decreasing trends with the non-parametric Mann-Kendall test and Sen's method for slope estimator, both methods the Mann-Kendall test is suitable for cases with monotonous trends and no seasonal or other cycles in the data. One advantage of this test is that the data need not conform to any particular distribution. The second advantage of the test is its low sensitivity to abrupt breaks due to inhomogeneous time series (Tabari et al. 2011). Sen's method uses a linear model to estimate the slope of the trend and the variance of the residuals should be constant in time (Salmi et al. 2002). By Mann-Kendall test, it wants to test the null hypothesis. H_0 of no trend, i.e. the observations xi are randomly ordered in time, against the alternative hypothesis, H_1, where there is an increasing or decreasing monotonic trend. The data values are evaluated as an ordered time series. Each data value is compared with all subsequent data values. If a data value from a later time period is higher than a data value from an earlier time period, the statistic S is incremented by 1. On the other hand, if the data value from a later time period is lower than a data value sampled earlier, S is decremented by 1. The net result of all such increments and decrements yields the final value of S (Shahid 2011).

Rainfall is a key characteristic of any watershed which plays a significant role in flood frequency, flood control studies and water planning and management.

Throughout the world, in the United States as in the rest of the other continents, the consequences of climate change on several areas such as hydrology, watersheds and the environment have been studied during recent times (Jha et al., 2004; 2006; Jha and Gassman, 2013; Takle et al., 2005; 2010).

So, it is to know that precipitation is one of the main climate factors that touch and have impacts on spatial and temporal patterns of water availability. One of the challenges posed by climate change or variation is to conduct a series of studies that focus on identifying and quantifying rainfall trends and their implications for river flow in order to achieve the formulation of adaptation policies (De Luis et al., 2000).

Several research studies on trend detection have been conducted in several regions of the world by different scientists, with the main goal being to identify when the climate has undergone a remarkable change. Many of these researches that have been conducted, those of the past 40 years their trend results were significant (Karl et al., 1993).

In articles published by Folland et al., (1992) and Srikanthan and Stewart (1991), they stated from their well-known scientific work that most regional rainfall time series experienced variations at different levels over time, rather than such a long trend or significant. Nevertheless, other scientists have proved with their studies that there are also in some parts of the world ever-decreasing trends. Other studies conducted in Africa, Nicholson and Palao (1993), in the Sahel for West Africa, have indicated that the series of precipitation indicate a rather prolonged downward trend from the year 1950, including the great drought period from 1968 to 1990.

In Turkey, Kadıoğlu (1993), using monthly rainfall data from 18 stations for the period 1929-1990, showed that for precipitation, there was a decrease in winters everywhere and an increase in spring. Özgürel and Koçman (1994) who focused on the Aegean region analyzed rainfall data and showed that annual and monthly precipitation was well below normal in 1989 and the years that followed. They concluded that drought-affected areas were spreading from the Aegean coasts inland during this period and suggested that cloud seeding in the area could promote other precipitations and drought in the short term. Using data from 68 stations for the period 1930-1992, Toros et al., (1994) examined these seasonal and annual precipitation data for western Anatolia and observed a decrease in precipitation after 1982. They concluded: this decrease was not due to climate change, but was only evidence of a change in precipitation.

In studies conducted by Topaloğlu et al., (1997), with both Spearman's and Mann-Kendall tests, they showed that annual instantaneous maximum flows (AIMF) of one streamflow station among 3 stations (n= 20-25 years) in Lake Van Closed basin near Iranian border exhibited a decreasing trend. Again in another study conducted on Seyhan river basin, Topaloğlu (1999) analyzed AIMF data from 13 stations (n=15-56 years), and a no evidence of significant trend was founded. Similarly, no significant changes were founded for AIMF data of 9 stations (n=14-29 years) in Central Anatolian Closed basin according to Spearman's correlation test (Topaloğlu, et al., 1999).

Önöz and Bayazıt (2003), compared the power of the parametric *t*-test and the nonparametric Mann-Kendall test using annual streamflow at 107 sites of study (n=25-65 years) in Turkey. Both tests detected a decreasing trend in different 29 series which are mostly identical. Recently, Kahya and Kalaycı (2004), for 56 stations based on the Mann-Kendall test using 31 year period (1964-1994) and a falling tendency was observed of monthly mean streamflows of 83 sites of study in Turkey. With serial correlation and cross-correlation for annual and monthly streamflows among 75 sites over Turkey at the national scale, recently Topaloğlu (2006) studied regional significance of trends and found only significant decreasing and no trends rather than upward trends for all streamflow variables.

However, the amount of precipitation that falls each month has not been the same over the years and this quantity varied greatly from year to year. Joshi and Pandey (2011) showed no tendency of annual rainfall over the entire Indian territory and specific Indian regions for a 100-year study period (1901-2000). Scientifically, in India it has been approved that there is a change in the monsoon season, and compared to what is currently thought, is not easy to prejudge the really season of the monsoon (Parthasarathy et al., 1988; Ramanathan et al., 2005; Auffhammer et al., 2006). Always in India, climatic parameter studies such as time series of annual precipitation have been studied statistically and trends have been analyzed annually and seasonally. Different statistical methods were used by Duhan and Pandey (2013) to identify hydrometeorological time series; during their study, they used a statistical analysis of the long-term temporal and spatial tendencies of precipitation data collected at Madhya Pradesh (India) stations in the period from 1901 to 2002. Afterwards, they were able to identify that precipitation fell throughout this region and 1978 was the most likely period of change for precipitation.

Rupa Kumar et al. (1992) used 100 years of data and they analyzed the trend for different parts of India: in northeastern India, in northwestern and northeastern peninsular India, and the analysis shows that the trend has the monsoon period. As for Kumar and Jain (2011) in 15 basins in 22 basins in India, they observed their trend and noted a downward trend in annual rainfall and rainy periods. Knowing that trend analysis of rainfall is an important element for studies of the hydrological system, and even bringing together recent studies, they conclude that there is real proof that rainfall is falling in Asia (Sinha Ray and Srivastava, 1999, Khan et al., 2000, Shrestha et al., 2000, Mirza, 2002, Lal, 2003, Min et al., 2003, Goswami et al., 2006, Dash et al., 2007).

Arijit Ganguly et al., (2015) they using Mann-Kendall test and Sen’s slope estimator to analyse the data for the period 1950-2005, to determine the trend in mean monthly precipitation data and mean seasonal. The results of monthly trend in precipitation shown deacresing trend for the months of July, August, September and October in all the rain gauge stations. However, they indicate that the falling trend is significant for the month of August for Dharamshala (0.05 level of significance). Interestingly the month of June shown rising trend of rainfall in all the stations, however, at Dharamshala the trend was significant (0.01 level of significance). Trend analysis for annual rainfall data shown significant deacresing trend for Dharamshala.

Rahman A. and Begum M. (2013) by using Mann-Kendall and Sen’s slope estimator for rainfall trend detection from 1966 to 2011 (45 years) from January to December along with its slope magnitude were found. Slopes were founded using both these methods and were compared. The result was quiet significant as the months where Mann-Kendall shown negative trend similar negative slopes also showed by Sen’s slope method.

Several different studies of global surface air temperature data have shown that the raising the temperature of the globe in recent decades is particularly related to the increase in minimum daily temperatures rather than daily maximum temperatures. The Report of Fourth Assessment of the IPCC (2007) shown that the global mean surface air temperature increased by 0.74 ºC while the global mean sea surface temperature rose by 0.67 ºC over the last century.

Osborn et al., (2000) and Ventura et al., (2002) concluded that with the study of trends and different temperatures effectively allows programming and orientation a better way to manage the water resources of a region. And they also add that several recent studies on climate trends have shown that the trend of climatic parameters observed is a complex work with regard to the climatic environment, the importance of rainfall and the season which are unstable.

In the case of trend analysis for temperature parameters, different methods and techniques, such as parametric and non-parametric tests, are also used to test to identify statistically significant trends or not during observational studies. The choice between parametric and non-parametric statistical methods, many scientists use for the most part the Mann-Kendall test which is non-parametric. Regarding to the Mann-Kendall monotonic trend test, the most level of temperature examination bring about in a global warming trend while the minimum mean temperature recorded cooling trend (Birhanu Hayelom et al., 2017).

In the cases of Jones and Jiusto (1980) as well as Solow (1987) all of them analyzed instrumental data to locate climatic trends in previous studies, and mainly they used parametric statistical methods, such as the moving average and linear regression methods, as well as two-phase regression models. As for parametric methods, they require the assumption of a normal distribution. Sneyers R. (1990) among others he mentioned the constraints of statistical methods of detection of climate change. He argues that parametric methods are based on the hypothesis of independent observations and can not be considered for correlated sequences. Then, trend analysis tests by non-parametric methods, such as those based on order rather than by variation of observations, do not depend on the correlation structure. And, like the Mann-Kendall statistic, departure from a normal Gaussian frequency distribution is not a concern (Mitchell et al., 1966, Sneyers R., 1990).

Jain and Kumar (2012) by using also Mann-Kendall, Regression and Sen's slope method for trend analysis of rainfall and temperature data for India. The results founded shown trend or temporal variation of annual rainfall, rainy days and temperature for basins. In the magnitude of trend is obtained using either regression or Sen's slope method.

He Y. et.al (2013) analyzed the trend of natural illuminance levels in 14 Chinese cities by Mann-Kendall trend analysis method withe data were collected from Meteorological center of China. These data considered for includes annual total light natural light illuminance or sun shine hours, cloud cover, aerosol, solar activity, water vapour values. Mann-Kendall method applied on annual light illuminance data and the result shown that some cities have a significantly trend. Reason for the decreasing trend was also discussed as due to increase in cloud cover, water vapour, aerosol and solar activity.

According to studies conducted by Karl et al., (1991) on both sides by Folland et al. (1992), they concluded that an increase in nighttime temperatures was most visible in different parts of the world as in the United States, the former USSR, China and Australia. And they consider that the marked increase in overnight temperatures may be due to the combination of high concentrations of anthropogenic greenhouse gases, increased cloud cover and urbanization. According to Balling (1992), actual analyzes have often been directly correlated with the greenhouse effect, the raising the temperature of the globe, urban heat islands, and aerosols that exert cooling effects on the climate. And also according to Changnon (1992), the effects generated by urbanization on temperatures and precipitation have also been widely discussed in different scientific studies.

In India, daily maximum and minimum temperature data collected in the period 1969-2009, and precipitation data for the period 1971-2010 (precipitation and temperature, collected by IMD, in the region of Pune) were studied and analyzed. To obtain seasonal variations in temperature and precipitation at Sangamner, moving point averages (3 points) were developed. Mann-Kendall statistical test was used to evaluate the trend of the time series (Yue, et al., 2002, Mondal et al., 2012**,** Jain et al., 2012). Pre whitened Mann-Kendall test has been applied where high values of autocorrelation were obtained. The confirmation of auto correlation alters the variance of the estimate of Mann-Kendall test and increases the percentage of rejecting the no-trend hypothesis; it can lead to trends to be detected that would not be observed significant if the series were independent (Bayazit et al., 2007).

Yunling and Yiping (2005) conducted climate change trends and characteristics of monthly air temperature and precipitation data series for 19 stations along the Lancang River (China) during 1960-2000; they found increases in temperature and decreases in precipitation.

For Istanbul, from 1975 to 2006, Karaburun et al. (2011) by using Mann-Kendall test and Sen's Slope method they studied three different variables for the evolution of annual, seasonal and monthly mean, minimum and maximum temperatures.

By ElNesr et al. (2010) temperature changes in the Kingdom of Saudi Arabia for 29 years using data obtained from 29 meteorological stations were investigated. They found a warming trend in the maximum, minimum and average temperatures throughout the year and except in the winter months of November to January they observed non-significant cooling trends.

Nasrallah and Balling (1993) and Jones et al., (1986) in their trend studies using the grid data set, they found that the anomalies that are related to the average monthly temperature of the Middle East region showed a significant trend towards global warming. According to the results, they concluded that most of the increase occurred in March-May, although moderate warmings occurred during June-August and during September-November. Their results indicate that Turkey, with the highest sulphate levels, had cooling trends in the west with -0.06 °C for 10 years and in the east with -0.08 °C for 10 years.

On the African side, Hughes and Balling (1996) studied the maximum and minimum temperature tendencies for South Africa for the period 1960 to 1990. But also they compared the different results obtained in urban and non-urban areas. The results obtained from maximum temperatures showed a trend, from which temperatures increased by 0.11 °C over ten years and by 0.12 °C over ten years also on average for stations in urban and non-urban areas respectively. On the other hand, for the minimum temperatures, an insignificant trend of 0.07 °C over ten years on average for stations non-urban areas and a significant trend of 0.34 °C over ten years for urban stations were determined.

As for King'uyu et al., (2000), they conducted their trend studies for 71 stations for the period 1939-1992, their studies were based on trends in the data of average minimum and maximum surface temperatures in East Africa, from South Sudan to insert Botswana, Zimbabwe and Mozambique. In the same region of Africa, Unganai (1997) also studied the trends in surface temperature variations in

Zimbabwe, one of the neighbors in northern South Africa, for the period from 1897 to 1993. A. C., Kruger and S., Shongwe (2004) computed trends in average annual maximum temperature data for the 26 stations in South Africa. A total of 23 stations out of 26 gave significant trends, 13 of which are more significant than the others. Depending on the location, the stations with significant trends in mean annual maximum temperature are mainly near the coast, with the exception of Bloemfontein, Polokwane, Upington and Vanwyksvlei. However, plant station trends appear to be higher than those closer to the coast. For the average annual minimum temperatures showed a trend, 18 of them being significant. Four stations had trends but not significant. Stations that did not show significant trends were mainly located in the center of the region, but not all stations located here showed the same tendency.

Türkeş M., et al., (2002) redid trend analyzes of temperature variations by using a recently updated dataset, as well as monthly average mean air temperature data, daily maximum and minimum of Turkey. These different temperature studies during the period 1929-1999, were recorded in TSMS stations. For studies conducted on variations for a long time and trends in temperature data are not common for Turkey. Türkeş M., et al. (1992) analyzed national mean annual temperatures using 1941-1970 (29 years) discharge, and noted that annual temperatures increased by about 0.5 °C from 1930 to 1965. Cooling tendency dominated for the year 1990. Kadioğlu (1993) mentioned significant upward and downward trends in minimum temperatures, using temperature data from 18 stations, particularly during March-May, and trends to lowering of maximum temperatures. Türkeş et al. (1995a) in a recent study, they analyzed the mean annual temperatures of 71 stations by applying non-parametric tests to observe changes and trends. According to the results obtained, they mentioned that there was a decrease in the whole of the studied regions of the average annual temperatures in Turkey. And in the last two decades all coastal regions have been characterized by cooling trends.

Repapis and Philandras (1988) and Philandras (1994) focused in the Eastern Mediterranean region on the study of annual mean air temperature. The results showed that the annual average temperature of the air is at about the same level as in the Northern Hemisphere, from the minimum at the beginning of the 20^{th} century to the heating of 0, 6 °C observed around the middle of the century and then the cooling of the decades of 1960 and 1970, after small variations. The cooling observed during this interval in the northern hemisphere is rapidly reversed and since the beginning of the 1980s the air temperature has exceeded normal temperature levels by the middle of the century. For the eastern Mediterranean, the cooling is stronger, it tends to -0.6 °C and even if it is reversed since the decade of 1980, the last two or three years seem to reach the temperature levels in the mid-century. During the period 1950-1988, Sahsamanoglou and Makrogiannis (1992) provided evidence that, the air temperature in the western Mediterranean region shows a very significant trend of 0.01-0.02 °C/ year and an equivalent insignificant trend of 0.01-0.02 °C/year in the Eastern Mediterranean region, due to the small variation in circulation observed in the Mediterranean region during the period studied. From Metaxas et al. (1991), they concluded same results after studying trends in sea surface temperature time series for the Mediterranean region. According to the study conducted by Piervitali et al., (1997) they concluded that the average air temperature in the Mediterranean and more specifically in the central and western Mediterranean region that show an increase of about 0.80 °C/100 years.

Giles and Flocas (1984) conducted their trend study on annual and seasonal air temperature time series for the Thessaloniki and Larissa stations in the Greek region. According to the results obtained, they showed that these annual and seasonal time series of air temperature showed negative trends for a period of 80 years whereas for Athens only during the period 1945-1981 the time series presented negative trends. Hasanean (2001) has also studied temperature trends in Athens and the results obtained show that there is a warming, i.e an increase in temperature in Athens during the period 1875-1940, and thereafter, there is a cooling down until 1991 which means that temperatures are decreasing. Feidas et al. (2004) have generally found that Greece shows a decreasing trend in winter (marked by a chill) for the period 1955-2001, while the summer shows an increasing trend nationally (marked by a warming) but none is statistically significant. As a result, the general trend of annual values is close to zero. During the period 1901-1998, according to a study recently carried out by Michel and Hulme (2000), for each country of the planet, which made it possible to calculate the linear trend of all the countries during the 20th century of which for Greece the results showed a decreasing trend (-0.1 ° C).

In Greece, Philandras et al., (2008) used and represented an annual series of air temperatures as well as 9-year moving linear filters and linear models adapted to meteorological stations. They actually argue that since the commencement of the period studied and for the next 15 years, the annual air temperature shows high values, most of which are higher than the average annual air temperature for the period 1951-2000. Subsequently, a statistically significant downward trend for the majority of stations (around -0.8 °C) at the 95% confidence level (cl). It tends to a minimum in the middle of the decade of 1970 which is the most satisfying decade in the Hellenic region. For the following regions, Iraklio's trend seems to be -0.014 °C/year and for Trikala its trend is -0.066 °C/year for the cooling period 1951-1976.

They also conclude that in most stations, in 1976 which is one of the coldest years, it appears the minimum of the annual temperature of the air. And they also argue that everywhere in the Hellenic region, the air temperature of all time series remains low below the average value of the period 1951-2000, since the commencement of the decade of 1990 when the trend is rising (heating). They point out that, only in the last two or three years, the air temperature has reached the limits of the air temperature observed in the middle of the century. With regard to the average annual extreme air temperature, the upper limit (mean + 2σ) reached the maximum limit in all stations except Kerkyra, NOA and Araxos stations in 1950 during the first five years of its decade and in 1990 in less stations during its last decade, approximately in the year 2000.

With all these literature review, many of which have been done for decades, for similar topics that have been discussed and studied in the four corners of the globe: in America, Africa and Asia, and in Europe for centuries . Our research was done on all regions to make our work more attractive. Various references are reported in this work for its scientific interest. This topic is still relevant today as the climate change domain remains sensitive to negative effect

4. AREA OF STUDY, DATA AND METHODS

4.1. Area of study

Grand-Comoros one of the four islands of Comoros that is located in south of the African continent, in the Mozambique Channel between Madagascar and Mozambique to the west and east respectively; between 11° 20' and 13° 14' south latitude and 43° 11' and 45° 19' east longitude in the Indian Ocean. Grand-Comoros has several physical features that contribute to high local variability in its climate.

Comoros hydrographic network is dense and has dug many narrow and deep valleys which give the whole of the island a rugged relief. The hydrographic potentialities are very different from one island to another. Only Mohéli has a hydrographic network, whereas at Grande-Comoros does not have permanent watercourse and in Anjouan the rivers are periodic. Water resources are available in relatively large quantities in Anjouan and Mohéli, where quite a number of rivers flow continuously even though they are decreasing and some have become temporary, notably due to the increase in runoff rapidly due to the retreat of the vegetation cover.

On a national level, Comoros benefits a humid tropical climate under oceanic influence characterized by two major seasons: a hot and humid season (which is called Kaskazi) and a dry and fresh season (which is called Kussi). This climate is characterized by large local variations in relation to exposure to prevailing winds and altitude. The annual rainfall varies between 2000 mm and 4000 mm. On the islands themselves, the rainfall changes significantly as a function of the altitude and the orientation with respect to the relief. In Grande-Comoros rainfall varies between 1 398 mm east of Foumbouni and 5 888 mm west of Nioumbadjou, at the foot of the Karthala massif. On the coast, the average annual temperature is around 25 °C. It decreases with altitude. The annual amplitude, low, is of the order of 4 °C.

The domain of study is the island of Grand-Comoros whose meteorological station finds its location, exactly in the compound of the international airport of Hahaya. The network for this one meteorological station that mainly comprises classical weather station collecting data since the 1900s is managed by the National Agency of Civil Aviation and Meteorology.

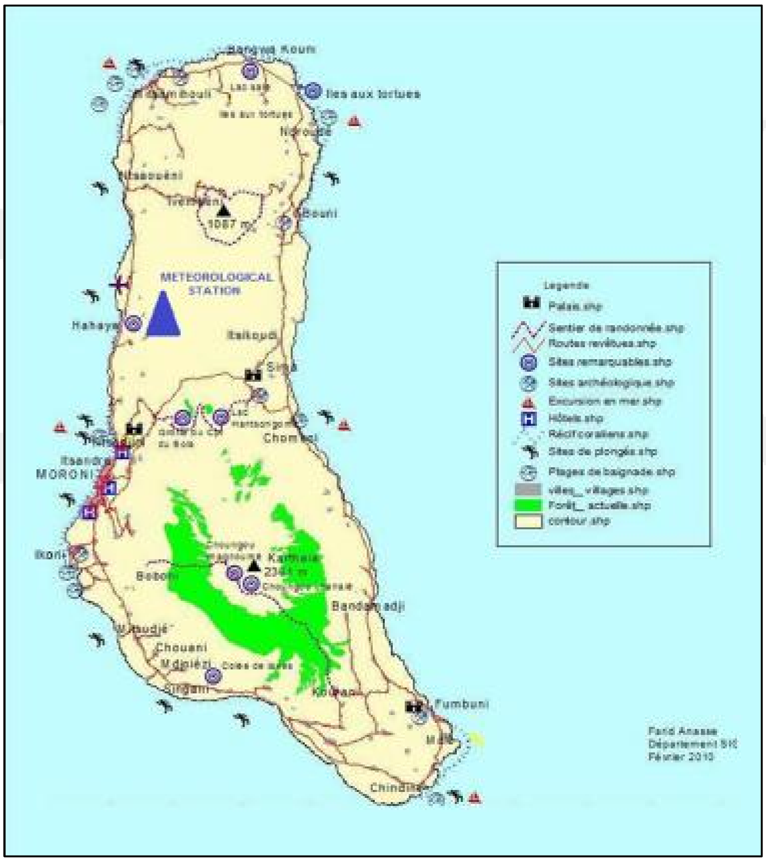

Figure 4.1. Map of Grand-Comoros Island (NAPA, 2006)

The island of Grand-Comoros above is the largest compared to other sister islands including its big city; Moroni is the Capital of the Union of Comoros. The meteorological station has its location at the exit of the city of Hahaya 18 km from the capital.

4.2. Data

The data of this study are focused on the mean of monthly precipitation, maximum temperature, average temperature and minimum temperature consisting of the last 32 years (1982-2013) respectively presented in Table 4.1., Table 4.2., Table 4.3. and Table 4.4. These data were collected by the most one meteorological station (NACAM) in Grand-Comoros.

Table 4.1. Monthly Precipitation data (NACAM, 2016)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Octo	Nov	Dec
1982	72	39	98	67	21	9	18	3	15	41	57	575
1983	243	290	296	66	48	40	7	3	37	14	54	363
1984	239	52	167	302	44	5	23	32	21	29	15	141
1985	125	420	91	108	14	2	33	14	55	31	60	87
1986	430	42	175	84	62	21	34	1	9	42	160	129
1987	381	149	261	41	11	10	2	16	18	113	186	114
1988	290	133	152	112	40	19	4	46	15	103	115	295
1989	654	40	258	152	60	34	78	15	6	25	42	259
1990	252	362	185	164	80	3	6	11	12	4	54	49
1991	352	32	282	256	55	19	5	11	17	56	155	669
1992	44	450	165	168	49	28	4	13	34	60	45	28
1993	482	208	208	57	29	32	11	1	3	9	115	47
1994	105	124	55	16	67	2	13	4	21	82	14	58
1995	236	191	383	262	114	3	2	39	4	42	37	154
1996	308	393	172	75	23	22	53	23	35	23	7	208
1997	196	38	176	128	11	15	7	9	11	24	44	287
1998	391	158	154	251	1	1	9	15	48	53	20	51
1999	134	134	466	149	66	22	21	82	17	29	56	122
2000	197	153	299	108	31	16	28	8	49	19	46	168
2001	520	168	279	40	17	4	8	4	3	10	5	32
2002	700	152	180	16	220	1	2	6	27	29	195	442
2003	70	420	57	191	20	31	1	23	5	7	68	163
2004	219	169	455	153	8	35	23	48	46	103	70	248
2005	301	282	108	38	27	5	2	30	40	62	4	203
2006	377	105	216	101	134	27	1	65	50	35	68	257
2007	170	440	159	65	14	4	23	17	87	83	89	262
2008	583	403	138	76	4	12	10	11	46	16	60	96
2009	48	293	613	188	11	1	1	45	24	49	58	374
2010	543	97	161	81	27	7	0	22	17	58	44	13
2011	225	479	306	113	56	22	2	16	62	29	129	141
2012	316	81	304	287	28	2	14	3	51	50	59	154
2013	45	268	147	195	41	0	4	16	31	92	60	362

Table 4.2. Monthly Maximum Temperature data (NACAM, 2016)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Octo	Nov	Dec
1982	30.5	31.5	31.9	31	31	30.1	29.6	29.4	28.9	30.9	31.3	30.9
1983	31.1	31.7	31.5	30.1	31.5	30.1	29.4	29	29.3	29.7	31.3	31.1
1984	30.5	30.8	30.7	31.2	30.2	28.8	28.3	27.9	28.9	29.8	31.4	30.9
1985	31.2	29.4	31.8	31.2	31	29.5	28.1	28.7	28.2	30.5	30.3	31.6
1986	30	31.3	32	31.3	30.8	29	28.5	28.3	29.4	30.8	31.1	31.1
1987	30.9	31.5	32.2	31.9	32	29.6	28.5	29.2	28.7	29.7	30.9	31.9
1988	32	28.1	31.2	31.6	30.8	30.2	29.4	28.9	29	29.7	30.3	31
1989	28.6	31.3	31.6	31.7	30.6	29.6	28.9	29.3	29.7	30.8	31.8	30.2
1990	31.1	32.1	31.9	31.2	31.1	29.9	28.7	29.3	29.7	31.2	32	31.2
1991	31.7	30.8	30.5	30.9	30.9	29.3	29.7	29.4	29.9	30.7	31.2	30.5
1992	31.9	31.2	31.8	31.2	30	30.4	29.3	28.9	28.7	30.1	32.1	32.2
1993	30.3	30.6	31.3	30.8	31.4	30.3	29.3	29.4	29.2	30.8	31.6	31.7
1994	30.9	31.3	31	31.6	31.3	30.1	30.6	29.9	29.8	31.4	31.2	31.4
1995	31.1	30.3	31.3	31.4	29.8	29.4	29	29.7	29.4	30.7	30.4	31.5
1996	30.7	30.6	31.5	30.8	30.9	29.8	28.3	28.1	28.9	29.7	31.5	30.9
1997	31.5	30.6	31.9	30.8	29.7	29.3	29.2	29.7	31	32.9	31.4	32.1
1998	32.6	31.9	32	30.7	30.1	30.2	29.7	30.1	32	32.6	32	32.8
1999	31.6	32.2	30.9	31.4	30.5	29.8	29.6	29.1	29.1	29.9	30.6	31.5
2000	31	31.1	31.6	31.3	30.6	30	28.4	29.1	28.9	30.6	32.4	31.7
2001	30.6	31.5	31.3	31.9	31.8	30.2	29	29	30	30.4	32.3	32.3
2002	30.6	31	31.3	31.9	30.5	30.6	29.4	30.6	30.2	30.1	31.2	30.9
2003	31.3	31.2	31.3	30.8	30	29.5	30	29.7	30.9	30.6	31.9	31
2004	31	31.1	31	31.4	31	29.6	29.6	29	29.2	30.5	31.4	32.5
2005	31.2	31.1	32.1	31.9	31.2	30.9	29.9	29	29.4	29.5	32.9	32.9
2006	31.9	30.8	30.6	31.8	29.8	29.6	29.5	29	29	30.9	32.5	29.1
2007	32	31	31.8	32.5	30.7	30.8	29.6	29.9	29.9	29.1	32.1	33.4
2008	31.1	30	31.7	30.3	31	29.8	28.2	29.2	29.7	32	32	31
2009	32.7	31	32.1	30.2	30.7	28.8	29.8	30.1	29.8	31.1	32.1	33.4
2010	31.4	32.3	32.7	32.8	31.1	32.2	30.6	29.9	29.4	30.9	31.4	32.6
2011	31.7	30.6	31.3	32.4	31.7	30.6	29.2	29.3	30.1	31.2	32.6	30.1
2012	30.2	31.5	31.5	31.1	31.3	28.8	30.2	29.6	29.6	30.5	31.5	32.4
2013	32.2	31.6	32.1	32.1	31.2	29.2	28.7	28.9	27.6	27.6	30.9	32.5

Table 4.3. Monthly Average Temperatures data (NACAM, 2016)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Octo	Nov	Dec
1982	27.3	27.4	27.9	27.1	26.9	25.9	25.2	24.8	24.5	27	27.2	27
1983	26.8	28.1	27.7	27	28.2	25.6	24.9	24.7	25	25.6	26.8	27.2
1984	27	26.9	27	27.1	26	25.4	23.9	23.5	24.7	26	27.2	26.9
1985	27.2	25.3	27.4	26.6	26.3	24.9	24.2	22	22.9	26.4	26.4	27.7
1986	26.7	27.3	27.8	27.3	26.4	24.8	23.9	23.7	24.9	26.9	27.6	27.2
1987	27.2	27.7	28.1	27.2	27.8	25.5	24.4	24.9	24.8	25.9	26.9	27.7
1988	28	27.8	29.2	27.7	26.4	26	25	25.6	24.6	25.7	26	27.2
1989	25	27	26.7	27	26.3	24.9	25.3	24.4	25.4	26.6	27.7	27.2
1990	29.1	27.7	27.9	27.6	27.1	25.5	25	24.6	25.3	27	28	28.1
1991	27.8	28.6	28.1	27.4	27	25.3	25	24.6	25.4	26.7	27.5	27.1
1992	28	27.5	27.6	28	26.7	26.1	25.2	24.3	24.8	26.4	27.8	27.1
1993	27.6	27.6	27.7	28.1	27.6	25.8	25.3	25.9	24.9	26.4	27.6	28
1994	27.3	27.3	26.6	27.7	27	25.1	24.1	25.2	25.4	27.5	27.2	27.7
1995	27.6	27.6	27.4	27.8	26.7	25.2	24.4	23.4	24.9	26.9	26.7	27.6
1996	27.1	27	27.5	27	26.8	25.1	25.4	24.3	24.4	25.9	27.3	27.7
1997	26.6	29.5	27.9	27.4	26.8	26.2	24.4	25.4	25.5	27.1	27.4	26.7
1998	28.7	28	28.5	28.1	26.3	25.1	23.4	23.6	25.3	25.6	27.4	28.1
1999	27.7	27	28	27.3	25.7	25.3	24.5	24.7	24.6	25.1	27	28.2
2000	27.2	27.8	27	27	27.2	25.7	24.4	24.5	24.3	25.9	27.9	28.1
2001	27.4	27.8	27.3	27.4	27.2	25.7	24.5	24.5	25.5	26.1	27.6	27.3
2002	26.9	27.5	27.3	27.7	26.6	25.4	24.6	25	25	26.9	26	26.8
2003	27.8	27.3	27.9	27.2	26.3	25.6	24.6	24.4	25.3	25.9	26.5	27.5
2004	27.7	27.4	27.3	27.3	26.5	25	24.4	24.4	25.1	26.4	27.3	28.4
2005	27.6	27.7	28	27.7	27	26	25.4	24.2	24.7	25.7	26.9	27.5
2006	27.5	27	27.1	27.1	26.1	24.5	25.1	24.4	24.6	26.1	26.5	26.7
2007	27.6	27.3	27.2	27.6	27.2	25.5	24.6	24.9	24.9	25.1	26.1	27
2008	27.3	29.7	27.2	28.4	25.3	25	24.3	24	25.3	26	27.2	27.3
2009	28	27.2	28	27.1	27	28.4	27	25	25.6	27	28.9	28
2010	28.1	28.7	29.1	28.9	28.1	26.7	25.9	25.6	25.2	26.7	28	28.3
2011	27.8	27.4	28.3	27.5	26.7	26	27.7	25.8	27.3	28.5	28.2	28.2
2012	27.9	27.8	27.9	27.6	27.2	26.3	25.9	25.2	25.4	26.5	27.7	28.3
2013	28.5	28.1	28.3	28.1	26.8	25.1	24.4	24.4	24.5	26.9	28.5	28.2

Table 4.4. Monthly Minimum temperatures data (NACAM, 2016)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Octo	Nov	Dec
1982	23.0	23.5	24.0	23.2	22.7	21.7	20.7	20.1	20.0	23.0	23.0	23.3
1983	22.5	24.5	23.9	23.9	24.8	21.1	20.3	20.4	20.7	21.6	23.0	23.3
1984	23.6	23.3	23.2	23.0	21.9	21.6	19.5	19.0	20.4	22.2	22.3	22.9
1985	23.1	23.1	23.2	22.0	21.8	20.4	20.2	17.2	19.6	21.4	23.0	23.8
1986	23.4	23.6	23.9	23.2	22.0	20.4	19.5	19.2	20.4	23.2	22.6	23.4
1987	23.5	24.0	24.1	23.5	23.6	21.4	20.3	20.6	20.8	22.0	24.0	23.5
1988	24.1	24.2	24.3	23.8	22.1	21.8	20.7	20.3	20.3	21.7	23.0	23.4
1989	22.6	21.9	22.3	22.3	22.0	20.4	19.3	19.6	21.1	22.5	21.7	24.2
1990	23.2	24.1	24.2	24.1	23.1	21.2	20.3	19.9	20.9	22.5	23.6	24.1
1991	23.9	25.2	24.3	23.9	23.1	21.3	20.8	19.9	21.0	22.7	24.0	23.6
1992	24.2	24.1	24.5	24.7	23.4	21.7	20.6	19.7	20.5	22.4	23.8	23.9
1993	23.9	24.0	23.8	24.4	23.9	21.6	20.6	20.5	20.5	21.9	23.6	23.8
1994	24.1	23.9	23.8	23.8	22.8	21.2	21.4	21.3	21.1	23.4	23.7	23.9
1995	24.2	23.8	23.8	24.0	22.6	20.8	20.6	20.7	20.5	23.0	23.1	23.9
1996	23.5	23.9	23.9	23.3	22.9	21.1	19.9	18.9	19.9	21.7	23.2	22.8
1997	23.9	23.9	24.2	23.6	20.8	21.7	20.5	20.6	20.0	21.3	23.9	24.5
1998	24.5	25.1	24.5	24.2	21.8	21.5	20.6	20.5	21.0	21.3	22.9	24.2
1999	23.8	23.8	24.1	22.9	22.1	20.4	19.3	18.2	20.3	20.4	23.3	22.1
2000	23.4	22.9	22.1	22.8	20.8	20.7	18.4	29.1	19.7	21.2	23.4	23.0
2001	23.5	23.2	23.4	23.0	22.6	21.2	20.0	20.0	21.1	22.4	23.8	24.7
2002	23.5	24.4	24.1	25.0	22.8	20.5	20.4	21.4	21.4	22.5	23.6	23.4
2003	24.4	23.8	24.5	23.3	23.2	21.6	20.1	21.0	21.5	22.1	23.8	24.2
2004	23.9	23.8	23.7	23.6	22.3	20.5	19.2	19.7	21.3	23.0	23.3	24.3
2005	24.1	24.4	24.5	24.0	23.5	21.6	21.8	20.8	21.6	22.0	21.9	23.5
2006	23.9	23.9	23.0	23.2	21.8	21.4	20.9	19.5	19.6	22.1	23.3	22.9
2007	24.4	24.3	23.9	24.3	21.4	23.2	20.1	20.9	21.1	21.2	23.4	23.7
2008	23.6	23.5	23.5	22.5	21.3	20.3	20.4	20.1	21.0	23.3	23.9	24.1
2009	25.2	24.2	24.2	24.1	22.6	21.1	24.6	20.5	21.4	22.3	23.9	24.9
2010	24.8	25.1	25.3	25.0	23.9	22.6	21.3	21.3	20.9	23.0	24.6	24.1
2011	24.4	24.2	23.6	24.2	23.1	22.0	20.7	20.2	21.6	23.7	24.3	24.3
2012	24.8	24.0	24.3	24.0	23.1	21.3	21.1	20.7	21.3	22.6	23.8	24.2
2013	24.9	28.1	28.3	28.1	22.7	21.2	20.2	19.9	21.5	22.9	24.5	24.3

4.3. Methods

In order to analyze these data sets, statistical methods will be used. In this study, the statistical methodological approach is applied by last or present adaptation initiatives.

Different monthly temperatures and precipitation data form 1982 to 2013, for climate parameters station (NACAM) are used. Given that the set of data are incomplete, firstly moving averages are applied to complete the data that miss in some periods. The Spearman's Correlation that is a non-parametric test, used first to measure the strength of association between two variables, after the Mann-Kendall and Sen's Slope Estimator Tests for trend analysis of monthly data are used in this work for trend analysis.

4.3.1. Moving averages

To checking the missing data, a moving average is used. A moving average is time series constructed by taking averages of several sequential values of another time series. It is a type of mathematical convolution. More generally, weighted averages may also be used. Moving averages are also called running means or rolling averages. They are a special case of "filtering", which is a general process that takes one time series and transforms it into another time series. Moving averages are used in two main ways: two-sided (weighted) moving averages are used to "smooth" a time series in order to estimate or highlight the underlying trend; one-sided (weighted) moving averages are used as simple forecasting methods for time series. While moving averages are very simple methods, they are often building blocks for more complicated methods of time series smoothing, decomposition and forecasting (Rob J. Hyndman 2009).

4.3.2. Spearman's rho Correlation Test.

Spearman's rank correlation coefficient, r_s (sometimes written as ρ, 'rho'), is the non-parametric equivalent of Pearson's product moment coefficient, r_s, and is used as a measure of association between two variables. When using the parametric correlation coefficient, r, it is required that the data values for the two variables are derived from populations with normal distributions. There is no such requirement for the Spearman's rank correlation, and it can be used with any data whose values can be ranked in order.

Spearman's rho (E. L. Lehmann, 1975 and Sneyers R., 1990) test is another rank-based nonparametric method used for trend analysis and was applied as a comparison with the Mann-Kendall test. In this test, which assumes that time series data are independent and identically distributed, the null hypothesis (H_0) again indicates no trend over time; the alternate hypothesis (H_1) is that a trend exists and that data increase or decrease with i (Yue et al., 2002). The test statistics R_{sp} and standardized statistics Z_{sp} are defined as

$$R_{sp} = 1 - \frac{6\sum_{i=1}^{n}(D_i - i)^2}{n(n^2 - 1)}, \tag{4.1}$$

$$Z_{sp} = R_{sp}\sqrt{\frac{n-2}{1-R_{sp}^2}}, \tag{4.2}$$

In these equations, D_i is the rank of ith observation, D_i is the chronological order number, n is the total length of the time series data, and Z_{sp} is Student's t-distribution with (n−2) degree of freedom. The positive values of Z_{sp} represent an increasing trend across the hydrologic time series; negative values represent the decreasing trends. The critical value of t at a 0.05 significance level of Student's t-distribution table is defined as $t_{(n-2,1-\alpha/2)}$ (E. R. Dahmen and M. J. Hall, 1990). If

$|Z_{sp}| > t_{(n-2,1-\alpha/2)}$, (Ho) is rejected and a significant trend exists in the hydrologic time series.

4.3.3. Mann-Kendall and Sen's Slope Estimator tests

Mann-Kendall Test: These methods rely on the relative rankings of data values. Knowledge of the precise form of population distributions is not necessary (EPA QA/G-9S 2006).

Mann-Kendall test involves computing a statistic S, which is the difference between the numbers of pairwise slopes that are positive minus the number that are negative. If S is a large positive value, then there is evidence of an increasing trend in the data. If S is a large negative value, then there is evidence of a decreasing trend in the data. The null hypothesis or baseline condition for this test is that there is no temporal trend in the data values, i.e., "H_0: no trend". The alternative condition or hypothesis will usually be either "H_A: upward trend" or "H_A: downward trend" (EPA QA/G-9 2000).

Mann (1945) presented a non-parametric test for randomness against time, which constitutes a particular application of Kendall's test for correlation commonly known as the 'Mann–Kendall' or the 'Kendall t- test' (Kendall, 1962). This non-parametric test allows to characterize a trend or an abrupt jump. It is based on the correlation between the ranks of a chronological series and their order. İts null hypothesis is that there is no tendency. For each pair of values y_i and y_j, where $i > j$, the test looks at whether $y_i > y_j(\mathrm{P})$ or $y_i < y_j(\mathrm{M})$. Its statistic is equal to the sum of the rank difference of two observations, that is, $\mathrm{S} = \mathrm{P} - \mathrm{M}$. The significance of a trend can be tested by comparing the standardized values U with the test variable at level of meaning desired (Önöz and Bayazik, 2003, Hamed KH, 2008). For the direct curve, this method is used starting from the beginning of the series. For the retrograde curve, it is applied starting from the end of the series (Moron, 1994).

Letting $X_1, X_2, \ldots X_n$ be a sequence of measurements over time, Mann proposed to test the null hypothesis, H_0, that the data come from a population where the random variables are independent and identically distributed. The alternative hypothesis, H_1, is that the data follow a monotonic trend over time. Under H_0, the Mann–Kendall test statistic is

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \operatorname{sgn}(x_j - x_i) \tag{4.3}$$

where

$$\operatorname{sgn}(x) = \begin{cases} 1 & \text{if} \quad x > 0 \\ 0 & \text{if} \quad x = 0 \\ -1 & \text{if} \quad x < 0 \end{cases} \tag{4.4}$$

Under the hypothesis of independent and randomly distributed random variables, when $n \geq 8$, the S statistic is approximately normally distributed, with zero mean and variance as follows:

$$\sigma^2 = \frac{n(n-1)(2n+5)}{18} \tag{4.5}$$

From where, the standardized Z statistics follow a normal standardized distribution:

$$Z = \begin{cases} \frac{S-1}{\sigma} & \text{if } S > 0 \\ 0 & \text{if } \mathrm{S} = 0 \\ \frac{S+1}{\sigma} & \text{if } \mathrm{S} > 0 \end{cases} \tag{4.6}$$

Sen's Slope Estimator test: If a linear trend is present in a time series, then the true slope (change per unit time) can be estimated by using a simple nonparametric procedure developed by Sen (1968). This means that linear model *f (t)* can be described as

$$f\ (t)\ =\ Qt\ +\ B \qquad (4.7)$$

where Q is the slope, B is a constant.

To derive an estimate of the slope Q, the slopes of all data pairs are calculated

$$Q_i\ =\ \frac{x_j - x_k}{j-k}, \quad i\ =\ 1,2, \ldots N, j\ >\ k \qquad (4.8)$$

If there are n values x_j in the time series we get as many as $N\ =\ n(n-1)/2$ slope estimator Q_i.

The Sen's estimator of slope is the median of these N values of Q_i. The N values of Q_i are ranked from the smallest to the largest and the Sen's estimator is

$$Q\ =\ \begin{cases} \frac{Q_{N+1}}{2}\ if\ N\ is\ old \\ \frac{1}{2}\left(Q_{\frac{N}{2}}\ +\ Q_{\frac{N+2}{2}}\right)\ if\ N\ is\ even \end{cases} \qquad (4.9)$$

To obtain an estimate of B in equation (9) the n values of differences $x_i - Qt_i$ are calculated. The median of these values gives an estimate of B (Sirois 1998). The estimates for the constant B of lines of the 99 % and 95 % confidence intervals are calculated by a similar procedure. Data were processed using an Excel macro named MAKESENS created by Salmi et al. (2002).

A positive Q_i value represents an increasing trend; a negative Q_i value represents a decreasing trend over time.

5. RESULTS AND DISCUSSIONS

In the Indian Ocean zone, recently, the negative impacts of climate change are observed in all neighboring countries. As for Comoros, with their geographical position between Madagascar in the East and the East Coast of Africa in the West, they benefit from their position of a decrease of the aggressiveness vis-a-vis the great climatic hazards that their countries undergo neighbors each year. But Comoros knows its own negative effects due to climate change. In the last 30 years; the country is experiencing a very significant reduction of watercourses, faces a high drought with a rise in temperature and torrential rain that cannot be managed and that destroys habitats. In research study, the main climatic parameters namely: with these data of the rainfall and the three different temperatures of the last 32 years, they allowed us to really conceive the exact periods of the climate change and the variation of the rate of the change of the parameters.

In this study, the monthly data are precipitation, maximum, average, and minimum temperatures. These data series were observed and recorded by the one station (NACAM) in Grand-Comoros during the period 1982-2013. First of all, Mouving averages were used to obtain satisfactory to carry out the checking for missing data. This allowed us to have complete data. Then to study relationships between months and trend analyses of climate parameters in Grand-Comoros were investigated by using first the Spearman’s rho correlation and secondly non-parametric methods with Sen’s Slope Estimator and Mann-Kendall tests.

The results obtained on the study of the correlations between the months and the tendencies of the climatic parameters on the Grand-Comoros, by using the different statistical methods, are the following ones.

5.1. Results of Spearman’s rho Correlation Test.

To better study the variations and modifications of climate parameters in the face of climate change, the analysis of the correlations between these climatic parameters over time is of major importance and plays a large role in the study of the impacts due to climate change. Hence the use of the Spearman's rho Correlation test for the identification of the different links or not between the climatic parameters as variables, namely the variables analyzed in this statistical test are:

- Precipitation between precipitation,
- Maximum between maximum temperatures,
- Average between average temperatures,
- Minimum between minimum temperatures,
- Average seasonal between all parameters,
- Average annual between all parameters.

5.1.1. Correlation results of precipitation

Correlation results between precipitations

Table 5.1. Correlation results between precipitations

1982-2013	Jan. Preci.	Feb. Preci.	Mar. Preci.	Apr. Preci.	May Preci.	Jun. Preci.	Jul. Preci.	Aug. Preci.	Sept. Preci.	Octo. Preci.	Nov. Preci.	Dec. Preci.
Jan. Preci.	1.000	-.316	.128	-.297	.076	.083	.018	-.223	-.162	-.192	.091	-.178
Feb. Preci.	-.316	1.000	-.100	-.078	-.204	.002	-.158	.177	.373*	-.157	.030	-.236
Mar. Preci.	.128	-.100	1.000	.254	.198	.229	-.033	.121	-.019	-.128	.136	.131
Apr. Preci.	-.297	-.078	.254	1.000	.040	-.059	-.035	.319	-.015	.051	-.054	.071
May Preci.	.076	-.204	.198	.040	1.000	.104	-.105	-.050	-.198	-.119	.061	.059
Jun. Preci.	.083	.002	.229	-.059	.104	1.000	.149	.074	-.147	-.266	.170	.043
Jul. Preci.	.018	-.158	-.033	-.035	-.105	.149	1.000	-.292	.099	-.164	-.162	-.048
Aug. Preci.	-.223	.177	.121	.319	-.050	.074	-.292	1.000	.155	.326	-.068	.123
Sept. Preci.	-.162	.373*	-.019	-.015	-.198	-.147	.099	.155	1.000	.278	.103	.099
Octo. Preci	-.192	-.157	-.128	.051	-.119	-.266	-.164	.326	.278	1.000	.175	.140
Nov. Preci.	.091	.030	.136	-.054	.061	.170	-.162	-.068	.103	.175	1.000	.276
Dec. Preci.	-.178	-.236	.131	.071	.059	.043	-.048	.123	.099	.140	.276	1.000

**. Correlation is very significant (at the 0.01 level 2-tailed)
*. Correlation is significant (at the 0.05 level 2-tailed).

The results of precipitation between precipitations obtained by Spearman rho correlation statistical test presented in the table 5.1.

January shows positive non-significant correlations with March, May, June, July and November; it shows also insignificant negative correlations with the months of February, April, August, September, October and December.

February shows a lot of nonsignificant negative correlations from January to December with the exception of June, August and September, whose correlation is significant (*r*= .036) and November, however, with their correlations are just positive.

March shows both positive and negative correlations but all are insignificant. The positive correlations are with the months of January, April, May, June, August, November and December. The negative correlations are with the month of February, July, September and October.

April shows negative and positive correlations but all are insignificant. The negative correlation are with January, February, June, July, September and November and indicates positive correlations with the months of March, May, August, October and December.

May reflects positive and negative correlation all nonsignificant. The positive correlations are with January, March, April, June, November and December. The negative correlations are with the month of February, July to October.

June shows more months of positive correlations with no significant except with the months of April, September, and October as the correlations are nonsignificant.

July shows all nonsignificant correlations. Many more of its correlations are negative, with the month of February to May, also with the month of August and October to December. July's positive correlations are with the months of January, June and September.

August shows all correlations that are not significant. But many of its correlations are positive with the month of February to April; the month of July also its correlation is positive, as in September, October and December. Its negative correlations were observed with the month of January, May, July and November.

September raises a lot of positive correlations of which only one with the month of February (*r*=.036) is significant, from July to December its correlations are just positive. Its non-significant negative correlations are with the month of January then from March to June.

October shows a lot of negative correlations compared to positive correlations but without any significant ones. Negative correlations are from January to March and May to July. The positive correlations are with the month of April then from month of August to December.

November shows much more positive compared to negative correlations but without any significant correlation. Negative correlations are only with the months of April and July. The positive correlations are with the month of January to March then May, June and then from September to December.

December reflects both positive and negative correlations but no correlation is significant. The negative correlations are with the month of January, February and July. And the positive correlations are with the months of March to June and then August to November.

5.1.2. Correlation results of maximum temperature

Correlation results between maximum temperatures

Table 5.2. Correlation results between maximum temperatures

1982-2013	Jan. Maxi. Temp.	Feb. Maxi. Temp.	Mar. Maxi. Temp.	Apr. Maxi. Temp.	May Maxi. Temp.	June Maxi. Temp.	July Maxi. Temp.	Aug. Maxi. Temp.	Sept. Maxi. Temp.	Octo. Maxi. Temp.	Nov. Maxi. Temp.	Dec. Maxi. Temp.
Jan. Maxi. Temp.	1.000	-.081	.131	.047	-.277	.121	.285	.143	.108	.006	.138	.298
Feb. Maxi. Temp.	-.081	1.000	.347	.141	.255	.113	.334	.146	.020	-.041	.005	.313
Mar. Maxi. Temp.	.131	.347	1.000	.023	.174	.086	-.083	.122	-.074	.056	.105	.549**
Apr. Maxi. Temp.	.047	.141	.023	1.000	.200	.374*	.047	-.040	-.085	-.320	-.004	.089
May Maxi. Temp.	-.277	.255	.174	.200	1.000	.242	-.001	-.119	-.117	-.149	-.015	.149
June Maxi. Temp.	.121	.113	.086	.374*	.242	1.000	.237	.182	.138	-.077	.334	.120
July Maxi. Temp.	.285	.334	-.083	.047	-.001	.237	1.000	.589**	.416*	.127	.121	.295
Aug. Maxi. Temp.	.143	.146	.122	-.040	-.119	.182	.589**	1.000	.695**	.487**	.112	.214
Sept. Maxi. Temp.	.108	.020	-.074	-.085	-.117	.138	.416*	.695**	1.000	.487**	.320	.027
Octo. Maxi. Temp.	.006	-.041	.056	-.320	-.149	-.077	.127	.487**	.487**	1.000	.225	-.161
Nov. Maxi. Temp.	.138	.005	.105	-.004	-.015	.334	.121	.112	.320	.225	1.000	.141
Dec. Maxi. Temp.	.298	.313	.549**	.089	.149	.120	.295	.214	.027	-.161	.141	1.000

**. Correlation is very significant (at the 0.01 level 2-tailed)
*. Correlation is significant (at the 0.05 level 2-tailed).

The results obtained on maximum temperatures with the Spearman rho correlation statistical test are presented in the table 5. 2.

January shows both positive correlations and negative correlations but any one is not significant. It is only with the month of February and May that we obtain negative correlations. Positive correlations are recorded with March, April and June through December.

February also shows the two types of correlation, positive correlations and negative correlations but without any significant. Months with negative correlations are January and October only. Positive correlations are observed from March to September and from November to December.

March also shows positive and negative correlations. It is with the month of July and September that the correlations are negative nonsignificant. But with the remaining months all the correlations are not significant, only with the month of December (*r*=.001) its correlation is highly significant.

April shows nonsignificant negative correlations from August to November. April's positive correlations of January with July and December; but it is only with the month of June (*r*=.035) that the correlation is significant.

May shows negative correlations and positive correlations, but they are all insignificant. With the month of January then from July to November all the correlations are negative. The positive correlations are with the month of February in June and then with the month of December.

June shows only one negative correlation with the month of October. For the other months all the correlations are positive but only with that of April (*r*=.035) that the correlation is significant. It reflects with the month of January to March, May to September, November and December positive correlations only.

Yu et al., (2017) used the data published by the State Statistical Office and the weather station data, the annual mean temperature, wind speed, humidity, light duration and precipitation of Dianchi Lake in 1990-2014 to analysed trends and correlation. They are combined with the population and the results shown that the climatic changes in Dianchi Lake basin were related to the climatic change in the past 25 years, and the correlation between these factors and the main climatic factors are analysed by linear regression, Mann-Kendall test, cumulative anomaly, R/S and Morlet wavelet analysis.

July shows only two nonsignificant negative correlations with the months of March and May. The other months such as January, February, April, June and October to December, it shows non-significant positive correlations. It is with the month of August (r=.000) that it indicates a highly significant positive correlation and the month of September (r=.018) a significant positive correlation.

August shows only two negative correlations not significant with the months of April and May. It reflects positive correlations from January to March then from June to December including those with the month of July (r=.000), September (r=.000) and October (r=.005) the correlations are highly significant.

September shows nonsignificant negative correlations with the month of March to May. It is with the month of January, February then from June to December that it shows positive correlations of which with the month of July the correlation is positive significant (r=.018) and those with the month of August (r=.000) and October (r= .005) the correlations are significant.

October shows nonsignificant negative correlations with February, April, May, June and December. But reveals positive correlations whose correlations with the month of January, March, July and November are positive non-significant, with the month of August (r=.005) and September (r=.005) the correlations are highly significant.

November reflects the two different correlations, the positive correlations and the negative correlations, they are all insignificant. Negative correlations are observed with the months of April and May. On the other hand positive correlations are observed with the month of January to March then of June to December.

December shows a single negative non-significant correlation with the month of October. With all the other months the correlations are positive that only with March (*r*=.001) the correlation is highly significant. The correlations with the month of January, February, April to September and November are not significant. El Kenawy et al. (2012) studied trend and variability of surface air temperature in northeastern Spain (1920–2006) by using the non-parametric Spearman Rho statistic. For the results of maximum temperature, the seasonal and annual trends of maximum temperature over the period 1960-2006 showed warming trend in annual, summer, winter, and spring temperatures respectively. The only exception is seen in autumn since only 29.7% of observatories showed a positive trend, while almost 43% of the observatories exhibited a negative tendency at the 95% level.

5.1.3. Correlation results of average temperature

Correlation results between average temperatures

Table 5. 3. Correlation results between average temperatures

1982-2013	Jan. Ave. Temp.	Feb. Ave. Temp.	Mar. Ave. Temp.	Apr. Ave. Temp.	May Ave. Temp.	June Ave. Temp.	July Ave. Temp.	Aug. Ave. Temp.	Sept. Ave. Temp.	Octo. Ave. Temp.	Nov. Ave. Temp.	Dec. Ave. Temp.
Jan. Ave. Temp.	1.000	.266	.599**	.540**	.096	.326	.298	.161	.147	.025	.339	.522**
Feb. Ave. Temp.	.266	1.000	.414*	.553**	.422*	.354*	-.029	.247	.267	.022	.240	.121
Mar. Ave. Temp.	.599**	.414*	1.000	.314	.176	.446*	.298	.314	.079	.027	.224	.351*
April Ave. Temp.	.540**	.553**	.314	1.000	.092	.199	-.007	.184	.221	.130	.136	.194
May Ave. Temp.	.096	.422*	.176	.092	1.000	.551**	.357*	.532**	.155	.093	.294	.216
June Ave. Temp.	.326	.354*	.446*	.199	.551**	1.000	.564**	.609**	.246	.100	.286	.093
July Ave. Temp.	.298	-.029	.298	-.007	.357*	.564**	1.000	.480**	.171	.144	.297	.112
Aug. Ave. Temp.	.161	.247	.314	.184	.532**	.609**	.480**	1.000	.355*	.268	.163	.132
Sept. Ave. Temp.	.147	.267	.079	.221	.155	.246	.171	.355*	1.000	.421*	.368*	.080
Octo. Ave. Temp.	.025	.022	.027	.130	.093	.100	.144	.268	.421*	1.000	.473**	.037
Nov. Ave. Temp.	.339	.240	.224	.136	.294	.286	.297	.163	.368*	.473**	1.000	.483**
Dec. Ave. Temp.	.522**	.121	.351*	.194	.216	.093	.112	.132	.080	.037	.483**	1.000

**. Correlation is very significant (at the 0.01 level 2-tailed)
*. Correlation is significant (at the 0.05 level 2-tailed)

The results obtained with average temperature with the Spearman rho correlation statistical test are presented in the table 5.3.

January does not show any negative correlation with every month. All correlations observed are positive. The correlations observed with the month of February, from May to November are not significant. The correlations observed with the months of March (*r*=.000), April (*r*=.001) and December (*r*=.002) are highly significant.

February shows only one significant negative correlation with July. It indicates ten positive correlations, with January, from August to December the correlations are non-significant. It shows with March (*r*=.019), May (of .016) of June (*r*=.047) significant correlations and highly significant with April (*r*=.001).

March does not show any negative correlation. The correlations observed with the months of April and May then from July to November are all positive but non-significant. The correlations observed with February (*r*=.019), June (*r*=.010) and December (*r*=.049) are positive and significant. The only correlation with the month of January (*r*=.000) highly significant.

Seasonal and annual changes in maximum, minimum, and mean temperatures had been assessed using the Ordinary Least Squares Method, while the significance of the observed trend has been assessed at a confidence interval of 95% using the non-parametric Spearman Rho statistic (El Kenawy et al., 2012). Their results reveal the linear trends of temperature variations in the regional series on seasonal and annual timescales assessed at the 95% significance level. Overall, the results demonstrate that there was a statistically significant uptrend in the maximum, minimum, and mean temperatures on both annual and seasonal scales. However, these observed warming was not uniform over time. In particular, maximum temperature showed stronger warming during warm seasons (summer and spring) than in cold seasons (winter and autumn).

April reflects one single negative non-significant correlation with July and ten correlations are positive and the correlations with January (*r*=.001) and February (*r*=.001) are highly significant.

May shows only positive correlations. The correlations with January, March and April, from September to December, the correlations are positive non-significant. The correlations with February (*r*=.016) and July (*r*=.045) are significant and highly significant with June (*r*=.001) and August (*r*=.002).

June does not reflect any negative correlation. İt indicates positive correlations. With January, April and from September to December, the correlations are positive but non-significant. The correlations with February (*r*=.047) and March (*r*=.010) are positive significant, with May (*r*=.001), July (*r*=.001) and August (*r*=.000) are positive highly significant. Kenawy et al., (2012) that they studied trend and variability of surface air temperature in northeastern Spain (1920–2006) by using the non-parametric Spearman Rho statistic. The results reflect the strongest change occurred during summer and spring, whereas the lowest change took place in winter and autumn for mean temperature. More observatories shown insignificant trend during autumn (46.1%) and winter (15.5%), whereas most observatories exhibited statistically significant trends during summer and spring (93%).

July shows two negative non-significant correlations with February and April. The correlations with January, March and September to December are positive non-significant. The correlation with May (*r*=.045) is positive significant. İt shows positive significant correlations with June (*r*=.001) and August (*r*=.005).

August did not show any negative correlation. The correlations with the months from January to April then from October to December are all positive but non-significant. The correlations with May (*r*=.002), June (*r*=.000) and July (*r*=.005) are highly significant and with September (*r*=.046).

September does not reflect also any negative correlations with all of the months. The correlations with the month from January to July and with December are positive but not significant. The correlations with August (*r*=.046), October (*r*=.016) and November (*r*=.038) are significant.

October does not show any negative correlations over all months. With January to August and with the month of December all the correlations are positive but not significant. It is only with September (*r*=.016) that its correlation is significant but the one with November (*r*=.006) is highly significant.

November reflects no negative correlation to all months. The correlations observed with January through August are positive but non-significant. The correlation with September (*r*=.038) is significant. The correlations with October (*r*=.006) and December (*r*=.005) are highly significant.

December does not show any negative correlation with all of the months. The correlations with February and April through October are positive, but not significant. The correlation with March (*r*=.049) significant. They are the correlations with January (*r*=.002) and November (*r*=.005) that they are positive and highly significant.

5.1.4. Correlation results for minimum temperature

Correlation results between minimum temperatures

Table 5. 4. Correlation results between minimum temperatures

1982-2013	Jan. Min. Temp.	Feb. Min. Temp.	Mar. Min. Temp.	Apr. Min. Temp.	May Min. Temp.	June Min. Temp.	July Min. Temp.	Aug. Min. Temp.	Sept. Min. Temp.	Octo. Min. Temp	Nov. Min. Temp.	Dec. Min. Temp.
Jan Min. Temp.	1.000	.539**	.553**	.628**	.137	.475**	.512**	.375*	.488**	.129	.457**	.474**
Feb. Min. Temp.	.539**	1.000	.714**	.850**	.483**	.438*	.535**	.322	.412*	-.016	.352*	.117
Mar. Min. Temp.	.553**	.714**	1.000	.628**	.461**	.418*	.417*	.276	.327	-.028	.321	.207
April Min. Temp.	.628**	.850**	.628**	1.000	.508**	.476**	.490**	.434*	.471**	.150	.395*	.295
May Min. Temp.	.137	.483**	.461**	.508**	1.000	.287	.371*	.222	.355*	.233	.298	.024
June Min. Temp.	.475**	.438*	.418*	.476**	.287	1.000	.461**	.326	.074	-.102	.232	.081
July Min. Temp.	.512**	.535**	.417*	.490**	.371*	.461**	1.000	.381*	.209	.277	.291	.172
Aug. Min. Temp.	.375*	.322	.276	.434*	.222	.326	.381*	1.000	.381*	-.005	.308	.193
Sept. Min. Temp.	.488**	.412*	.327	.471**	.355*	.074	.209	.381*	1.000	.404*	.345	.607**
Oct. Min. Temp.	.129	-.016	-.028	.150	.233	-.102	.277	-.005	.404*	1.000	.294	.341
Nov. Min. Temp.	.457**	.352*	.321	.395*	.298	.232	.291	.308	.345	.294	1.000	.489**
Dec. Min. Temp.	.474**	.117	.207	.295	.024	.081	.172	.193	.607**	.341	.489**	1.000

**. Correlation is very significant (at the 0.01 level 2-tailed)
*. Correlation is significant (at the 0.05 level 2-tailed)

The results obtained with the minimum temperature with the Spearman rho correlation statistical test are presented in the Table 5.4.

January shows only positive correlations, with May and October they are non-significant, with August (*r*=.035) the correlation is significant. But the correlations with the following months: February (*r*=.001), March (*r*=.001) April (*r*=.000), June (*r*=.006), July (*r*=.003), September (*r*=.005), November (*r*=.009) and December (*r*=.006) are highly significant.

February shows only one negative non-significant correlation with October, it indicates ten positive correlations with August and December are non-significant, with June (*r*=.012), September (*r*=.019) and November (*r*=.048) are significant and with January (*r*=.001), March (*r*=.000), April (*r*=.000), May (*r*=.005) and July (*r*=.002); the correlations are highly significant. El Kenawy et al. (2012) studied trend and variability of surface air temperature in northeastern Spain (1920–2006) by using the non-parametric Spearman Rho statistic. Their results shown similar to maximum temperature, the trend was globally positive throughout the study area. Also, the strongest warming occurred during summer and spring, whereas autumn exhibited little warming. The degree of warming varied considerably throughout the study area though being very similar to those of maximum temperature. The strongest increase in minimum temperature was noted at coastal stations, with more observatories with statistically significant trend close to the Cantabrian Sea, particularly during wintertime. The continental observatories exhibited the lowest temperature rise suggesting strong spatial gradient from thecoast to mainland. Also, of interest, the annual, winter, and summer temperatures indicated a south-north gradient with less warming in southern sites.

March shows only one negative non-significant correlation with October. August, September, November and December indicates non-significant correlations positive. The correlations with June (*r*=.017) and July (*r*=.018) are significant, with January (*r*=.001), February (*r*=.000), April (*r*=.000) and May (*r*=.008) the correlation are highly significant.

April does not reflect any negative correlation. All correlations observed are positive. October and December, all the correlations are positive but they are not significant. August (*r*=.013) and November (*r*=.025) their correlations are positive and significant. The correlations with the month of January (*r*=.000), February (*r*=.000), March (*r*=.000), May (*r*=.003), June (*r*=.006) of July (*r*=.004) and September (of. 006), are positive and significant.

May does not show any negative correlation with all of the months. The correlations with January, June, August and October through December are positive but not significant. The correlations with July (*r*=.037) and September (*r*=.046) are significant positives. And with the month of February (*r*=.005), March (*r*=.008) and April (*r*=.003) their correlations are highly significant positives.

June showed only one negative and non-significant correlation with the month of October. But with the other months, all the correlations are positive. May, August and September, similarly with the months of November and December, their correlations are positive and non-significant. The correlations with February (*r*=.012) and March (*r*=.017) are positive and significant. For the correlations with January (*r*=.006), April (*r*=.006) and July (*r*=.008), are highly significant.

July doesn't show any negative correlation. All correlations are positives. The correlations with the month of September to December are positive and non-significant. March (*r*=.018), May (*r*=.037) and August (*r*=.031) their correlations are significant positives. For the month of January (*r*=.003), February (*r*=.002), April (*r*=.004) and June (*r*=.008) their correlations are positive highly significant.

August indicates only one negative and non-significant correlation with the month of October while other months the correlations are positive. The correlations with the month of February and March; May and June; November and December are positive but no significant. The correlations with January (*r*=.035), April (*r*=.013), July (*r*=.031) and September (*r*=.032) are positive and significant.

September does not show any negative correlation. All correlations with all the months are positive. The correlations with the months of March, June, July and

November are positive but not significant. The correlations with February (*r*=.019), May (*r*=.046), August (*r*=.032) and October (*r*=.022) are positive and significant. For the correlations with the month of January (*r*=.005), April (*r*=.006) and December (*r*=.000) are positive and very significant.

October shows both negative and positive correlations. With the month of February, March, June and August, the correlations are negative and non-significant. other correlations are positive, such as: the correlations with January, April, May, July, November and December are non-significant positives; it is only with the month of September that the correlation is significant positive.

November did not show any negative correlation. It shows only positive correlations. With the months of March and May until October, the correlations are positive and non-significant. The correlations with February (*r*=.048) and April (*r*=.025) are positive and significant. With the month of January (*r*=.009) and December (*r*=.005) their correlations are positive and highly significant.

December does not show any negative correlation. The correlations with February to August are positive but not significant. With the month of January (*r*=.006), September (*r*=.000) and November (*r*=.005) their correlations are positive and very significant.

5.1.5. Seasonal correlation results between all parameters

The seasonal results of Spearman's test rho correlations between the parameters are presented in the Table 5.5.

Table 5.5. Seasonal correlations of precipitation and maximum temperature

1982-2013	Prec. Sum.	Prec. Win	Prec. Fall	Prec. Spri	Ma.Te. Sum.	Ma.Te. Winter	Ma.Te. Fall	Ma.Te. Spring	Av.Te. Sum.	Av.Te. Winter	Av.Te. Fall	Av.Te. Spring	Mi.Te. Sum.	Mi.Te. Winter	Mi.Te. Fall	Mi.Te. Spring
Prec. Sum.	1	0.228	0.111	-0.02	-0.176	0.052	0.114	-0.065	0.105	0.14	0.031	0.015	0.163	0.041	0.093	0.201
Prec. Win.	0.228	1	-0.053	0.076	-0.223	-.360*	-0.235	-0.269	-0.274	-0.308	-.435*	-.507**	-.394*	-0.328	-0.349	-0.322
Prec. Fall	0.111	-0.053	1	-0.119	-0.307	-0.094	-0.141	-0.029	-0.241	-0.026	-0.106	0.292	-0.115	-0.138	0.18	0.26
Prec. Spring	-0.02	0.076	-0.119	1	0.262	0.04	0.076	-0.286	0.163	-0.056	0.077	-0.011	.351*	0.252	0.044	0.158
Ma.Te.Sum.	-0.176	-0.223	-0.307	0.262	1	.423*	0.177	-0.023	.485**	0.272	.440*	-0.023	.542**	.540**	0.191	-0.084
Ma.Te.Win.	0.052	-.360*	-0.094	0.04	.423*	1	0.041	0.309	0.232	.562**	0.308	0.118	.555**	.664**	0.26	0.034
Ma.Te. Fall	0.114	-0.235	-0.141	0.076	0.177	0.041	1	-0.149	0.27	0.337	.591**	0.091	0.096	0.146	.533**	0.288
Ma.Te.Spri.	-0.065	-0.269	-0.029	-0.286	-0.023	0.309	-0.149	1	0.266	0.159	-0.146	.559**	0.138	0.094	-0.215	.363*
Av.Te.Sum.	0.105	-0.274	-0.241	0.163	.485**	0.232	0.27	0.266	1	.422*	0.265	0.18	.690**	.403*	0.285	0.224
Av.Te.Win.	0.14	-0.308	-0.026	-0.056	0.272	.562**	0.337	0.159	.422*	1	.547**	0.282	.485**	.501**	.525**	0.091
Av.Te. Fall	0.031	-.435*	-0.106	0.077	.440*	0.308	.591**	-0.146	0.265	.547**	1	0.093	0.322	.535**	.546**	-0.044
Av.Te. Spri	0.015	-.507**	0.292	-0.011	-0.023	0.118	0.091	.559**	0.18	0.282	0.093	1	0.322	0.079	0.098	.688**
Mi.Te.Sum.	0.163	-.394*	-0.115	.351*	.542**	.555**	0.096	0.138	.690**	.485**	0.322	0.322	1	.599**	.395*	0.237
Mi.Te. Win.	0.041	-0.328	-0.138	0.252	.540**	.664**	0.146	0.094	.403*	.501**	.535**	0.079	.599**	1	0.274	0.002
Mi.Te. Fall	0.093	-0.349	0.18	0.044	0.191	0.26	.533**	-0.215	0.285	.525**	.546**	0.098	.395*	0.274	1	0.233
Mi.Te. Spri	0.201	-0.322	0.26	0.158	-0.084	0.034	0.288	.363*	0.224	0.091	-0.044	.688**	0.237	0.002	0.233	1

*. Correlation is significant (at the 0.05 level 2-tailed)

The seasonal results (Table 5.5) between precipitations show six negative and positive correlations of without any significant correlation. Between the precipitation and the maximum temperature, the results show five non-significant positive correlations and eleven negative correlations of which only the correlation between precipitation (winter) and maximum temperature (winter) is significant. Between precipitation and mean temperature, the results indicate seven non-significant positive correlations and also indicate nine negative correlations whose correlations between precipitation (winter) and average temperature (Fall *r*=.013 and Spring *r*=.003) are significant. And the results obtained between precipitation and minimum temperature show ten positive correlations of which only the correlation between precipitation (Spring) and minimum temperature (Summer) is significant and shows six negative correlations of which only the correlation between precipitation (Winter) and minimum temperature (Summer) is significant. Found statistically significant decrease in one station compared to Spearman rank correlation and Mann-Kendall tests applied to 3 stations with 20-25 years installed in the Van Lake Closed Area, while the decrease in the other two was not significant (Topaloğlu et al. 1997). Applied the Spearman rank correlation test to the annual maximum instantaneous data (n = 15-56 years) of 13 stations located in the Seyhan river basin and did not find any significant flow in the currents. However, a trend in the direction of decrease in the basin currents was found (8 stations) in general (Topaloğlu 1999). The seasonal results for maximum temperature by the Spearman rho Correlation test show four insignificant negative correlations and eight positive correlations whose correlation between maximum temperature summer and winter is significant. Between maximum temperature and average temperature, the results show two insignificant negative correlations between maximum temperature (summer) with average temperature (spring) and between maximum temperature (spring) with average temperature (fall), the results also show fourteen positive correlations of which four are highly significant between summer with summer (r=.005), winter with winter (r=.001), fall with fall (r=.000) and between spring with spring (r=.001). The results show between maximum temperature and minimum temperature two insignificant negative correlations (summer) and minimum (spring) still as maximum (spring) and minimum (fall), they also show fourteen positive correlations, the most significant are observed between maximum (summer) and minimum (summer), maximum (summer) and minimum (winter), maximum (winter) and minimum (summer), maximum (winter) and minimum (winter) and maximum (fall) and minimum (fall).

The correlation results observed for average temperature by the Spearman Correlation test indicate between mean temperature only positive correlations of which between summer and winter, the correlation is significant, between winter and fall the correlation is highly significant. The results obtained between average temperature and minimum temperature show a single negative correlation reflected between average temperature (fall) and minimum temperature (spring), the other correlations are all positive, the highly significant correlations are between summer and summer (r=.000). , winter and summer (r=.005), winter and winter (r=.004), winter and fall (r=.002), fall and fall (r=.001) and between spring and spring (r=.000).

For seasonal correlation results for the minimum temperature between other parameters are already detailed with their results previously interpreted. The results of correlations between minimum temperatures show only positive correlations whose correlations between summer and winter (r=.000) and between summer and fall (r=.025) are significant.

5.1.6. Annual correlation results between all parameters

Table 5.6. Annual correlation results between all parameters

1982-2013	Precipitation	Max. Temp.	Ave. Temp.	Min. Temp.
Precipitation	1.000	-.160	-.006	.088
Max. Temp.	-.160	1.000	.546**	.641**
Aver.Temp.	-.006	.546**	1.000	.751**
Min. Temp.	.088	.641**	.751**	1.000

**. Correlation is significant at the 0.01 level (2-tailed)

In this part, the results of annual correlations between annual averages of all parameters are presented in the Table 5.6.

The correlations between precipitation and maximum and average temperature show non-significant negative correlations, whereas between maximum and minimum temperatures their correlation is non-significant positive. A negative correlation already shown negative between the precipitation and the maximum temperature, but between the maximum temperature and the average and minimum temperature the results show these two positive and highly significant correlations (*r*=.001 and *r*=.000). Also a negative correlation with precipitation and also a positive correlation with the maximum temperature already shown above, between the mean temperature and the minimum temperature, the results indicate a highly significant positive correlation (*r*=.001 and *r*=.000). The results show between minimum temperature and precipitation, maximum and average temperature three positive correlations of which those of the maximum and average temperature are highly significant (*r*=.000 and *r*=.000).

5.2. Results of Mann-Kendall Test and Sen's Slope Estimator Tests

Results of Mann-Kendall and Sen's Slope Estimator Tests

Table 5. 7. Results of Mann-Kendall and Sen's Slope Estimator Tests

1982-2013	Precipitation		Maximum Temperature		Average Temperature		Minimum Temperature	
	M-K (*Z*)	Slope (*Q*)	M-K (*Z*)	Slope (*Q*)	M-K (*Z*)	Slope (*Q*)	M-K (*Z*)	Slope (*Q*)
January	0.39↑	2.52	1.68↑	1.32	1.92↑	1.58	4.01*↑	2.99
February	1.65↑	3.90	-0.35↓	-0.51	0.64↑	0.35	1.49↑	1.12
March	0.80↑	1.59	0.11↑	0.10	0.25↑	0.18	1.26↑	0.94
April	-0.27↓	-1.08	1.19↑	1.30	1.76↑	1.51	2.03*↑	1.50
May	-0.83↓	-1.16	0.06↑	0.00	0.22↑	0.18	-0.08↓	-0.17
June	-0.39↓	-0.17	1.10↑	1.02	1.23↑	0.64	0.41↑	0.27
July	-1.81↓	-0.79	2.28*↑	2.08	1.99*↑	1.54	1.16↑	0.74
August	1.60↑	1.08	2.18*↑	1.99	1.18↑	0.90	1.79↑	0.05
September	1.67↑	1.49	2.28*↑	2.04	2.01*↑	1.57	3.05*↑	2.97
October	0.03↑	0.35	0.82↑	0.78	0.08↑	0.06	0.85↑	0.59
November	-0.05↓	-0.11	2.78*↑	2.12	0.83↑	0.70	2.99*↑	1.99
December	-0.24↓	-1.53	1.95↑	1.36	1.89↑	0.62	2.69*↑	1.79

$Z_s = \pm 1.96$

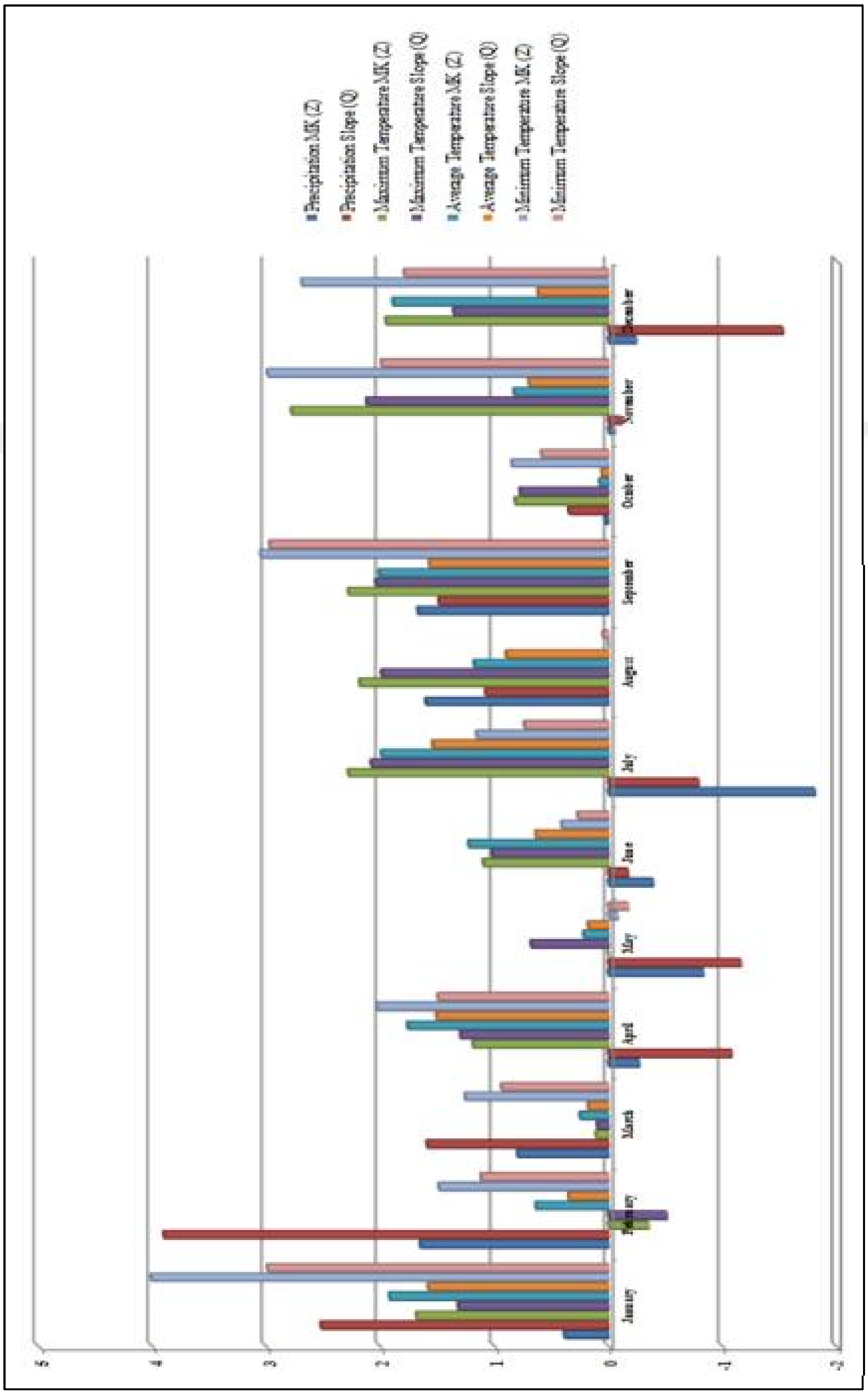

Figure 5.1. Trends for Mann-Kendall and Sen’s Slope

The results of the applied Mann-Kendall and Sen's Slope tests for monthly over the period 1982-2013 are presented in Table 5.7. Precipitation results of Mann-Kendall and Sen's Slope tests showed six increasing and six decreasing tendencies and similary for all slopes that all are insignificant trends. Özfidaner and Topaloğlu (2007), the results founded indicate that precipitation data for Turkey of seven regions was determined decreasing trend, especially in winter. In autumn, spring and summer, increasing tendency of precipitation was determined. There was a general decrease in precipitation in the South East Anatolia Region, while in other regions increasing and decreasing trends within the year were close to each other. The results obtained showing a general downward trend during the winter months in the Central Anatolia region may be due to climatic factors, the modernization of agricultural activities and land use, plantations, reforestation, forest fires, road construction and urbanization. And the reduction of precipitation in spring and winter will cause the problem over the semi-period in the Central Anatolia region for the cultivation and production of cereals (Özfidaner et al. 2018).

Maximum temperature showed a single insignificant decreasing trend and slope at February and all eleven months indicated increasing trends that four highly significant increasing trends and slopes were obtained for months of July, August, September and November, seven significant increasing trends and slopes were observed for months of January, March, April, May, June, October and December.

According Mann-Kendall and Sen's Slope tests all trends observed are increasing and two trends are highly significant in July (Z=1.99) and in September (Z=2.01) for average temperature. Yunling and Yiping (2005) analyzed climate change trends and characteristics during 1960-2000 at 19 stations along the Lancang River (China) according to the archival data of monthly air temperature and precipitation series. They found increases in temperature and decreases in precipitation.

The minimum temperature showed one decreasing trend and slope in May and the rest of the trends and slopes are all increasing but the highly significant are observed in January (Z=4.01), in April (Z=2.03), in September (Z=3.05), in November (Z=2.99) and in December. Gan (1998) conducted a Mann-Kendall test on temperature and precipitation data from 37 stations for the period 1949-1989 in Canada and determined that the temperature had increasing and the drought had started for the last 40-50 years. At the beginning of the droughts they stated that temperature was more effective than precipitation.

Comparing the observed Spearman correlation results and Mann-Kendall trends results, the Spearman test results show 72 positive correlations and 60 negative correlations and Mann-Kendall shows 6 increasing trends and 6 decreasing trends with a very low significant rate on precipitation. In terms of maximum temperature Spearman's test results show 100 positive correlations and 32 negative correlations and Mann-Kendall shows 11 increasing trends and a decreasing trend. The mean temperature results show with the Spearman correlation test128 positive correlations against 4 negative correlations and Mann-Kendall shows 100% increasing trends. For the minimum temperature, the Spearman test results show 124 positive correlations and 8 negative correlations and Mann-Kendall shows a decreasing trend and 11 increasing trends.

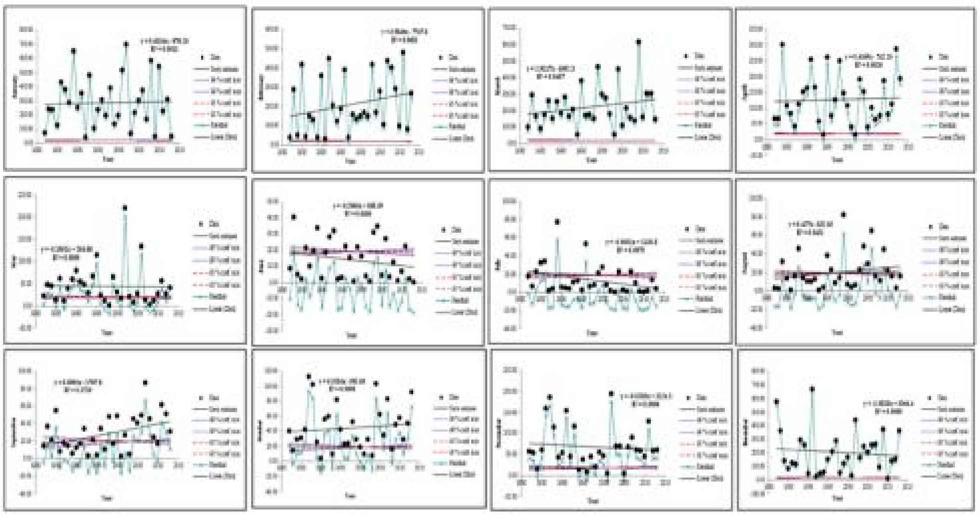

Figure 5.2. Mann-Kendalla and Sen's Slope trends of precipitation

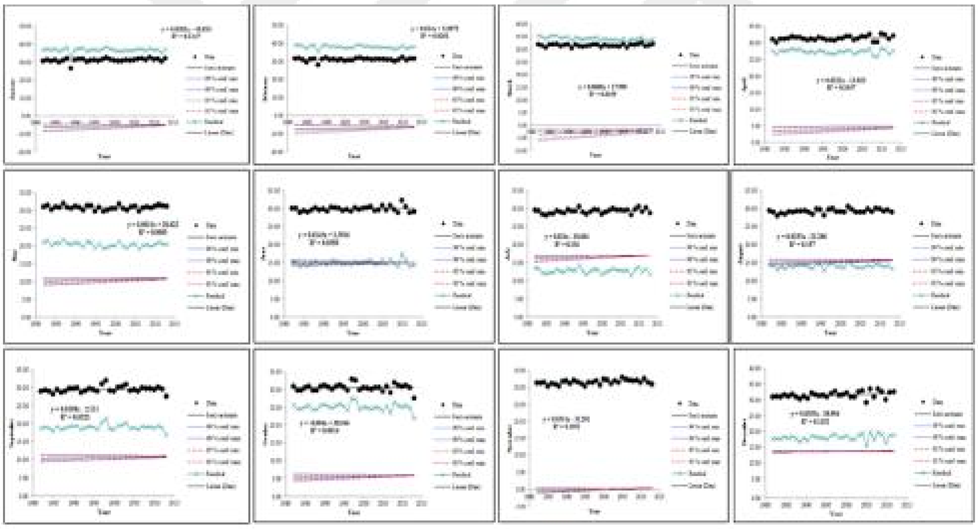

Figure 5.3. Mann-Kendalla and Sen's Slope trends of maximum temperature

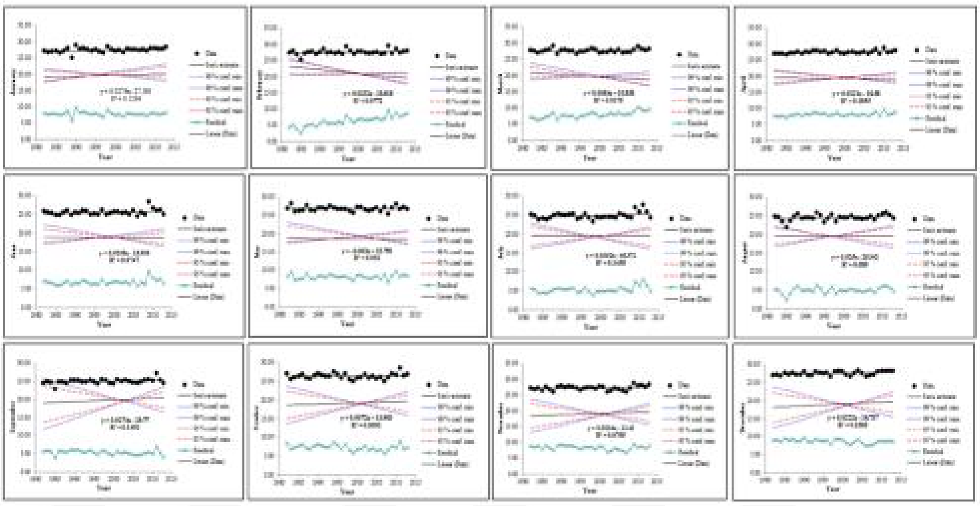

Figure 5.4. Mann-Kendalla and Sen's Slope trends of average temperature

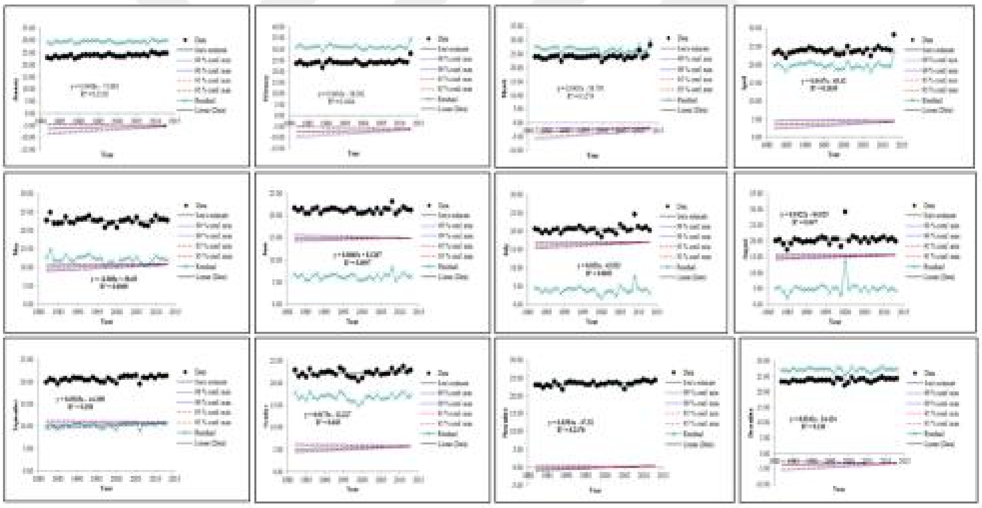

Figure 5.5. Mann-Kendalla and Sen's Slope trends of minimum temperature

6. CONCLUSION AND RECOMMENDATIONS

This study has given satisfying results that allowed looking at the changes of climate over the last 32 years (1982-2013) at Grand-Comoros.

As the results of Spearman test that show positive and negative correlations between precipitations, maximum, average and minimum temperatures.

The precipitation's results obtained show one positive significant correlation and 35 months show positive but not significant correlations. But also observe 30 months shown insignificant negative correlations. Between rainfalls, an influence has been proved that concludes that during this month, the growth or the decrease of the rain is related to each other. The 35 months of insignificant positive correlations prove the influences but insignificantly as well as for the 30 months of negative correlations. Yu et al., (2017) in their study of analysis on the climate change characteristics of Dianchi Lake Basin under the background of global warming by using Spearman rho correlation according to the results; they concluded that the change of humidity affected the temperature change to a certain extent. Precipitation had a trend of increasing 31.32mm/10 years before the year of 2006 and declining trend since 2006 (52.03mm/10 years), while the population had a tendency of increasing.

The maximum temperatures indicate 32 non-significant negative correlations and 100 positive correlations that 14 correlations are significant: 4 are significant and 10 are highly significant. All months show positive significant correlations means that these maximum temperatures increase or decrease by more influence between themes.

Average temperature showed 4 negative insignificant correlations and 128 positive correlations that 40 correlations are significant: 22 are highly significant and 18 are significant. All months show positive significant correlations means that these maximum temperatures increase or decrease by more influence between themes. Nakimbugwe Annet Kateregga, (2009) studied relationship between daily temperatures and rainfall at Uganda by using Spearman's rank correlation analysis and concluded that the regression analysis of daily measurements of maximum temperature showed strong positive trend and significant relationship at 95% confidence level whereas regression analysis of daily of minimum temperature indicated a weak positive significant relationship at 95% confidence level. The regression analysis of daily rainfall amounts revealed a very weak positive trend and significant relationship at 95% confidence level.

Minimum temperature (Table 4) obtained with Spearman rho correlation test shown 8 negative insignificant correlations and 124 positive 68 correlations are significant: 40 are highly significant and 28 are significant. All months show positive significant correlations means that these maximum temperatures increase or decrease by more influence between themes.

In the study on the trend and variability of the surface air temperature in Spain by using Spearman non-parametric rho; in general, there have been increasing trends in both seasonal and annual temperatures. The remark made meant that regional trends in annual or seasonal temperature are closely related to changes in the global climate system. And the global warming of the period 1920-2006 could be largely related to the growing trend observed over the last decades, especially from the mid-1970s (El Kenawy et al. 2012).

The results of the seasonal correlations between all the parameters show that the precipitation influences more negatively (32 correlations) than positively (28 correlations) the other parameters; the maximum temperature influences more positively (41 correlations) than negatively (19 correlations) the other parameters; the average temperature influences more positively (48 correlations) than negatively (12 correlations) the other parameters and the average temperature influences more positively (51 correlations) than negatively (9 correlations) the other parameters. Compared to the annual correlation results (table 5.7) obtained between all the parameters, the results agree that the precipitation did not influence the maximum and average temperatures, but it influenced the minimum temperature with a positive correlation. The maximum temperature strongly influenced the mean and minimum temperatures as they showed positive and highly significant correlations. The average temperature has highly influenced maximum and minimum temperatures. The minimum temperature influenced all the parameters since it showed positive but high correlations with the maximum and average temperatures with respect to precipitation.

Based on the results of the Mann-Kendall and Sen's Slope tests (Table 5.7) showing six increasing trends and slopes and six decreasing trends and slopes, all of which are insignificant for precipitation, meaning that precipitation increases as follows: 2.52 mm, 3.90 mm, 1.59 mm from January to March; then decreases from -1.08 mm, -1.16 mm, -0.79 mm from April to July, increases following of 1.08 mm, 1.49 mm, 0.35 mm from August to October and finally decreases of -0.11 mm, -1.53 mm from November to December.

According to the results of the maximum temperature, February reflects a trend and decreasing slope insignificant which justifies the decrease of the maximum temperature of -0.51 °C and showing for all the other months insignificant trends and slopes justify a slight increase in January (1.32 °C), Mars (0.10 °C), April (1.30 °C), May (0.00 °C), June (1.02 °C), October (0.78 °C) and December (1.36 °C) and justifies the high increase in July (2.08 °C), August (1.99 °C), September (2.04 °C) and November (2.12 °C) compared to their trends and increasing slopes highly significant.

In relation to the results of the average temperature showing only insignificant and significant increasing trends justify all the equally increasing slopes observed. The average temperature showing only trends and slopes in increasing some of them are significant in July (1.54 °C) and September (1.57 °C) and insignificant in January (1.58 °C), February (0.35 °C), Mars (0.18 °C), April (1.51 °C), May (0.18 °C), June (0.64 °C) , August (0.90 °C), October (0.06 °C), November (0.70 °C) and December (0.62 °C).

And the minimum temperature indicating an insignificant decreasing trend and slope in May (-0.17 °C) and for the other months their trends and slopes are in increasing, the minimum temperature in February (1.12 °C), Mars (0.94 °C), June (0.27 °C), July (0.74 °C), August (0.05 °C) and October (0.59 °C) are not significant but in January (2.99 °C), April (1.50 °C), September (2.97 °C), November (1.99 °C) December (1.79 °C) months their trends and slopes are highly significant.Thus, the trend rate obtained shows 83.3% for increasing trends and 16.7% for decreasing trends.

As recommendations, Comoros currently has a total of five weather stations with good automatic very equipped; this study must continue with all these stations for an effective deepening of trend analysis and others statistical studies like homogeneity test of climatic parameters of Comoros. Further research should be undertaken with the participation of all sectors (public and private) to carry out this work and collective studies to better deal with the consequences of climate change.

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BIOGRAPHY

I am Comorian, born in 27 July 1985, the fourth born in the family whose 8 children five boys and three sisters. I was born to a modest family of a father (driver): Bourhane Ahmed Salim born in 1947 and a mother (housewife): Nourou Daoud Zoubert born in 1955; both from Domoni. I studied General education in high school where I passed and successful national exams in 2004 which qualified me to start my undergraduate studies in 2005 at former Professional Training Unit now called Institute of Applied Biology (IBA). In Jun 2009 I got my bachelor’s degree from the Faculty of Sciences of Life and Earth University of Majunga (Madagascar), in Agriculture as option. Before awarded the scholarship of Turkish Government (Türkiye Busları) for the promotion of 2014-2015, I worked as a Consultant trainer to benefit farmers on the composting of organic waste in compost from 2011 to 2013 within the PNDHD Project (Comoros). And, as Monitoring and Recovery Agent from 2012 to 2014 in the AMIE Project (Comoros). Now day I am completing my Master’s degree in the Agricultural Structures and Irrigation Department at Çukurova University.