Drought effects on reservoirs inflows in Tunisia: Case of Lakhmess and Siliana reservoirs

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Drought effects on reservoirs inflows in Tunisia: Case of Lakhmess and Siliana reservoirs

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Abstract. This study relates to the interaction between the rainfall, the inflow of water and the storage management of reservoirs in semi-arid zones. It consists on studying and analyzing the behaviour of the hydro meteorological variables on the level of the catchment area of Siliana, in Tunisia. The concerned basin is characterized by a wet and cold climate in winter, dryness and heat in summer. It was the subject of several development works (benches, little lakes and two big dams). The measures carried out are made on the basis of a package of observed data on the different sites of reservoirs, collected from the DGBGTH of the Ministry of Agriculture and Hydraulic Resources Hydrological Books. Precipitations during the last decades were lower than the normal on the whole country. The rainfall shortage in Siliana area is about 30% or even more. It is probable that this downward trend is explained partly by the climate change. Indeed, we noticed an increase in the temperature and evaporation on the level of reserves of the Siliana and Lakhmess reservoirs. The rainfall deficit is reflected on the flows of the rivers and consequently on the reservoirs inflows. This situation requires vigilance on the state of the water resources and rigor on the level of their management in order to satisfy the requirements of water for the irrigated perimeters downstream of these reservoirs. The consequences of drought are numerous: rainfall deficit, low rate of reservoirs filling and demand fulfilment of irrigated perimeters. Thus, the inventory control must be made with caution to be able to face the risk of a prolonged drought.

Keywords. Rain – Inflow – Evaporation – Temperature – Drought – Reservoir – Management – Tunisia.

Effet de la sécheresse sur l'apport d'eau aux barrages de Tunisie : Le cas des lacs de barrage de Lakhmess et Siliana

Résumé. *L'objet de ce travail consiste à étudier l'interaction entre les précipitations et les apports d'eau aux barrages dans la région de Siliana située en zone semi-aride. Il s'agit d'analyser l'évolution des variables hydrologiques (pluie et apports) ainsi que la température moyenne journalière. Les données traitées sont collectées auprès de la DG/BTH et le CRDA Siliana. Nous avons observé une décroissance significative des pluies jusqu'en 2001 où la série change de comportement, avec tendance vers la hausse. La température et l'évaporation semblent croître. Le déficit pluviométrique influe beaucoup sur les apports et par conséquent le bilan hydrologique. Dans des conditions de pénurie d'eau ; il est nécessaire de procéder à une gestion rigoureuse pour satisfaire les demandes en eau et atténuer les impacts de la sécheresse.*

Mots-clés. *Pluie – Débit entrant – Évaporation – Temperature – Sécheresse – Barrage – Gestion – Tunisie.*

I – Introduction

There are different types of drought (meteorological, hydrological and agricultural ones); (Bergaoui and Alouini, 2001). Different approaches are used to define drought. Bagnouls and Gaussen (1953, 1957) consider that the ombrothermic diagrams permit to determine dry periods. Other authors consider that when the quantity of water received by the soil becomes less than or equal to half the potential evapotranspiration, the period is characterized as a dry one. To make the characterization and identification of drought, we have developed our approach in Siliana Basin case study by using hydro rainfall data observed at Siliana Agricultural Station (CRDA). Siliana region is located in semi arid North West of Tunisia.

II – Methods and data

Three methods are used in the present work. We studied the following:

(i) Inter-annual variability of the inflows and rainfall time series. This is to analyze the timing of the annual series, to verify the normality of the series and to detect break sequences, and the changes on averages. The trend is determined by moving averages. An analysis of the temporal evolution of daily temperature has been made over an observation period of 40 years.

(ii) The calculation and analysis of rainfall deficit, with establishment of the relationship between rainfall and deficit.

(iii) Finally, the characterization of meteorological drought has been made based on the deviation from the normal annual rainfall. A dry period is characterized by its duration, the observed deficit and its intensity.

1. Data

The hydrometric data, rainfall and climate used in this study are those observed at the Siliana Agricultural Station (DGRE). The observation period is from 1946 to 2007. Potential evaporation is that observed at Lakhmess reservoir.

2. Exploratory analysis and temporal variability

The analysis of rainfall time series for 40 years has allowed to know its evolution over time and to determine its general trend. Indeed, those series presents some failures of average change. It can be assumed as the succession of two periods. By applying the test of Hubert segmentation Hubert *et al.* (1989), we found a change in the average in 2001. The first period, located between 1966 and 2001, is a succession of wet and dry periods. The second period, after 2001, has an increasing behaviour. The segmentation results are given in Table 1 below.

Table 1. Rainfall time series, Hubert segmentation

Period	Average (mm)	Standard deviation
1966-2001	397.097	118.833
2002-2006	578.220	133.630

We note the significant difference between the two averages. Figure 1 shows the sequence of values and the evolution trend. Indeed, there is a look downward until after 2001 and the trend seems to grow. The effects of extreme fluctuations are mitigated by smoothing by moving average package of fifteen values. The change is observed in 2001 (Fig. 1).

For the time series of water inflows, the overall trend is decreasing (Fig. 2).

As for the evolution of daily mean temperatures (1966-2006), we observe a marked increase during the observation period (Fig. 3). There was an increase of one degree for 40 years. Certainly, this increased temperature and the reduced water inflows have a negative impact on the management of water resources and on agricultural production.

3. Identification and characterization of drought

The identification is made by computing the rainfall deficit relative to the average between years. The characterization is defined by calculating the duration, the deficit and the intensity of the dry period. The results of the calculations, on an annual basis, are detailed in Tables 2 and 3 below.

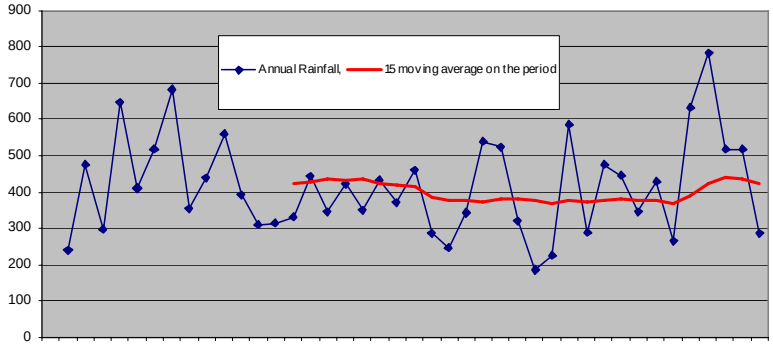

Fig. 1. Annual rainfall (mm) and moving averages (1966-2006).

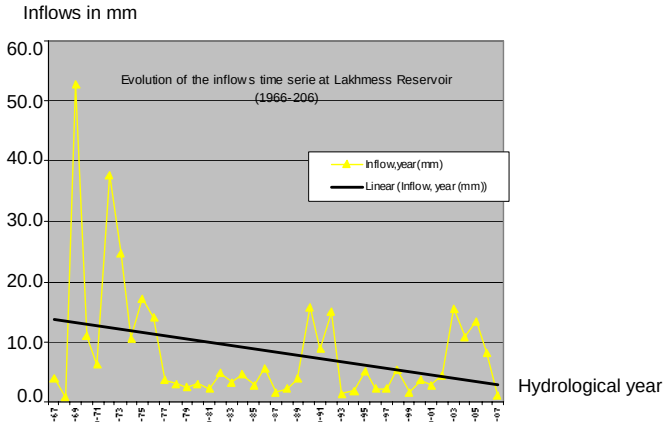

Fig. 2. Evolution of the inflows time series at Lakhmess reservoir.

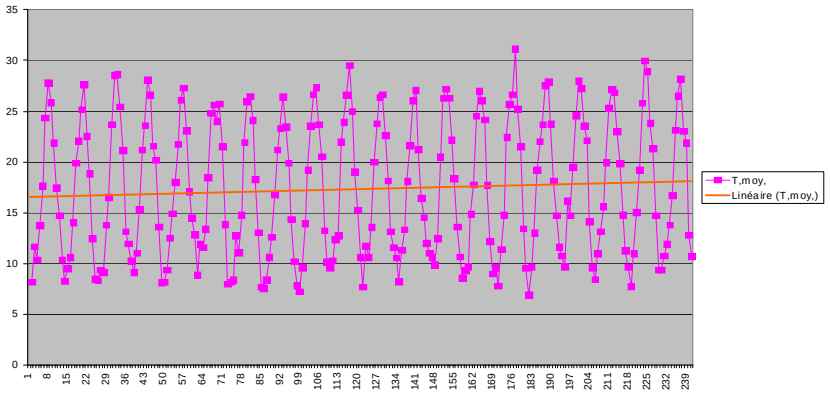

Fig. 3. Evolution of daily mean temperature, Siliana Station (1966-2006).

Table 2. Drought characteristics

No.	Beginning	End	Duration (years)	Cumulated deficit (mm)	Intensity (mm/year)
1	1966	1966	1	180	180
2	1968	1968	1	123	123
3	1970	1970	1	7	7
4	1973	1973	1	66	66
5	1976	1979	4	27	81
6	1981	1981	1	71	71
7	1983	1983	1	68	68
8	1985	1985	1	47	47
9	1987	1989	3	83	127
10	1992	1994	3	527	175
11	1996	1996	1	129	129
12	1999	1999	1	72	72
13	2001	2001	1	155	155

Site analysis: Siliana Station; Aggregation time scale: years (from 1966 to 2006); Initial month: January; Hydrological variable: precipitation; Threshold: average 50%; Threshold (mm): 419.19.

Table 3. General characteristics of drought periods

Mean	Average	Max	Min
Duration (years)	1.5	4	1
Cumulated deficit	119.6	527.0	7.0
Drought Intensity	100.0	180.0	7.0

We highlighted thirteen dry periods with a maximum duration of four years, for a rainfall deficit of 527 mm and a maximum intensity of 180 mm/year.

III – Conclusions

This study permits to highlight the dry and wet periods, with a change on average of the behaviour of the time series of precipitations. The maximum duration of a drought period is about 4 years. The maximum intensity of dryness is around 180 mm/an. We showed an increase in the temperature with a reduction in the inflows even for relatively wet hydrological years.

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