Rainfall and Runoff in the western region of Libya

Dr.Abdulfatah F Abeufayed

The third assessment report of intergovernmental panel on climate change (IPCC) represented a consensus among the world's leading climate scientists that rapid climate changes were occurring on a global scale and define climate change as "any change in climate over time, whether due to natural variability or as a result of human activity". Climate change indicators should give an overview of the climate and it's development. Climate change indicators are primarily used to simplify the complex reality and to communicate, more succinctly of crucial information regarding climate trends. In establishing indicators, a distinguish can be made between primary indicators based on analyses of directly observed meteorological data, and secondary indicators based on responses of the living world to climate changes which provoke in living organisms. Precipitation data in the region were obtained from the Libyan National Climate Center (LNCC). The runoff collected in dam records were obtained from General Water Authority (GWA). The research has assessed a few of potential indicators for western region of Libya and has established several potentially valuable data sources which satisfy or partially satisfy the requirements that a good indicators should have. The month monitoring began 1972 when there is no awareness of climate change, but the importance of this data has now been realized. Both the meteorological data and water resource monitoring data have been shown to provide useful information on climate change in Libya. Clearly the climate in Libya is changing, as it always has and as it always will. The indicators examined in this study suggest that Libya is a maritime location buffered by the Mediterranean sea from extremes of climate. Libya is warming, albeit at a somewhat delayed the climate change rate, not as the trends apparent in global scale. This study shows importance of climatological data and water resource data records, and importance of depending on charting at climate data for more accuracy in predicting climate change.

Key words: Climate, Climate change, Climate change indicators, Libya, Western region.

1 Introduction

Climate change is the most international research issue over the whole world. The IPCC report asserts that the evidence for a human influence on global climate is now stronger than ever before and states that "increasing concentrations of anthropogenic greenhouse gases have contributed substantially to the observed warming over the last 50 years." The average atmospheric CO_2 concentration has increased from 280 ppm in 1850 to 365 ppm at present, and could exceed 700 ppm by the end of the present century if emissions continue to rise at current rates (IPCC, 2001). European annual mean temperatures have increased by 0.5-0.6°C since 1900. A further increase of 2°C above the 1990 level is predicted for 2100 (EEA,1998). This will have increasing impacts on natural and agro-ecosystems, human health, and water resources. Some of the climate driving forces may be sudden, having an immediate impact, while others may take much longer to be felt (Tyrrell, 1994). Globally precipitation has been increasing by 0.5-1% per decade over the course of the 20th century and most global climate models predict winter precipitation to increase and summer to be

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to/provides information's about/describes the state of a phenomenon/environment/area with significance extending beyond that directly associated with a parameter value" IPCC (2007) . In establishing indicators a distinguish can be made between primary indicators based on analyses of directly observed meteorological data, and secondary indicators based on responses of the living world to climate changes which provoke in living organisms. Climate change indicators are primarily used to simplify the complex reality and to communicate, more succinctly of critical information regarding climate trends (LBA, 1999). This study aims to assess potential indicators of climate change for western region of Libya and to establish several potentially valuable data sources which satisfy or partially satisfy the requirements that a good indicators should have. Therefore, precipitation data in the region were obtained from the Libyan National Climate Center (LNCC) and the runoff collected in dams entrance records were obtained from General Water Authority (GWA).

3. Materials and Method

3.1 Area of study

The area of study is located in the north western region of Libya, where the most population of Libya were concentrated. The area of study with almost triangular in shape is a part of Tripolitania bounded by the following coordinates, long. 11° 00' – 15° 00' E, Lat. 31° 52' – 32° 54' N. The area under study extends for 470 km from west to east its width (distance from sea side) varies between 80 and 315km from east to west. The relief of the Tripolitania territory under study has developed in the course of geomorphologic evolution in the recent geologic period of tectonic activity. The intensification of fault tectonics gave rise to volcanic activity. Basalt lava effusion from fissures led to the formation of spacious volcanic plateau on Jebel Nefusa (Nefusa mountain). As a result, there appeared three largest morphostructures of the western region, namely: the littoral plain (Jeffara lowland) and outlier plains on the Jefra lowland and in between Jebel Nefusa plateau as in the fig (3.1).

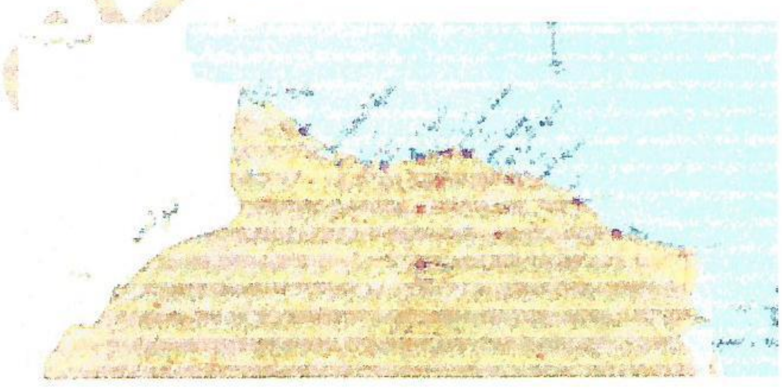

Figure 3.1 Region topography and station location after National atlas of Libya 1981.

There are many wadis cross the Jeffara Plain in the western region as (wadi El Mjinin , wadi Ghan, wadi Jeffara Plain . The width of the largest wadis reaches 100 m and more. The wadis cut a depth of 5-7 m.

3.2 Climate and hydrology of region

The region is situated in Mediterranean climate type (rainy cold in winter and warm dry in summer). Precipitation period from October up to March is 85-90% of the annual precipitation its maximum being distinctly evident in winter because of increased cyclonic activity in the Mediterranean zone. Most of the precipitation comes as rain form but sometimes it comes in hail or snow form as well, especially on the mountainous area (Nefusa upland). Precipitation has been began measured by instruments in Libya since the end of the nineteenth century by the Italian and French embassies at that time in Tripoli city. The first oldest network of precipitation observations was established since twenties of the last century at Italian occupation duration for Libya, the number of installed stations reached 214 station where 66 of them considered as climatic station the rest of them as rain gages only , therefore this data is considered as the oldest set of data available in climate archive shelves. The recent network has been established since the beginning of the sixties of the last century consist of 300 stations (40 as meteorological stations and rest of them as rain gages only) where the maximum density coverage the north west region of Libya (Elfadli, 2009). Small amount of precipitation in the rainy season causes episodic surface runoff. The runoff forming during the rainy period, discharges partially into the sea along the dry beds, especially for the eastern part of the region. In the western half of the region only Wadi Lingmer reaches the Mediterranean sea. Thus, the major part of the Jeffara plain is characterized by the absence of natural surface drainage. The precipitation and runoff infiltrated into the ground to recharge the surface ground water aquifers (Gomes, 1971).

3.3 Material of study

The monthly basis historic climate data (precipitation) for long term data stations in the Western zone of Libya were obtained from Libyan National Climate Centre (LNCC). Four stations represented Jeffara plain from east to west (Misurata, Tripoli city, Tripoli A/P and Zawara) and two stations represent Nefusa upland (Ghariyan and Nalut) were used to provide primary indicator for the region. These stations are considered a good representative for the Western zone, as they cover the north- west, north- east, south- west and middle- east part of Western zone region as shown by Fig (3.1). The entire climate database period 1961-1990 represents the recent historic prediction or baseline.

3.3.1 Precipitation indicators for western zone region

Long term (1961-2002)on monthly basis records of the most of the main synoptic 7 station in the region, due to big variation in rainfall in the region two more rainfall data were taken . Al-koms synoptic station where Nefusa upland drops in the sea in location between Misurata and Tripoli city, and Al-Azezyah rainfall gage in the middle of Jeffara Plain in the mid distance between Tripoli city and Gharian city. The annual amount of these stations were evaluated and the average of this period were estimated and contrasted by the previous mean for a few number of long term station as Tripoli city and Gharian . The

trends of 75 stations with different data long were checked with time and the results trend as shown in

3.3.2 Secondary Indicators

Surface water in the region: the data recorded for the monthly runoff at the entrance of dames' in the

Authority (GWA). The annual runoff and mean of it were estimated and seven years average and seven years average moving on were estimated too. The trends of annual runoff in these dams were investigated and it's relation to annual rainfall in the catchment's area were studied the results are shown in result chapter.

4. Result and Discussion

4.1 Precipitation as primary climate change indicator for the western region of Libya

Precipitation is generally occurs in the form of rain and sporadic storms from time to time in the forms of hail and snow. There is great variability from place to place and from year to year in the same place. The statistic analysis shows that the mean annual rainfall for the region is 278 mm/year, the range (100-411) for years, while the standard deviation and variance between locations and years are very high (Stdev; 70 and 77) and (Var: 4972 and 5995). Mean annual precipitation indicators had been used globally to expect change in climate. The rain distribution over the whole months of the year for the main stations of the region as shown in the Fig 4.1. These stations considered a good representative for the region, as they cover the north- west (Zwara station), north east (Misurata station), west south (Nalut) and the Mideast (Gharian). While Tripoli city has the highest monthly rain in September, October, November and December, Gharian has the highest monthly rain in January, February, March and April.

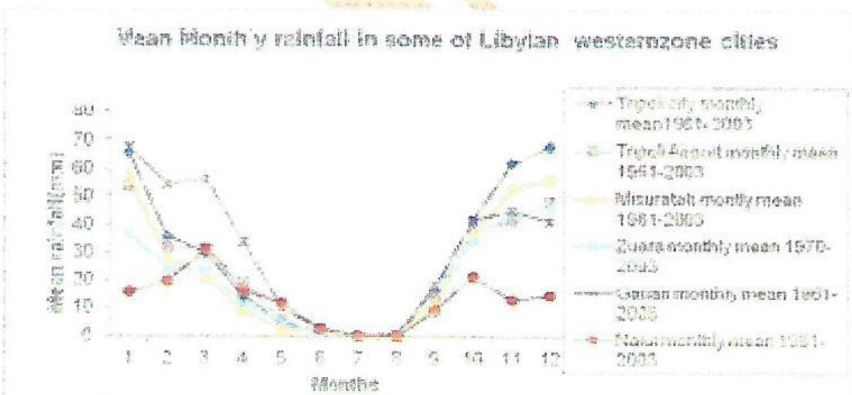

Figure 4.1 Mean monthly rainfall over the whole year for the most station represent the region

The mean monthly and mean annual rainfall for the periods (1919-1970) and (1961-2003) were estimated and compared for the two long term stations (Tripoli city and Gharian). The result show that the mean of the latest period is greater than the previous period as shown in Fig 4.2

Figure 4.2 Contrast between mean monthly and annual rain for two periods (1919-1975) and (1961-2002) for two stations in the region

While Gharian has the highest annual rain mean (370 mm/hr) and Tripoli city comes after (350 mm/hr). The regression analysis shows an increasing trend for Tripoli city while it decreasing trend for Gharian as shown in the Fig 4.3, therefore 22 rain stations in the region checked their trend and results shows a decreasing trend for the most of them although Tripoli airport except for stations around Tripoli city along the coastal area from Garabolle in the east up to Sorman in the west. This confirm what mention by Folland 2001 "Although most global climate change models predict winter precipitation to increase, this trend is not corroborated convincingly for all world regions".

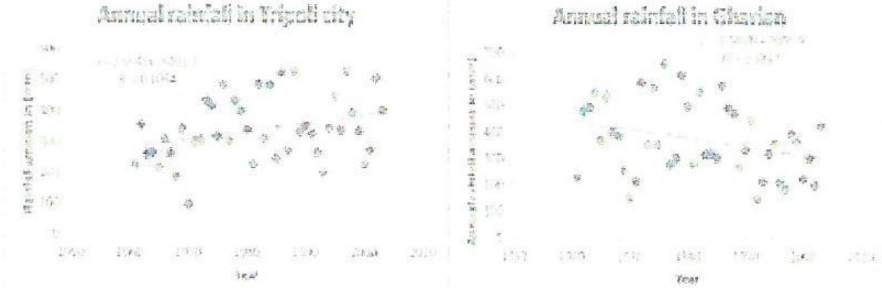

Figure 4.3 Contrast between annual amount of rainfalls and their trends in two areas represent the region

The mean annual rainfall was estimated for the region, annual rainfall, ten years average and ten years moving on were estimated also and all of them were plotted in the same Fig 4.4 to give a picture for change in the rain amount from year to year and from period to period by ten years average and ten year moving on average as they used to smooth the fluctuation in annual rainfall mean. The annual mean goes up and down from year to year except for five years period (1967-1971) and seven years period (1996-2002) where the annual rainfall below the mean of the region. While Ten years av parameter were below mean for the first and forth decades and greater for second and third ones. The Ten years av moving on smoothing the fluctuation a bit more and give an increasing trend up to 1971 and decreasing after that as shown by the Fig 4.4.

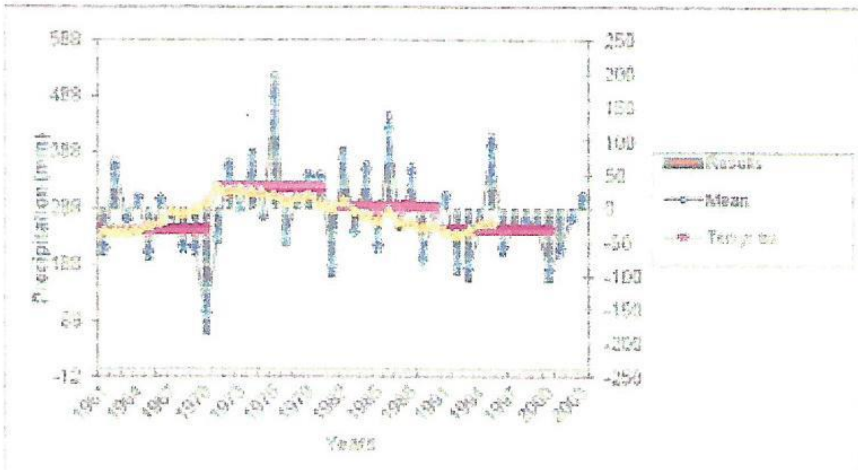

Figure 4.4 Annual mean of precipitation, Ten years average and Ten years average going on for the western region

4.3 Secondary Indicators

4.3.1 Run off collected in dams as a Secondary Indicator

The average annual rainfall is 288 mm in the western region of Libya. The highest rainfall occurs in Tripoli city area on Jiffara Plain and in Gharian area on Jebel Nefusa upland. Rainfall occurs during the winter months and shows an extreme variability from year to year and from place to place. The measure annual runoff amount at the entrance of dams shows significant increasing trend. Although the rainfall data in the recharging area (Nafousa upland) is showing a decreasing trend but this could be due to change on the nature of the rain as it become more intensive and the most of its lost as surface runoff collected in dams reservoirs, as shown at fig below. This confirms what was mention in the third assessment report that some signs of increased rain intensities are being measured in different parts of the world and confirm importance of checking gauges records as well.

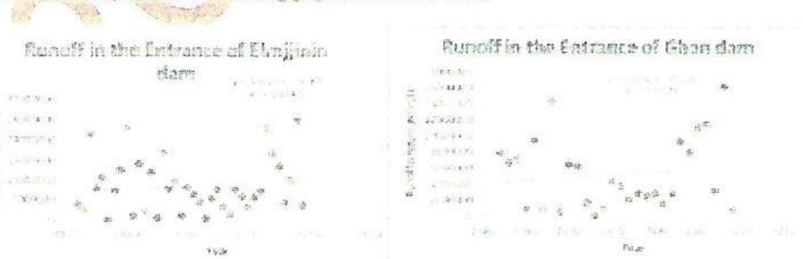

Figure 4.5 Annual mean of runoff collected in Al-mejinin and Ghan dams and their trends.

The figure below shows a proportional relation between annual amounts of runoff collected in Al-

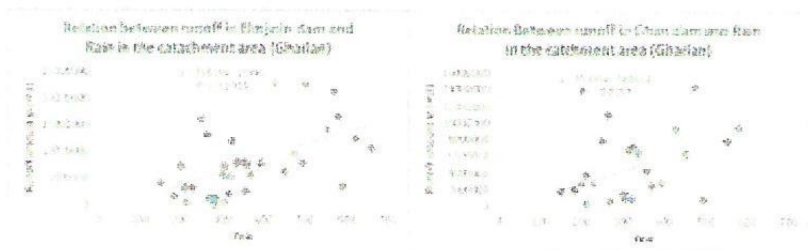

Figure 4.6 Relation between Annual runoff collected in Al-mejenin and Ghan dams and the rainfall in recharge area (Gharian).

Figure 4.7 displays an index derived from the annual runoff collected in Al-mejenin dam and also the seven years moving average and seven years moving on average . The annual runoff amount is different from year to year while ninths decade is below the average of the first thirty years (1977- 2001) which is taken as the base line data after that start to increase and five from the last seven years greater than line mean. The first seven years average equal to the base line mean while second over it, the third and forth keep decreasing below base line mean and last seven years sequence goes greater than the base line mean. The seven years moving on average shows a decreasing trend up to the end of ninth decade when where it shows an increasing trend.

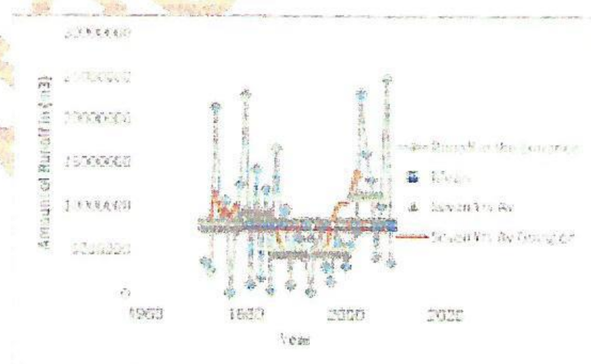

Figure 4.7 Annual of runoff, 10-yrs av and 10 yrs moving on av for Al-mejenin dam.

The water resource monitoring began 1972 when there is no awareness of climate change and it wasn't long enough to be used as climate change indicators, but the importance of this data has now been

useful information on climate change in Libya. Clearly the climate in Libya is changing, as it always has, and as it always will. The indicators examined in this study suggest that despite a maritime location

delayed the climate change rate, not as the trends apparent at global scale. This study show also importance of climatological data and water resource data records, and importance of depending on charting of climate data for more accuracy in predicting climate change.

5. Conclusion

This study show importance of climatological data and water resource data records, and importance of depending on charting of climate data for more accuracy in predicting climate change. This study has assessed a few of potential indicators and has established several potentially valuable data sources which satisfy or partially satisfy the requirements that a good indicator should have. Although water resource monitoring records not long enough to be used as climate change indicators, but the importance of this data has now been realized. Both the meteorological data and water resource monitoring data have been shown to provide useful information on climate change in Libya.

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As Climate change Indicators

Abdulfatah F Aboufayed

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decreased, but this trend looks not corroborated convincingly for all regions of world as for Britain and Ireland (Folland et al., 2001). The third assessment report of intergovernmental panel on climate change represented a consensus among the world's leading climate scientists that rapid climate changes were occurring on a global scale and define climate change as "any change in climate over time, whether due to natural variability or as a result of human activity" IPCC (2001) . Climate change indicators should give an overview of the climate and it's development. The Organisation for Economic Co-operation and Development (OECD, 1993) defined an indicator as " a value derived from parameters, which point to/provides information's about/describes the state of a phenomenon/environment/area with significance extending beyond that directly associated with a parameter value" IPCC (2007) . In establishing indicators, a distinguish can be made between primary indicators based on analysis of directly observed meteorological data, and secondary indicators based on responses of the living world to climate changes which provoke in living organisms. Climate change indicators are primarily used to simplify the complex reality and to communicate, more succinctly of critical information regarding climate trends (EEA, 1999).. This study aims to asses potential indicators of climate change for western region of Libya and to establish several potentially valuable data sources which satisfy or partially satisfy the requirements that a good indicators should have. Therefore, precipitation data in the region were obtained from the Libyan National Climate Center (LNCC) and the runoff collected in dams entrance records were obtained from General Water Authority (GWA).

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Figure 3.1 Region topography and station location after National atlas of Libya 1981.

There are many wadis cross the Jeffara Plain in the western region as (wadi El Mijinin , wadi Gan, wadi Zarit and others). Numerous wadis originating from Jebel Nefusa upland terminate as dry deltas on the Jeffara Plain . The width of the largest wadis reaches 100 m and more. The wadis cut a depth of 5-7 m, having steep and abrupt banks and flat bottom covered with coarse- texture alluvium. Sometimes, a fluffy mantle is stripped off, and the bottoms expose bedrocks or crusts (Russian study, 1980).

3.2 Climate and hydrology of region

The region is situated in Mediterranean climate type (rainy cold in winter and warm dry in summer). Precipitation period from October up to March is 85-90% of the annual precipitation, its maximum being distinctly evident in winter because of increased cyclonic activity in the Mediterranean zone. Most of the precipitation comes as rain form but sometimes it comes in hail or snow form as well, especially on the mountainous area (Nefusa upland). Precipitation has been began measured by instruments in Libya since the end of the nineteenth century by the Italian and French embassies at that time in Tripoli city. The first oldest network of precipitation observations was established since twenties of the last century at Italian occupation duration for Libya, the number of installed stations reached 214 station where 66 of them considered as climatic station the rest of them as rain gages only, therefore rain data is considered as the oldest set of data available in climate archive shelves. The recent network has been established since the beginning of the sixties of the last century consist of 300 stations (45 as meteorological stations and rest of them as rain gages only) where the maximum density coverage the north west region of Libya (Elfadli, 2009). Small amount of precipitation in the rain season causes episodic surface runoff. The runoff forming during the rainy period, discharges partially into the sea along the dry beds, especially for the eastern part of the region. In the western half of the region only Wadi Elmjjinin reaches the Mediterranean sea. Thus, the major part of the Jeffara plain is characterized by the absence of natural surface drainage. The precipitation and runoff infiltrated into the ground to recharge the surface ground water aquifers (Jounes, 1971).

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Long term (1961-2003)on monthly basis records of the most of the main synoptic 7 station in the region. due to big variation in rainfall in the region two more rainfall data were taken . Al-homs synoptic station where Nefusa upland drops in the sea in location between Misurata and Tripoli city, and Al-Azezyah rainfall gage in the middle of Jeffara Plain in the mid distance between Tripoli city and Gharian city. The annual amount of these stations were evaluated and the average of this period were estimated and contrasted by the previous mean for a few number of long term station as Tripoli city and Gharian . The

trends of 25 stations with different data long were checked with time and the results trend as shown in results chapter below.

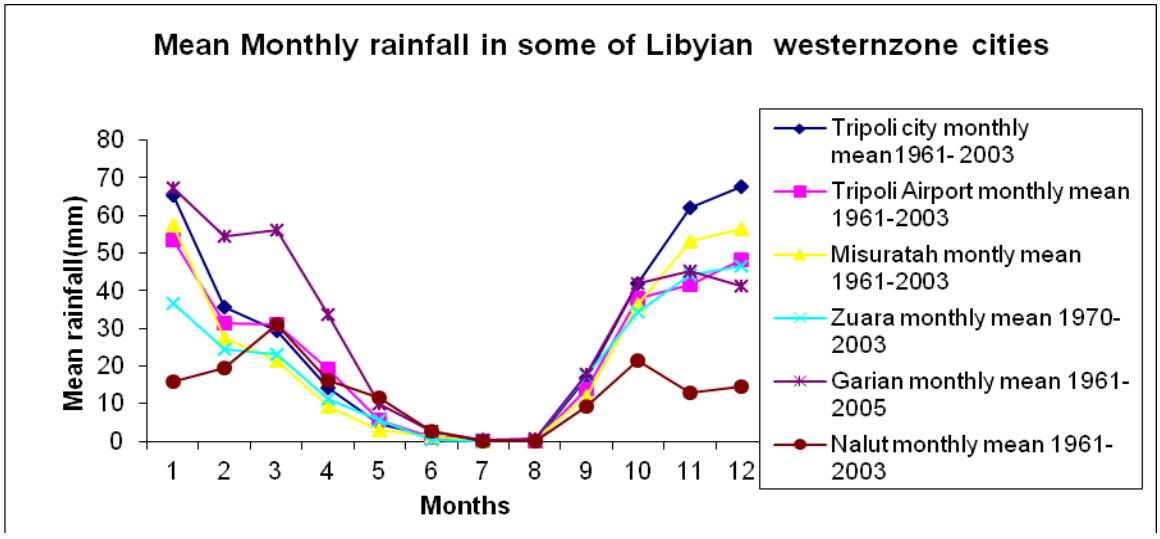
3.3.2 Secondary Indicators

Surface water in the region, the data recorded for the monthly runoff at the entrance of dames' in the region (El-mejjinin dam (1972-2009) and Ghan dam (1982-2009))where obtained from General Water Authority (GWA). The annual runoff and mean of it were estimated and seven years average and seven years average moving on were estimated too. The trends of annual runoff in these dams were investigated and it's relation to annual rainfall in the catchment's area were studied the results are shown in result chapter.

4. Result and Discussion

4.1. Precipitation as primary climate change indicator for the western region of Libya

Precipitation is generally occurs in the form of rain and episodic storms from time to time in the forms of hail and snow. There is great variability from place to place and from year to year in the same place. The statistic analysis shows that the mean annual rainfall for the region = 278 mm/year, the range (100-401) for years, while the standard deviation and variance between locations and years are very high (Stdev; 70 and 77) and (Var; 4972 and 5995). Mean annual precipitation indicators had been used globally to expect change in climate. The rain distribution over the whole months of the year for the main stations of the region as shown in the Fig 4.1. These stations considered a good representative for the region, as they cover the north- west (Zawara station), north-east (Misurata station), west south (Nalut) and the Mideast (Gharian). While Tripoli city has the highest monthly rain in September, October, November and December, Gharian has the highest monthly rain in January, February, March and April.



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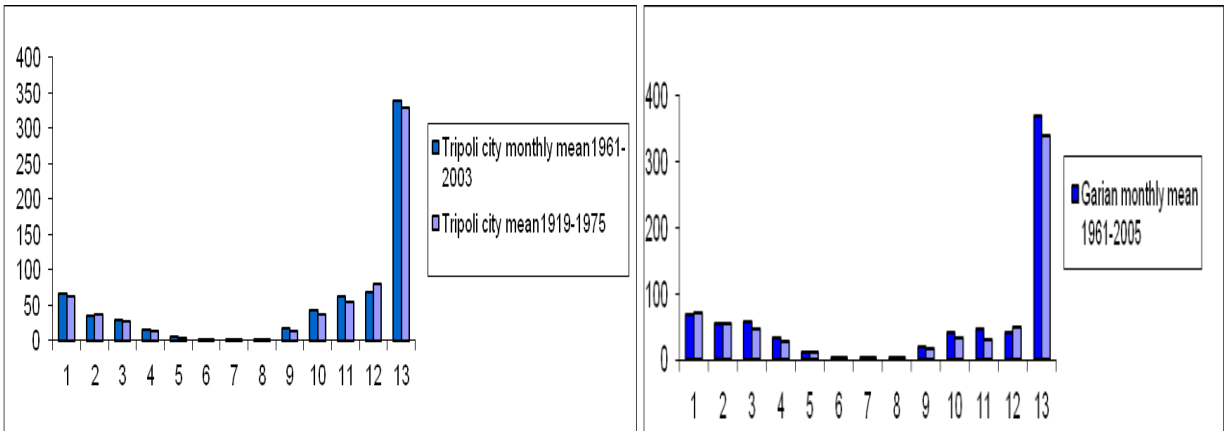

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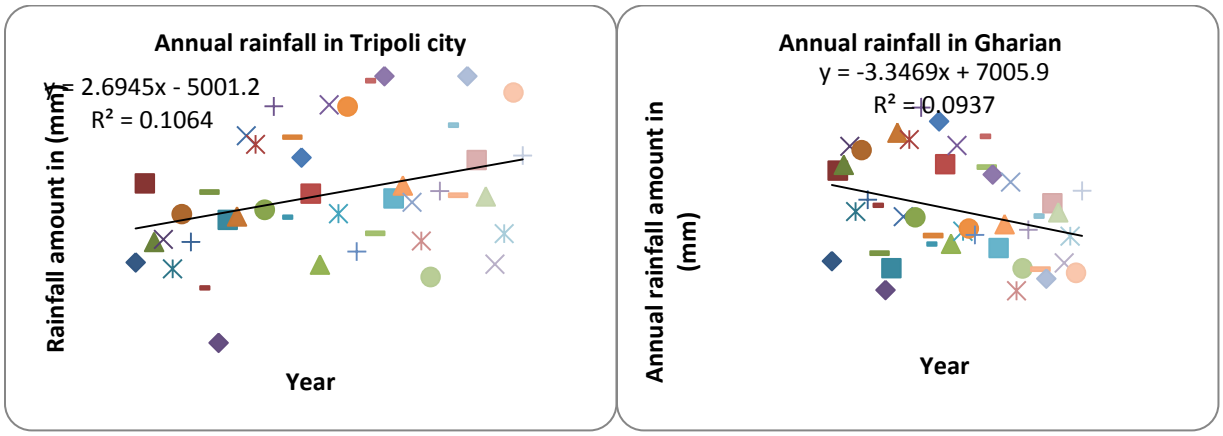

Figure 4.3 Contrast between annual amount of rainfalls and their trends in two areas represent the region

The mean annual rainfall was estimated for the region, annual rainfall, ten years average and ten years moving on were estimated also and all of them were plotted in the same Fig 4.4 to give a picture for change in the rain amount from year to year and from period to period by ten years average and ten year moving on average as they used to smooth the fluctuation in annual rainfall mean. The annual mean goes up and down from year to year except for five years period (1967-1971) and seven years period (1996-2002) where the annual rainfall below the mean of the region. While Ten years av parameter were below mean for the first and forth decades and greater for second and third ones. The Ten years av moving on smoothing the fluctuation a pet more and give an increasing trend up to 1971 and decreasing after that as shown by the Fig 4.4.

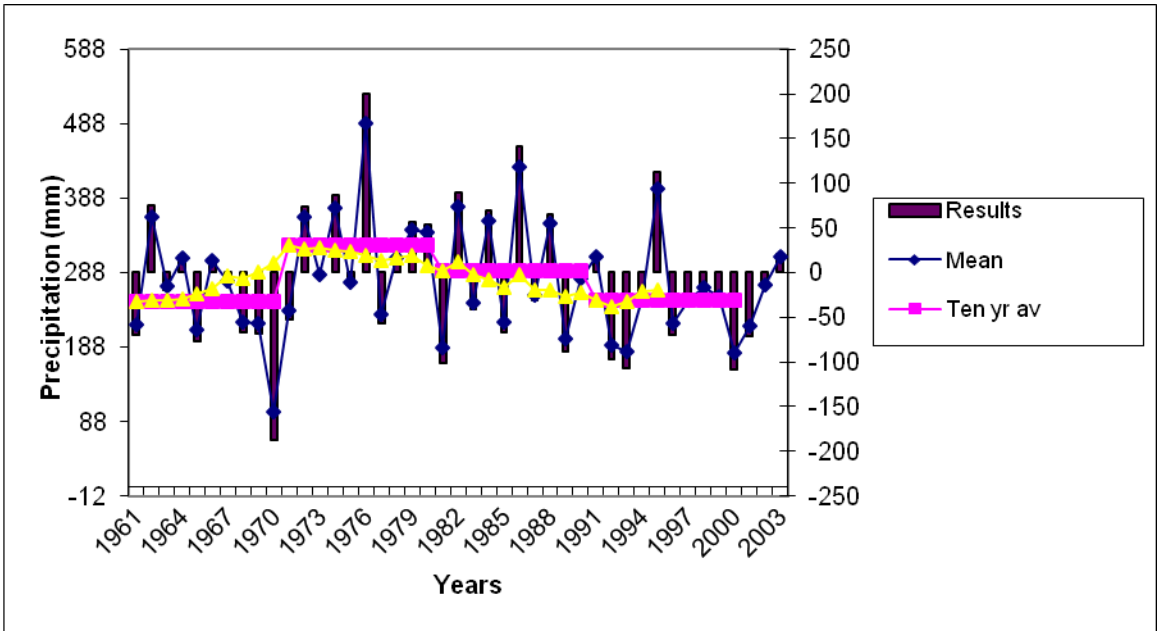

Figure 4.4 Annual mean of precipitation, Ten years average and Ten years average going on for the western region

4.2. Secondary Indicators

4.2.1. Run off collected in dams as a Secondary indicator

The average annual rainfall is 288 mm in the western region of Libya. The highest rainfall occurs in Tripoli city area on Jiffara Plain and in Gharian area on Jebel Nefusa upland. Rainfall occurs during the winter months and shows an extreme variability from year to year and from place to place. The measure annual runoff amount at the entrance of dams shows non significant increasing trend. Although the rainfall data in the recharging area (Nafousa upland) is showing a decreasing trend but this could be due to change in the nature of the rain as it became more intensive and the most of its lost as surface runoff collected in dams reservoirs, as shown in fig below. This confirms what was mention in the third assessment report that some signs of increased rain intensities are being measured in different parts of the world and confirm importance of charting gages records as well.

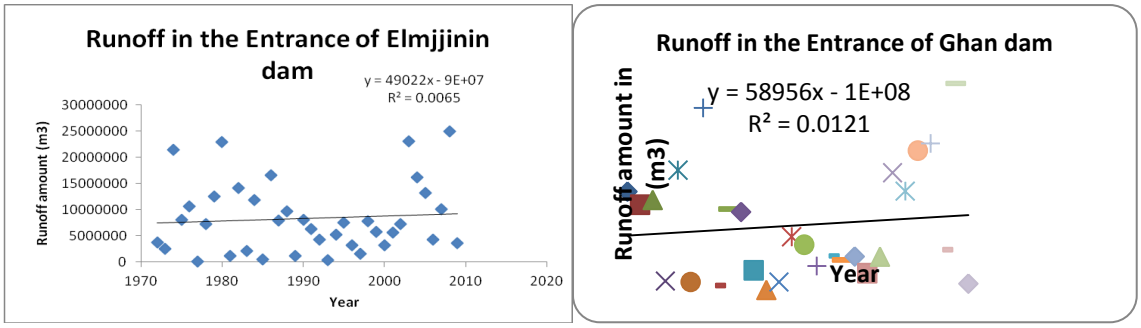

Figure 4.5 Annual mean of runoff collected in Al-mejinin and Ghan dams and their trends.

The figure below shows a proportional relation between annual amounts of runoff collected in Al-mejinin dam and annual rainfall amount in catchments area (Gharian) and also for Ghan dam with determination coefficient = 0.29 and 0.23 consequently.

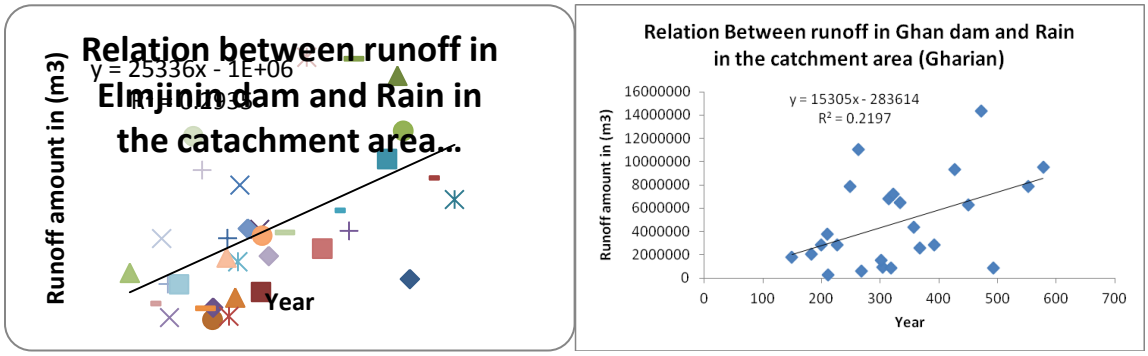

Figure 4.6 Relation between Annual runoff collected in Al-mejinin and Ghan dams and the rainfall in recharge area (Gharian).

Figure 4.7 displays an index derived from the annual runoff collected in Al-mejinin dam , and also the seven years moving average and seven years moving on average . The annual runoff amount is different from year to year while ninths decade is below the average of the first thirty years (1972- 2001)which is taken as the base line data after that start to increase and five from the last seven years greater than line mean. The first seven years average equal to the base line mean while second over it, the third and forth keep decreasing below base line mean and the fifth seven years sequence goes greater than the base line mean. The seven years moving on average shows a decreasing trend up to the mid of ninth decade when where it shows an increasing trend.

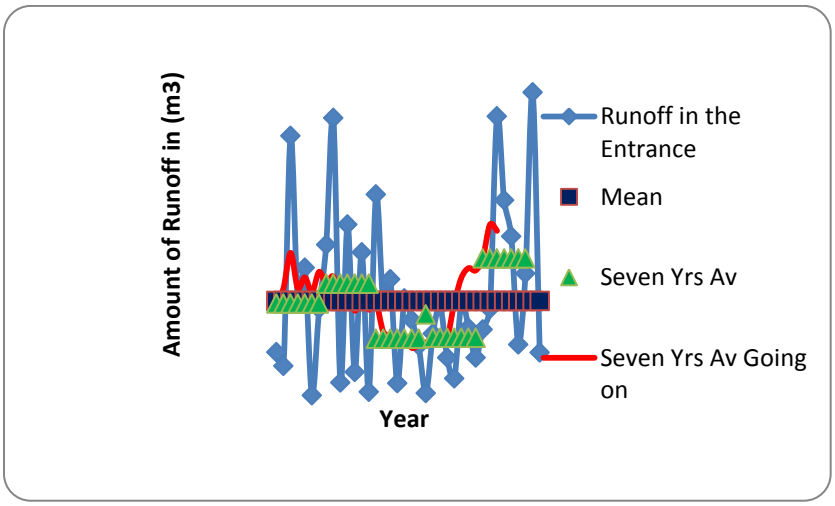

Figure 4.7 Annual of runoff, 10-yrs av and 10-yrs moving on av for Al-mejinin dam.

The water resource monitoring began 1972 when there is no awareness of climate change and it wasn't long enough to be used as climate change indicators, but the importance of this data has now been realized. Both the meteorological data and water resource monitoring data have been shown to provide useful information on climate change in Libya. Clearly the climate in Libya is changing, as it always has, and as it always will. The indicators examined in this study suggest that despite a maritime location buffered by the Mediterranean sea from extremes of climate. Libya is mirroring, albeit at a some what delayed the climate change rate, not as the trends apparent at global scale. This study show also importance of climatological data and water resource data records, and importance of depending on charting of climate data for more accuracy in predicting climate change.

5. Conclusion

This study show importance of climatological data and water resource data records, and importance of depending on charting of climate data for more accuracy in predicting climate change. The study has assessed a few of potential indicators and has established several potentially valuable data sources which satisfy or partially satisfy the requirements that a good indicators should have. Although water resource monitoring records not long enough to be used as climate change indicators, but the importance of this data has now been realized. Both the meteorological data and water resource monitoring data have been shown to provide useful information on climate change in Libya.

6. References

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