IMPACT OF CLIMATIC VARIABILITY ON THE WATER RESOURCES IN THE CATCHMENT SEYBOUSE

Mrad Dounia, Dairi Sabri and Djebbar Yassine

Université Mohammed Chérif Messadia, Laboratoire Gestion, Maintenance InfraRes, Souk-Ahras (Algérie)

ABSTRACT

The Algeria of the North is a Mediterranean country is characterized in arid and semi-arid climates. Surface water is a factor limiting the economic development of the country. Precipitation are a main factor of water courses feeding, have a great interest on the variability of flows at all scales of time. This study aims to show the impact of climate variability on water resources in the basin of Seybouse. For illustrated this phenomenon and gives an idea of its impact, several methods have been used. Reduced centered variable (index of Nicholson), shows a succession of two phases, a rainy phase that occurs between the beginning of the 1940 and the end of the 1970, another deficit phase, which would be held in the early 1980. To better understand the contribution of annual rainfall in the reduction of flows, we applied to the time series of this scale the following statistical tests: statistics U of Buishand, Pettitt test, the Lee Heghinian Bayesian method and procedure of segmentation of Hubert. We concluded that breaks obtained by different methods lie mostly between 1980 and 1990. Resulting that rain falling after the breakdown is between 15% and 20% and there is that this decline has caused a consequence on the flows of major rivers (Oued Cherf, Oued Bouhamdane).

KeyWords: Rain Fall, Statistical Methods, Seybouse.

1. INTRODUCTION

The economic and social development, the growth of the cities, industries as well as the modernization of agriculture involve a considerable increase in the demand for water. Opposite Algeria is a Mediterranean country mainly located in arid region at semi-arid, with a very irregular space-time distribution of precipitations and demands for water increasingly accentuated, the resources become limited and difficult to exploit. Indeed, we knew several periods of dryness which are characterized by overdrawn rain fall and very weak flows of the principal wadis of the basins slopes. For the periods dry, the surface water resources and consequently, stored volumes undergo a very clear reduction. It becomes sometimes difficult to satisfy the demand for water, in particular that intended for agriculture and involving serious consequences on the whole of the socio-economic activities of the country. The major objective of this study is to characterize pluviometric variability using statistical methods and the evaluation of its impact on the water resources in a zone of 6471 km ^{2} of North East of Algeria. From data collected on a network of around fifty pluviometers.

2. PRESENTATION THE ZONE OF STUDY

The zone of study is localized in North East of Algeria. It lies between 5 and 8° northern latitude and 35 and 37° of western longitude. The basin covers 68 communes in seven wilayas of Annaba, Tarf, Skikda, Constantine, Oum El Bouaghi, Guelma and Souk-Ahras. Thirty (30) common are entirely included in the basin and thirty-eight (38) partially. Only agglomerations of Annaba represent eighteen percent (18%) of the total population of the basin. Figure 1 shows watershed of Seybousse basin in under basin according to book of the catchment agency of area Constantinois-Seybouse-Mellegue Numéro 1.

2.1. Collect and formatted of the data

➢ Pluviometric network

The volume of pluviometric information collected in this area consists of a dozen stations distributed in a way at least uniform. We retained that (12) stations because it functioned without stop since 1970. The stations were retained over the period 1970 to 2007 is 37 years except the Bouchegouf station covers a long rain fall series going 1910 up to 2007. Two criteria then allowed us to select the selected stations. We retained only the stations having possible set of data a most complete. We preserved a geographical distribution of these stations so as to cover the largest catchment area. The data are obtained starting from the Agency National of the Hydrous Resources and the Institute of Meteorology. The characteristics of the stations are indicated in Tableau1 and Figure 1.

Table 1. Characterization of rain fall station

Désignation	C	Lat	Long	Alt,m	P. O	Min	Mean	Max	CV
Berriche	140103	921.85	300.5	800	1970-2007	128.50	271.99	492.30	0.34
Ksar Sbahi	140104	910.5	319.05	850	1970-2007	168.50	366.13	627.02	0.38
Aioun Settara	140105	922.4	318.35	741	1970-2007	159.50	322.06	625.70	0.34
Ain Babouche	140109	905.0	303.10	860	1970-2007	45.90	262.10	420.00	0.38
Bordj Sabath	140302	889.1	355.10	525	1970-2007	309.10	538.67	963.40	0.28
Heliopolis	140403	925.15	366.85	280	1970-2007	257.30	594.07	904.70	0.28
Guelma ONM	140407	923.8	362.2	270	1970-2007	222.60	524.31	802.00	0.26
Mechroha	140502	961.15	351.85	748	1970-2007	298.60	1041.86	1952.90	0.43
Bouchegouf	140505	949.2	362.45	800	1910-2007	146.00	570.00	942.00	0.30
Ain Berda	140606	937.6	387.75	100	1970-2007	368.20	616.72	973.00	0.25
El-Kerma	140609	943.69	394.66	14	1970-2007	325.20	575.57	917.10	0.25
Pont Bouchet	140631	949.97	402.82	3	1970-2007	366.10	595.39	961.60	0.24

C : Code; Lat: Latitude; Long: Longitude; P.O: Période Observation; Min: Minimum; Max: Maximum; CV: Coefficient of variation.

➢ Hydrometric network

Several hydrometric stations were established on the rivers of the area catchment Seybouse. We selected two of them located on the principal ones under basins and for which we have the hydrometric data. These stations are Moulin Rochefort on the Cherf River (draining a surface of 1710 km^2) and Medjez Amar on the Bouhamdane River (draining a surface of 1105 km^2). The characteristics of these two stations are indicated in Tableau2 and Figure 1.

Table2 : Caractérisation of flows station

Station	Code	X	Y	Period of observation
Moulin Rochfort	140202	922,349	618,643	1969-2003
Medjez Amar II	140301	912,297	358,723	1969-2003

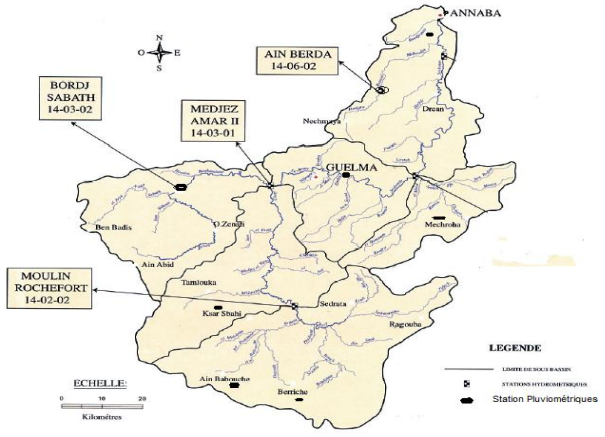

Figure1.Localization of pluviometric and hydrometric stations

3. METHOD

3.1 Index of Nicholson

The index of Nicholson seems a centered and reduced variable. This method makes it possible to follow the fluctuations of the modes pluviometric and hydrological of the area.

Nicholson S.E. et al. (1988) defined an index which is calculated for each year and expresses itself as follows: $I = \left(X_i - \overline{X}\right) / \sigma_\varepsilon$

With Xi: Height of rain per year i (mm); $\overline{X}$: average of the period of study mm; σ: standard deviation of the rain over the period of study.

3.2 Detection of ruptures within the rain fall series

A "break" can be defined by a change in the law of probability of the random variables whose successive achievements define studied time series (Lubes et al., 1994).

From series were analyzed using three methods for detection of average breaks in time series: Pettitt test (1979), the procedure of segmenting series hydro rainfall Hubert and Carbonnel (1987), and the Bayesian of Lee and Heghinian procedure (1977).

These methods were originally programmed in a Pascal environment. The results of this program have been confirmed using the KhronoStat program developed at the Science House of water (ESM) of Montpellier (Lubès et al., 1998).

- Test of Pettitt (Pettitt, 1979): recognized by its robustness, the test is non-parametric and derived from the wording of the Mann-Whitney test. The absence of a break in the time series X is the hypotheses is H_0 void.

- Procedure for segmentation (Hubert et al, 1989): the method is to cut the series m segments (m >1) so that the average calculated on any segment is significantly different from the average of the adjacent segment. This procedure is seen as a test of stationary. If the procedure does not acceptable segmentation of order greater than or equal to 2, then the hypothesis invalid (stationary series) is accepted.

- Bayesian from Lee Héghinian (1977): procedure is used for research of the average change in the sequence of independent random variables. It assumes that a change in average exists in a time series, and then considers the probable date of this change and the magnitude of the change made. A significance level of 10% was used for testing.

-

4. RESULT AND DISCUSSION

4.1. Annual variability on an annual scale

We take the pluviometric station of Bouchegouf as example in order to highlight the variability of the annual rains which were centered and reduced (Figure 2). The visual analysis the figure below shows an alternation of dry and wet periods of variable durations, not exceeding five years successive for the wet years, and four years successive for the overdrawn years. Thus, one observes only the end of 1985 at the end of the years 1990, a tendency to draining clear and durable. That corroborates work of Meddi (2007) which finds a rupture as from the years 1980. It corresponds to a rain fall deficit particularly net during the period 1980-1990. If this dryness can be regarded as most important of the last century, in deficit, extended and duration, it is not exceptional all the same on a historical scale, bus of the studies aiming at quantitatively reconstituting the flows since the beginning of the last millenium seem well to show certain periods of so remarkable dryness (Servant, 1967; Maley, 1981; Sircoulon and Olivry, 1986).

Since 1997, the increase in the rainfall is perceptible, but it does not arrive yet at the level of the surpluses and especially the wet interlude is of rather short duration. The curve of moving average

decrease then since 2000 to grow again. Year 2003 is made conspicuous by an important pluviometer and exceptional falls of snow in all the Maghreb countries, even in the littoral zones which are traditionally deprived by it.

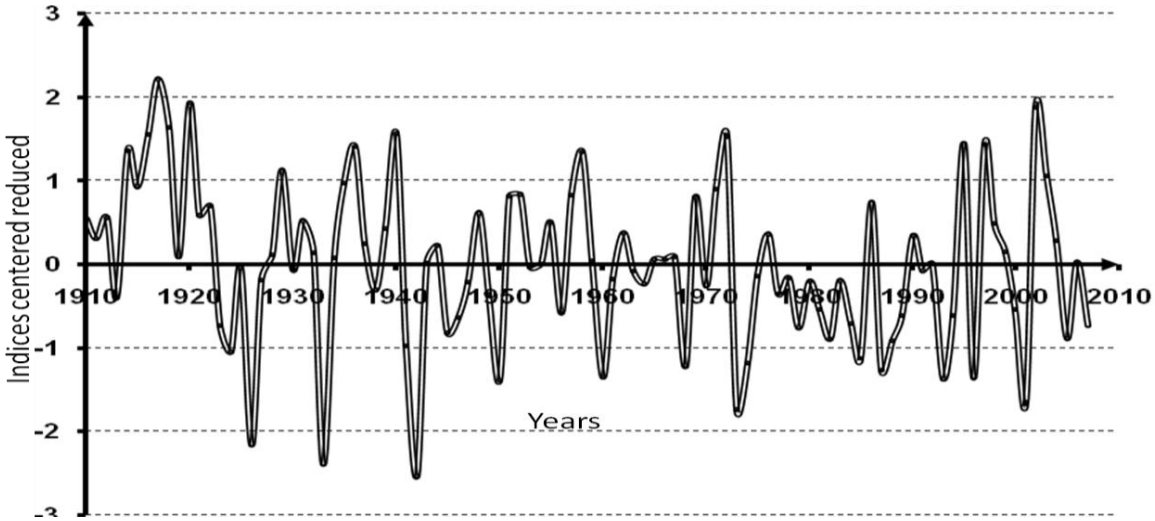

Figure 2. Indices centered reduced calculated on the annual pluviometric series of the Bouchegouf station

4.2. Application the methods of detection ruptures within the pluviometric series the results of the methods of detection of ruptures in the pluviometric series are gathered in table 3. The application of the procedure bayésienne of Lee and Heghinian show that for the annual rain, this one presents a rupture in all the stations.

Table3: Result of the methods of detection of rupture

Station	Code	Test Pettit	Bayésienne	Segmentation Hubert	Average before break	Average after break	%
Berriche	140103	1984	1984	-	302.92	251.81	19
Ksar Sbahi	140104	1980	1980	-	320.19	300.85	15
Aioun Settara	140105	1988	1988	1988	339,02	305,99	10
Ain Babouche	140109	2001	2001	-	337,78	247,91	14
Bordj Sabath	140302	1989	1989	-	576,31	504,80	13
Heliopolis	140403	2001	2001	-	698,53	574,48	21
Guelma ONM	140407	1982	1982	-	545,69	483,19	12
Mechroha	140502	1989	1989	1996	1102.06	894.11	20
Bouchegouf	140505	1940	1940	1940	632.97	543,03	16
Ain Berda	140606	1996	1996	-	679,41	591,19	14
El-Kerma	140609	1988	1988	-	607,42	543,73	11
Pont Bouchet	140631	1989	1989	-	619,57	573,62	8

These results confirm the appearance of a pluviometric deficit during the decade 1980-1990. This phenomenon still currently persists and produces a problem of an economic and social nature, taking into account the increasing pressure which is exerted on the water resource, (Meddi et Hubert, 2004).

4.3. Analyze flow annual

The Cherf River occurs in the High Plains (Berriche and Ain Babouche) and meets in the West of Guelma, the Bouhamdane River which runs South-western - the North-East, along the slope South-tellien. Figure 3 shows the variability of annual throughputs for the two stations hydrometric during the period 1969-2002. The curves show that these rivers have also a great variability of the flows in the course of time. Certain years, they can approach or exceed 80 m^3/s, whereas the values remain

variable. For the two stations, a reduction in past volumes of water occurred between 1975 and 1982. These hydrometric fluctuations are similar to those of the scale pluviometry annual.

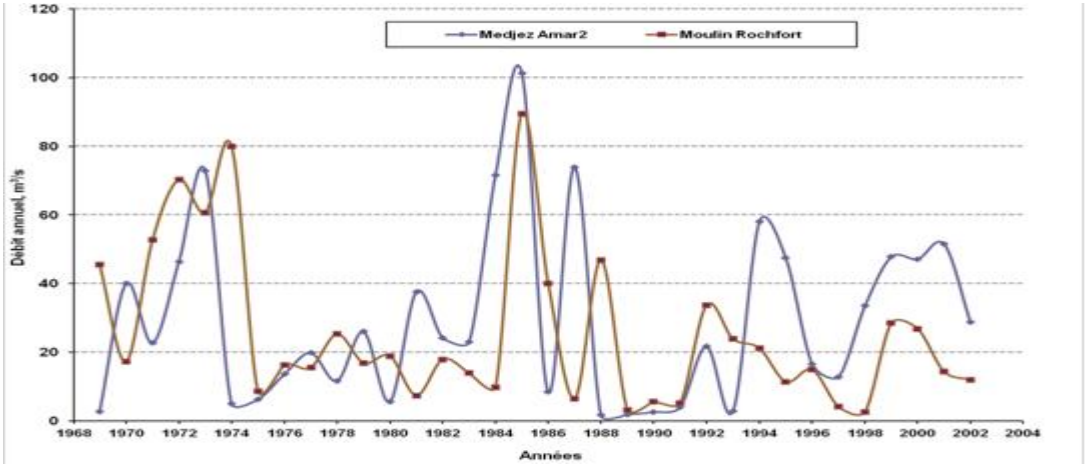

Figure 3: Evolution of annual flows of the two stations

The impact of climatic variability on the water resources was the subject of several studies in Algeria. Thus work of Laborde et Al., (2009) show a reduction in rain of 15% would result in a fall of 40% of the flows of surface into North of Algeria. In the same order of idea, work of Meddi and Meddi. (2009) show a fall of annual precipitations which exceeds 36% in the area of Mascara and the extreme West. In the same order of idea, a study of Meddi and Hubert of the series of flows of certain areas catchment of the Western North of Algeria showed a reduction of the liquid contribution with reached 67% which caused a disturbance of the rain fall mode and a reduction in the underground resources moreover 60% and one fall of the piezometric level of the tablecloth.

Kingumbi et Al., (2000) highlights a significant fall (without break stationnarity in the series) of annual precipitations in central Tunisia, between 1976 and 1989.

CONCLUSIONS

The methods of detection change in the series pluviometric (test of Pettitt, procedure Hubert, and the method of Lee and Heghinian) show ruptures in the decade 1980-1990 (reduction of rain fall) for the totality rain gage. The hydrometric study of the series of flows of two stations exposed a change of the hydrological mode during the decade 1975-1982. This reduction pluviometric is noted during the period of study and with the factor of the human activity which appears by its effect on the environment. These reports allow to the managers water resources to trace a good strategy for the rational use and probabilized of hydraulic works.

REFERENCE

[1]. Cahier de l'agencedu bassin hydrographique Constantinois Seybousse Mellegue 2000.

[2]. Hubert, P., et Carbonnel, J.P. (1987), Approche statistique de l'aridification de l'Afrique de l'Ouest. Journal of Hydrology, 95, 165-183.

[3]. Kingumbi A., Bergaoui Z., Bourges J., Hubert P. et Kalled R. (2000), Étude de l'évolution des séries pluviométriques de la Tunisie centrale. Documents Techniques en Hydrologie, n° 51 ("Hydrologie des Régions Méditerranéennes" Actes du Séminaire de Montpellier, 2000), UNESCO, Paris, 341-345.

[4]. Laborde JP, Assaba M., Demmak A. et Behlouli L.(2009), La ressource en eau de surface de l'Algérie du nord : que se passeRAIT-il si la pluviométrie baissait? Colloque international sur la gestion intégrée des ressources en eau Batna, 10 et 11 Novembre 2009, Batna, Algérie.

[5]. Lee A.F.S., Heghinian S.M. (1977), A shift of the mean level in a sequence of independent normal random variables: A Bayesian approach. Technometrics, vol. 19, n° 4, 503-506.

[6]. Lubes H., Masson J.M., Servat E., Paturel J-E., et Boyer J.F (1994), Caractérisation de fluctuations dans une série chronologique par application de tests statistiques. Etude bibliographique, Rapport 3, Programme ICCARE. ORSTOM, Montpellier, France.

[7]. Lubes H., Masson J.M., Servat E., Paturel J.E. et Servat E. (1998), Variabilité climatique et statistique : Etude de simulation de la puissance et de la robustesse de quelques tests utilisés pour vérifier l'homogénéité de chroniques. Revue des sciences de l'eau, 3, 383-408

[8]. Maley J., (1981) Etudes palynologiques dans le bassin du lac Tchad et paléoclimat de l'Afrique Nord tropicale, de 30000 ans à l'époque actuelle. Travaux et Documents Ortom 129, 586.

[9]. Meddi M. et Hubert P. (2003), Impact de la modification du régime pluviométrique sur les ressources en eau du Nord-Ouest de l'Algérie. Hydrology of the Méditerranéen and semi-aride Régions. IAHS publication N° 278.

[10]. Meddi, H., Medii, M., 2007. Variabilité spatiale et temporelle des précipitations du Nord-Ouest de l'Algérie. Geographia technica, pp49-55

[11]. Meddi H. et Meddi M. (2009), Variabilité des précipitations annuelles du Nord-Ouest de l'Algérie. Sécheresse, vol. 20, n° 1, 57-65.

[12]. Nicholson S.E., Kim J., Hoopingarner J. (1988), Atlas of African rainfall and its inter annual variability. Department of Meteorology, Florida State University Tallahassee, 237.

[13]. Pettit A.N. (1979), A non parametric approach to the change-point problem. Applied Statistics, vol. 28, n° 2, 126-135.

[14]. Servant M., (1967) Nouvelles données stratigraphiques sur le quaternaire supérieur et récent au Nord-est du lac Tchad (Kenem). Congr. Panafr. Preh. et d'Etudes quat. Dakar 20 p.

[15]. Sircoulon J., Olivry J.C. (1986), Caractérisation de la sécheresse actuelle en Afrique de l'ouest et centrale (considération sur les stations pluviométriques de longue durée et les débits des rivières) In: Compte rendu du colloque international sur la révision des normes hydrologiques suite aux incidences de la sécheresse, CIEH, Ouagadougou, 20 au 24 mai.